**ASIAN DEVELOPMNT BANK**
**TSUNAMI EMERGENCY ASSISTANCE PROJECT**

☐ **IEE REPORT**

# INITIAL ENVIRONMENTAL EXAMINATION FOR MAAFARU ELECTRICITY UPGRATION

**POWER PROJECT**

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## Abbreviations

| | |
|---|---|
| ADB) | Asian Development Bank |
| DEG | Diesel Engine Generators |
| EC | Electrical Conductivity |
| EIA | Environmental Impact Assessment |
| EMM | Extended Mission in the Maldives |
| IDC | Island Development Committee |
| IEE | Initial Environmental Evaluation |
| MEB | Maldives Electricity Bureau |
| MEEW | Ministry of Environment, Energy, and Water |
| MSL | Mean Sea Level |
| PVC | polyvinyl chloride |
| TDS | Total Dissolved Solids |
| TEAP | Tsunami Emergency Assistance Project |
| TEB | Tender Evaluation Board |

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# Introduction

Tsunami of 26th December 2004 has caused significant damage of the infrastructure of Maldives including electricity in all the impacted islands. Upgrading of the replacement of electricity generating and supply systems in several islands is currently underway through government and international donor assistance. Noonu atoll Maafaru has been identified as one of the 7 islands for upgrading electrical supply systems funded by Asian Development Bank (ADB).

This Initial Environmental Evaluation (IEE) report thus fulfils the requirements specified in the terms of reference prepared for this project specific to the environmental specialist. In preparing the report consideration has been given to cover the environmental requirements by ADB for these kinds of projects as well as the environmental requirements by the government of Maldives.

This IEE was carried out between 10th and 11th June 2006 during the field visit made to the project site by the by the environmental consultant and other relevant consultants for the project.

# Terms of Reference

The 26 December 2004 tsunami inflicted widespread damage to the infrastructure and severely affected the living conditions of the population on the outer islands of the Maldives. The rehabilitation and reconstruction efforts on several areas are currently underway through assistance by several international organizations including Asian development Bank (ADB)

ADB's assistance as Tsunami Emergency Assistance Project (TEAP) is to provide the Government of the Maldives with the equipment, civil works, goods and other related services required for the rehabilitation and reconstruction of the tsunami-damaged infrastructure facilities. The Ministry of Environment, Energy, and Water (MEEW), in association with Maldives Electricity Bureau (MEB) has selected 7 islands for rehabilitation/reconstruction of the power stations under the Project. The designs for the 7 power stations have been completed under a separate contract awarded by MEB and financed by the Government of Maldives and are currently in the process of preparation of tenders for submission to the Tender Evaluation Board (TEB). In order to thoroughly examine each of the 7 power stations, additional studies are necessary to be carried out that include: (i) an initial environmental evaluation (IEE) and if required an EIA, (ii) a socio-economic assessment, and (iii) an economic and financial analysis for each power station. In order to carry out the additional studies, the consulting services are required to assist the Government and ADB. During the study period, the consultant will be administered by ADB HQ and assisted, as required, by ADB's Extended Mission in the Maldives (EMM).

Detailed Tasks and specific activities carried out by the environmental specialist specific

activities to be carried out during the project include, but are not limited to:

1. Preparation of the initial environmental examination (IEE), and if required an EIA, for the 7 power stations; This will include a description and location of each station (maps, aerial photographs, satellite imagery), description of the environment, screening of potential environmental impacts and mitigation measures, institutional requirements, public consultation and information disclosure, findings and recommendations, and conclusions.

2. Preparation of the environmental monitoring and management plans for each power station;

3. Inclusion of clauses in the tender documents that are directly related to the environment and mitigation measures required of the contractor and to be followed explicitly by the contractor, or others, in order to monitor the environmental aspects during construction.

# Project description

This project involves construction of a new powerhouse for the island community as a replacement of the existing powerhouse which provides electricity to the island which is managed by Island Development Committee.

As part of the new facility three diesel generator sets with total capacity of 110KW, a control room with automatic switching control panel, an office and billing area and an accommodation facility will be provide. In addition fuel and water storage tanks will also be constructed as part of the project (figure 1).

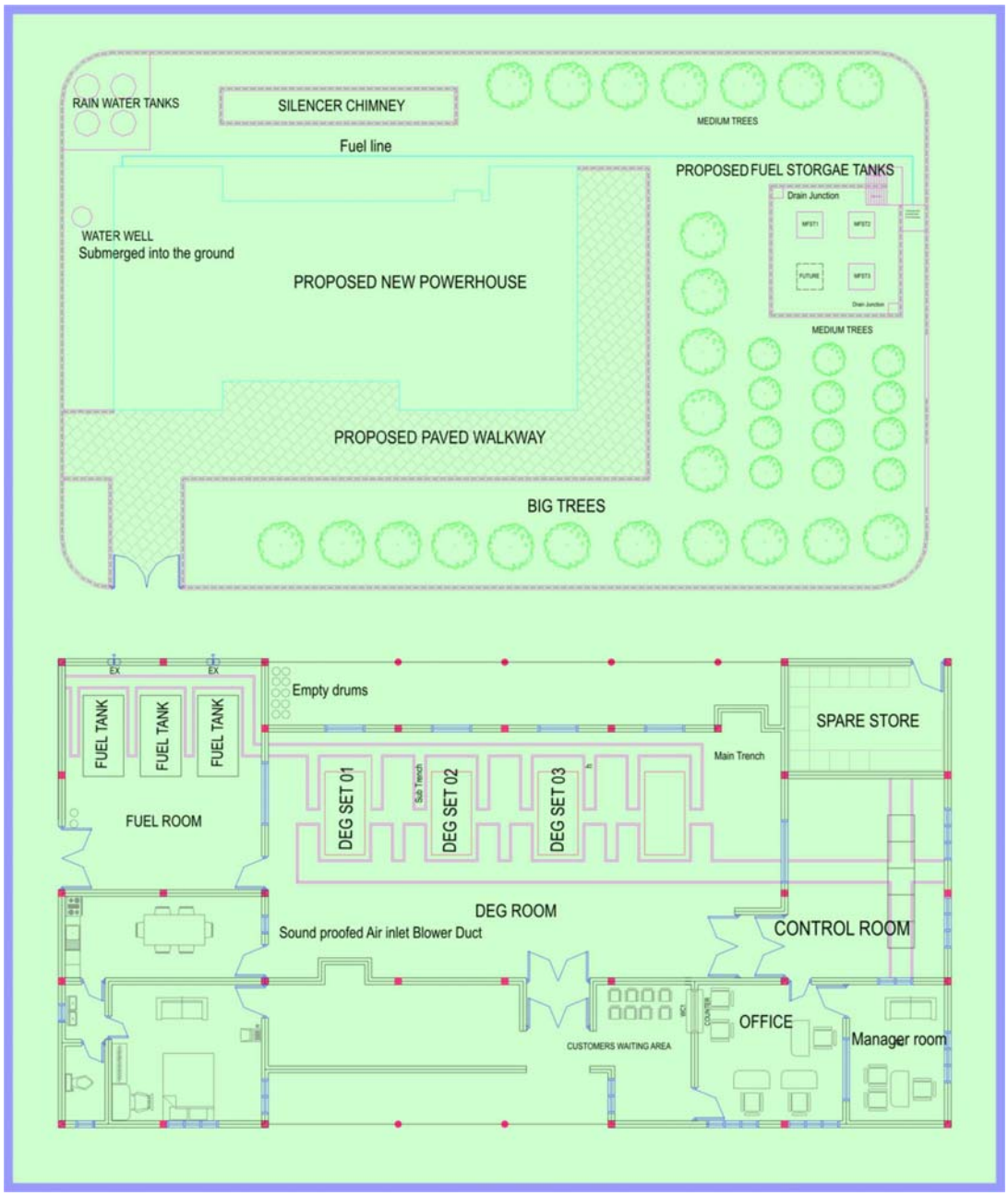


**Figure 1 General layout of the powerhouse**

# Description of the environment

## General setting: Project location

Geographically distinct, each community or village is physically separated from each other by sea where the islands are part of the atoll archipelago of Maldives in the north and central part of Indian Ocean. As such the island of Maafaru is located on the east side of Noonu atoll, an administrative atoll with in Ha Alif to Noonu atoll complex (not a distinct geographic atoll) in the country. Maafaru is a fairly large island which is elongated with a length and width of 4630m and 630m respectively. The eastern side of the island is exposed to the ocean side where as the western side is facing the atoll lagoon. The inner lagoonal margin is proliferated with seagrass, predominantly *Thallasia hemprichii.* The island reef system also has a natural harbour with a small excavated harbour basin near the village. The island has an area of approximately 114 hectares with a population density of 8 persons per hectare. The village is located on the north and central part of the island near the western coast (figure 2).

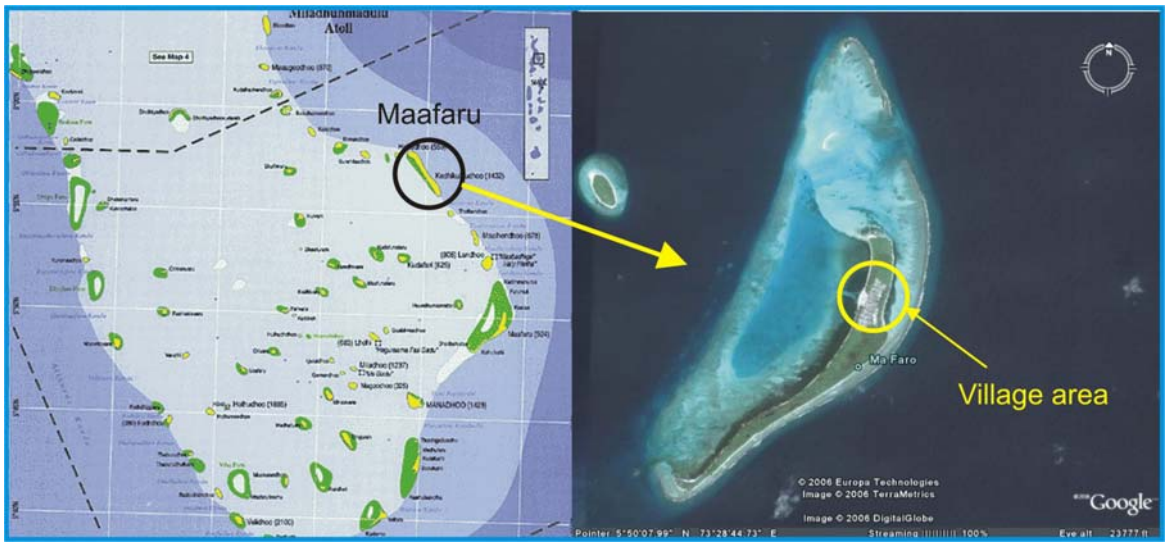


**Figure 2 General location of Maafaru and its general location within the atoll**

## Physical environment

### Air quality

Air quality is generally good at the project site. There are few point source emissions or engine exhausts that would cause a significant impact to the environment. Among these include few mechanized fishing vessels, other sea transport vessels, a few motor cycles and the existing powerhouse, and the powerhouse is the only source which emits exhaust fumes

continuously all year around. The existing powerhouse is located within the housing plots potentially exposing the residents to exhaust fumes. However, the tropical climate with monsoonal winds provides an environment with good flushing and mixing of air and leaves little or virtually negligible traces of foul air in the immediate environment from the current sources of exhaust emissions.

Although emissions from the motor vehicles are not a significant concern in outer islands such as Maafaru, it is already a significant issue and a concern in the capital Male. There are few regulatory measures to minimize the impacts on air quality. A road worthiness certification is imposed by the Ministry of Transport and Communication (MTC) on motor vehicles every two years however, these routine checks are mostly on the physical aspects of the vehicle rather than the checks on limiting the exhaust fumes.

The powerhouse exhaust is currently not equipped with appropriate exhaust chimney. Chimneys are small bore pipes without a hood and emissions are directly discharged to the open air. As a result soot and other particulate matter are accumulated on the boundary wall of the powerhouse and on some of the plants in the vicinity of the chimneys.

**Noise**

In general, noise pollution is not a significant human health issue in the Maldives as there are no large motorized industries. The most significant source of noise in the islands including the project site is from the electric power house which is powered by diesel generators (DEG). These generators are generally operated in compliance with the regulations imposed by the Maldives Electricity Bureau (MEB) of Maldives.

The existing powerhouse compound is in the vicinity of housing plots which is only separated by narrow streets from all sides. None of the generators are sound proof and the building is not equipped with sound attenuators. As such sound levels from the powerhouse are in excess of 85 dB (A) in the immediate vicinity of the powerhouse (60m radius). As such, currently the powerhouse is not in compliance with MEB regulation which specifies all diesel power generating systems should have a minimum distance of 60m from the residential areas (articles no. 8.4 of MEB Regulation Handbook, 1995).

**Soil and groundwater**

Soil in these small tropical islands are poor and highly alkaline in nature as result of the sediments been saturated by calcium carbonate (100% coral sand). Only the top thin layer of the soil contains humus which varies depending on the vegetation and canopy. As the soil is highly sandy the water retaining capacity of the soil is poor. Maafaru soil can be categorized as fair compared to majority of the islands in the Maldives since the island is large and densely vegetated. There are no large agricultural activities that can be considered a significant economic activity. Major economic activities of the island are thatch weaving and fishing.

Groundwater is the only source of water for cooking and sanitation purpose and is reported slightly saline and not appropriate for drinking. Sewage disposal is generally through septic tank systems where the effluents are disposed to the ground which may eventually mix with the freshwater lens through drainage and precipitation and have the potential to contaminate the groundwater. As a result the community uses rainwater as the main source of drinking water. Many households have rainwater tanks to collect rainwater during the rainy season. There are also communal rainwater collecting facilities on the island with public finance.

Maafaru Island was significantly flooded with sea water during the tsunami of December 2004 except for very few areas on land. Groundwater of all the islands inundated by the tsunami has been affected through contamination and saline intrusion. As a result the groundwaters in many islands are slightly saline, however significantly improved over the several months since the tsunami. Groundwater was tested for salinity, electrical conductivity and Total Dissolved Solids (TDS) from the well in the premises of the power house and a reference location about within 100 meter radius of the powerhouse. The primary intention of the tests for the water are to find out whether there is any trace of fuel in the groundwater as there is good indication of substantial spill of diesel in the area of fuel refueling. However, the Public Health Laboratory (PHL) in the Male does not have the reagents for testing trace levels of hydrocarbons at the time of the surveys. The salinity from both the powerhouse and the reference station was less than 2ppt (1.4ppt in the powerhouse well and 1.2ppt in the reference station). Similarly TDS and electrical conductivity (EC) was much higher in both the reference station and the powerhouse water sample. The EC of the powerhouse well water were higher than WHO reference standards for drinking water (less than 1500 µs/cm) and are 3300 µs/cm and 4510 µs/cm respectively. These results indicate that the groundwater, though slightly saline has high levels of dissolved solids (29110 mg/l for the powerhouse well-water and 2120 mg/l for the reference station well-water sample). For comparative purpose the groundwater of Male was also tested for salinity and electrical conductivity. The sample of water tested from Male has a salinity of 10.3ppt and electrical conductivity of over 19000 µs/cm.

## Climate and oceanography

Maldives is affected by the Southwest monsoon (SW) (May – September) and the Northeast monsoon (NE) (December – February). The period between March and April is the transition period from the NE monsoon to SW monsoon known locally as the Hulhangu Halha, while the transition period from SW monsoon to NE monsoon known as Iruvai Halha is from October to November. The SW monsoon is generally rough and wetter (locally known as the rainy season) than the NE monsoon. Storms and gales are infrequent in this part of the Indian Ocean and cyclones do not reach the Maldivian archipelago.

The average temperature of Maldives is around 28 °C with little variation across the latitudes it spans close to the equator. The average daily temperature which can be applied to the project area is from Hanimaadhoo is between 31°C and 25°C. Rainfall records for the area shows about 1780mm of rain annually.

### Tides

Tides experienced in Maldives are mixed semi-diurnal and diurnal with a strong diurnal inequality. There are few tidal record stations in Maldives. The tide station at Hanimaadhoo in Ha Dhaal atoll is relatively close to Maafaru. Tidal estimates for the year 2005 indicate that the maximum tidal range at Hanimaadhoo is approximately 1.34m (tide calculations based on the tide data available for Hanimaadhoo at www.iikai.soest.hawaii.edu/uhslsc.woce.html). The highest astronomical tide level is +0.56m (MSL) and the lowest astronomical tide level are -0.78m (MSL). These tide measures can be applied to Maafaru because of the insignificant tidal variations in tide levels throughout the Maldives. Tidal variation reported from National Meteorological Centre (NMC) reports about 0.15m north to south variation where the tidal range is slightly larger in the southern atolls of Maldives. Site specific records and calculations for the tide were not taken at the project site because these parameters are not directly relevant to the proposed project activities.

### Waves

The swell and wind waves experienced at Maafaru are conditioned by the monsoons and the swells generated by the storms in the Indian Ocean. The waves approaching the shoreline of Maafaru are conditioned by the two monsoons the NE and SW monsoon. The east side of the reef more exposed to the wind and wave generated waves compared to the west side because of the exposure of the southern Indian Ocean swells. The western side of the island occupies a wide reef flat occupied by a wide lagoon with a deep sandy lagoon at the centre. Although this side of the island is exposed to the SW monsoon the width and reef and shallow peripheral reef flat significantly reduces the wave energy before it reaches the shoreline. Because of this lagoon provide the natural harbour fro this island.

### Currents

Generally oceanic current flow through the Maldives is driven by the monsoon winds. Westward flowing currents are dominated from January to March (NE monsoon) and eastwardly from May to November (SW monsoon). The change in current flow patterns occurs in April and December (roughly the beginning of monsoon change). In April the westward currents are weak and eastward currents flow will slowly take place. Similarly in December eastward currents are weak and westward currents will take over slowly. Near shore currents are slightly different from the oceanic currents and are largely influenced by the location, orientation and morphology of the reef s around the islands.

## Ecological resources

### Terrestrial environment

Due to the low population density and the village centered and concentrated on one area of the island large part of the island is unexploited and undeveloped except for coconut

harvesting. Therefore the vegetation of the island can be regarded as unspoiled. Timber size trees such as coconut (*Cocos nucifera*) palms (Nika (*Ficus bengalensis*), Funa (*Caloplyllum inophyllum*), Kaani (*Cordia subcordata*), Dhiggaa (*Hibiscus tiliaceus*) and Hirundhu (*Thespesia populnea*) are also common but not abundant. The vegetation structure in addition to the timber size tree, include Kuredhi (*Pemphis acidula*), Magoo (*Scaevola taccada*) and Halavel (*Suriana maritima*) dominate the nearshore or coastal area as in tropical coral islands such as in Maldives.

The area designated to construct the new powerhouse is located on the central but eastern side of the island. This area is within the undeveloped part of the island. The nearest infrastructures to this site are the island cemetery and some residential plots that are newly developed. There is more than the regulatory distance (60m) between the new powerhouse and these infrastructures to fulfill the minimum compliance distance required by MEB. The vegetation here is wild and several trees have to be felled in order to clear the land for the new powerhouse. These include approximately 40 mature coconut palms, 25 young coconut palms, few Dhigga, 5 screw pines, 5 Uni and several species of bushes and shrubs as undergrowth. There is a small banyan tree within the designated compound which may need to be removed to construct the powerhouse building. This would be avoided where possible. Another banyan tree relatively small is also in the vicinity of the powerhouse plot.

This designated powerhouse plot area is actually within the forest area of the island generally used for coconut harvesting. As such many of the coconut palms and trees are either privately or publicly owned. If these trees need to be remove for the construction and also access to the powerhouse appropriate compensation has to be arranged. Generally the IDC in each community takes care of the compensation and other issues related to the site clearing.

Soil here is generally good composed of thin layer of humus and plant litter. Land clearing would lessen the richness of the soil with almost full exposure to the sun and rain. However this is directed to a small area and would have little residual effects to the surrounding areas.

**Marine environment**

Marine environment of Maldives is highly diverse in context of coral reef environment in which the whole Maldivian island ecology is dependent. The coastal marine environment is comprised of several coral reef related marine organisms many of which are ecologically important in addition to the myriad species in the ecosystem. Currently there are over 1200 species of fish, 250 species of corals, 13 species of mangroves, several species of sea grasses, 25 species of whales and dolphins, five species of sea turtles among many other several animal groups from the coastal environment. Reef environment is highly important to the economy of Maldives both from a fishery and tourism perspective.

This project and its impacts are not directly related to the marine environment and its associated components. Therefore little effort is made to describe marine environment in detail.

**Ecologically important habitats**

The marine environment, the island environment and associated habitats are all ecologically important ecological entities in a national context. Some of the more significant habitats are reefs, sea-grass beds, mangroves and inter-tidal area which have more of an ecological value than economic value. There are no major habitats associated with the project site (island) except the coral reef around the island and the sea grass bed near-shore on the western side which would have no or negligible impact from the proposed project activities. There are no mangroves associated with the project but there is a mangrove depression on the southern end of the island which is few kilometers away.

**Rare and endangered species**

There are no rare or endangered species associated or would be directly impacted as a result of this project. Rare and endangered species in the Maldives are more confined to the marine environment. Not rare but endangered species that are of highly significant even at global level are all the 5 species of sea turtles found in Maldivian waters. In addition to sea turtles several other marine species are protected. There are several species with an export ban and few species with ban on exploitation

**Protected areas**

Protected areas are few in the country which is mostly confined to marine protected dive sites. There are 25 protected dive sites in the Maldives but none in the vicinity of the project site. In addition to these protected dive sites a protected area has been recently declared in Addu atoll, known as Eidhegili kilhi area on of the first protected area that encompass both marine and terrestrial habitats. In addition 4 new areas have been protected in last June under the environmental protection and preservation act of Maldives. There are no protected areas associated with this project.

# Potential impacts and mitigation measures

The existing powerhouse at Maafaru is located in vicinity of residential plots towards the northern end of the village (see figure 3). There is a low elevated boundary wall all around the powerhouse. The power house is equipped with three generator sets (80KW) which are partially damaged but repaired after the tsunami and the condition of the generator sets are bad and the electricity provided is scanty and unreliable.

The existing building is not constructed to minimize the sound generated by the powerhouse apart from the lack of sound attenuators. The exhaust is open (without a chimney) so that all the particulate matter from the exhaust is widely dispersed to the vicinity. Accumulation of soot from some surfaces of the powerhouse compound indicates deposition of these materials in

the vicinity. No attempts were made to quantify the amount of soot which may have been accumulating over the past several months.

Fuel storage at the existing powerhouse is not adequate with evidence of substantial oil spill around the pumping area. Waste oil is stored in barrels and left on the ground without any impervious material to retain any spill or leakage.

The potential environmental impacts associated with the project activities and their likely magnitudes are described in table 1. These impacts were based on key environmental components and specific parameters within each component which is associated with the project. Considerations were also given taking to account the magnitude of the project and project activities in assessing these impacts.

**Table 1 Potential areas of environmental impacts from the proposed project**

| KEY COMPONENTS | | NO | YES | | |
|---|---|---|---|---|---|
| | | | MINOR | MODERATE | MAJOR |
| **Atmospheric** | Air Quality | | √ | | |
| **Terrestrial** | Vegetation Loss | | √ | | |
| | Soil | | √ | | |
| | Habitat | | √ | | |
| | Waste management | | √ | | |
| **Water Resources** | Groundwater | √ | | | |
| | Freshwater Lens | √ | | | |
| **Coastal & Marine** | Damage to Reef | √ | | | |
| | Damage to sea grass | √ | | | |
| | Marine Pollution | √ | | | |
| | Beach Erosion | √ | | | |
| | Fisheries | √ | | | |
| **Socio-Economic** | Noise | | √ | | |
| | Public Safety | √ | | | |
| | Public Health | | √ | | |
| | Employment | | √ | | |
| | Land/Seascape | | √ | | |

As described in the table 2, many of the environmental components are identified to have a minor impact. These minor impacts are from activities either during the construction and operation phase of the project. As outlined earlier the magnitude of the proposed project and its components are not large, therefore the likely impacts associated with various activities are also not highly significant. The mitigation measures for the various impacts identified are given in table 2. In addition the magnitude and duration of the impacts, mitigation costs and responsible agencies are also identified.

Even though some of the impacts associated with the project are minor, the major components that may cause these impacts are outlined below. Description of these are based on the finding of field visit to the project site, consultations with the project engineer, published information and reports and consultants own knowledge through several references in this field.

**Table 2 Potential environmental impact mitigation measures**

| PHASE | POSSIBLE IMPACTS | MITIGATION MEASURES | LOCATION | TIME FRAME | MITIGATION COSTS | INSTITUTIONAL RESPONSIBILITY |
|---|---|---|---|---|---|---|
| **CONSTRUCTION** – temporary impacts | **Air quality**<br>• Dust and construction related dust from site clearing and structural construction | Follow and adhere to code of conduct followed inn the local construction industry. Such practices may include;<br>• Cover loose and dry material with canvas or other appropriate method.<br>• Wet the construction area if it becomes dry to minimize potential dust issues. | Powerhouse plot and the vicinity | During the construction | Covered by the contractor | Contractor<br>Project management consultant |
| | **Noise and vibration**<br>• from construction works and machinery | Limit all work between 0600hrs and 1800 hrs<br>Adherence of motor-vehicle noise standards | Powerhouse plot and the vicinity | During the construction | Covered by the contractor | Contractor<br>Project management consultant |
| | **Vegetation loss**<br>• site clearing at the powerhouse construction site<br>• site clearing for construction material storage and workforce camp | Minimize land clearing to absolute necessary level by<br>• avoid cutting trees where possible<br>• transplant and relocate large trees where possible<br>• planting and landscaping works carried out in the final stages of construction | Powerhouse plot and the vicinity<br><br>Access to the powerhouse | During the construction | Covered by the contractor | Contractor<br>Project management consultant |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Pollution**<br>• waste generated from construction work force<br>• construction waste<br>• sewage disposal related to construction workforce | • Good code of conduct adhered by the workforce<br>• Aggregate and segregate waste and dispose it according to the local waste management practice or to a higher standard (e.g. make arrangements to transport hazardous waste to municipal waste disposal site in Thilafushi, Male atoll.<br>• Avoid if possible setting up construction workforce away from the community | Powerhouse plot and the vicinity Residential area | During the construction | Covered by the contractor | Contractor<br>Project management consultant |
| **OPERATION** – permanent impacts | **Air quality**<br>• Smoke from engine exhaust<br>• Particulate matter in the exhaust fumes | • Good engine maintenance and adherence to repair and maintenance schedule specified by the manufacturers<br>• Design and construction of silencers so that exhaust emissions dispose through the chimney | Powerhouse plot and atmosphere in the vicinity of the powerhouse | During the operation of the powerhouse | Covered by the contractor | PMU, project design engineer |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Noise and vibration**<br>• Engine operation (continuous sound) | • Powerhouse constructed to design specifications, away from residential area (minimum 200 feet radius from residential plots)<br>• Install sound attenuators<br>• Powerhouse operated to design specifications (proper use of double doors, door closers | Powerhouse plot and atmosphere in the vicinity of the powerhouse | During the operation of the powerhouse | Covered by the contractor | PMU, project design engineer |
| | **Waste**<br>• Waste oil generated from the engines<br>• Radiator waste<br>• Waste rugs or cloths | • Good house keeping<br>• Drain empty container before they are disposed burn waste clothes if they are in small quantities. | Powerhouse | During the operation of the power house but more during repair and maintenance | Powerhouse manager/ management unit | Powerhouse manager/ management unit |
| | **Oil pollution**<br>• Oil and fuel is designed to be stored in the powerhouse premises. Accidental spill and leakages are likely during fuel transfer and transport | • Fuel storage tanks constructed by reinforced steel<br>• Fuel storage area bunded to contain accidental leakages coated with impermeable material<br>• Adhere to the code of conduct for engine repair and maintenance followed by MEB | Powerhouse and fuel storage area | Operation of the powerhouse; during fuel transfer and refueling times. | Powerhouse manager/ management unit | Powerhouse manager/ management unit |

## New Powerhouse

### Location and land clearing

The powerhouse is located in the vicinity of the football field (figure 3). An area of 60x50 meter plot has been selected near the football field after consultation with the community leaders. The consultants advised on the MEB powerhouse site regulation to IDC which specifies that there has to be a minimum distance of 60 meters from a residential area. This location for the new powerhouse complies with the MEB regulations.


**Figure 3 Location of the new powerhouse with respect to significant infrastructures**

There are substantial amount of vegetation in the designated area for the new powerhouse since it is located within the forest area of the island. They are mainly coconut palms; few small sized wood plants but mainly small bushes and shrubs as undergrowth. Trees and significant vegetation with the plot would be either relocated within the plot where possible or transplanted elsewhere on the island.

The damage to the terrestrial environment is anticipated to be minor as a result of the project. This is outlined in table 1. Trees have to be cut down only to accommodate the powerhouse building. As some of the larger trees belong to the residents arrangement has been made to pay the compensation for the trees through the IDC. By the government.

There isn't also any major land clearance involved in the project, as the designated powerhouse compound is approximately 1400 square meters. Therefore, no major soil erosion or soil run off is anticipated as a result of this project.

**Construction of powerhouse**

The new powerhouse consists of DEG set room, control room, office/billing area, fuel room, fuel storage tanks and water storage facility (figure 1).

The construction works involve largely civil masonry works and commissioning and installment of new generator sets. Civil and masonry that may have impact if any would come from mainly sand and cement

Coral sand would be used for construction. Sand would be mined locally as it could be collected from approved designated areas within an atoll. Thus almost negligible impact is anticipated on the marine environment as a result of the project especially due to the small scale of the project. Cement for the project would be brought from Male in bulk quantities and stored in the construction site.

Water for the concrete and masonry works would be groundwater. The groundwater quality assessment indicates that it is more or less appropriate for the concrete and masonry works. It's not anticipated that the groundwater would be significantly affected by the level of its extraction and usage for the project. On order to minimize the level of extraction and its impacts all the excess water would be drained to the ground.

Dust from the cement has the potential to cause negative health impacts to the work force. However, with health conscious work practice followed by the construction workforce such as wearing simple masks in the immediate cement handling areas such negative impacts would be minimized.

In addition to the masonry works the project includes commissioning of three DEG sets, installment of associated equipment and partial repair and installment of underground power distribution cables.

All cables would be buried along the earthen (unpaved coral sand) streets. The trenches are narrow (0.3 meters) with an approximate depth of 1 meter (more or less above the groundwater lens). All cables would be covered with an inert polyvinyl chloride (PVC) sheath. The trenches will be open for only a short while and will be buried immediately after the cables are laid. Therefore disturbance to the soil structure is anticipated. Some level of discomfort to the community is anticipated as the cables would be buried in the existing streets. This is only for the duration of the cable distribution and is temporary.

**Waste generation and waste management**

The waste generated from the construction workforce is anticipated low given the scale and number of the workforce. Approximately 30 people are estimated to be involved during the construction of the project. The best option for accommodating the construction workforce is to find suitable accommodation within the community (temporary) so that a separate camp for them is not needed. Additionally, unskilled and semi skilled worker can be recruited from the local community so that some economic return from the project is provided to the community even at the construction stage.

Construction related waste from the project can disposed following sound environmental practices followed in the country. It is proposed that organic and non hazardous waste is burned (common local practice as the land is scarce. Harmful waste has to be separately managed by the contractor and disposed to Thilafushi.

**Noise and vibration**

The new powerhouse, away from the residential area would have improved noise control measures as compared to the old powerhouse. The building is designed to equip double doors into the generator room. There is no sound attenuators considered as part of the new design neither in the old design. However the double door concept together with the engine silencer emitting the exhaust through a chimney. The chimney also has sound absorbing capacity. In addition the powerhouse compound would be planted with tress to further mitigate the noise levels outside the powerhouse

The generator sets are allocated for the powerhouse is all high speed light diesel engines and ground vibrations are not a significant issue. In addition anti-vibration mounts will be used when the DEG sets are installed, which comes with the DEG sets.

**Emissions**

Currently the exhaust fumes from the engines are dispersed without a chimney. However the new powerhouse would be equipped with residential class primary silencers emitting exhaust through a chimney. This action would reduce exhaust emission as compared to the old powerhouse which would have a positive impact on the air quality. The chimney in addition facilitate the sound reduction would also facilitate to reduce the particulate matter emitted through the exhaust. It is believed high level of carbon would be accumulated inside the chimney which has to be removed periodically by scraping the chimney floor. The carbon collected would be disposed to the local disposal site.

**Diesel oil and other chemicals**

The most significant environmental impact associated with the powerhouse would be related to the running and operation of the DEG sets. 3 generator sets with a total capacity of 110 KW would be installed and operational at the powerhouse. Assuming approximately 45% operation of the DEG sets (50 KW generator set) the estimated annual fuel consumption is 150,000 liters. The total fuel storage capacity of the powerhouse is 18,000 liters, 3 tanks each with a capacity of 6000 liters. Diesel tanks would be constructed with steel with an outer bund-wall made from reinforced sand/cement structures. The purpose of this bund-wall is to contain accidental spill during fuel transfer and also to accommodate leakages. The main fuel storage tanks would be connected to the fuel day tank which feeds fuel to the engines through a fuel line.

Waste oil generated from the DEG sets would produce a substantial amounting to over 350 liters annually. Presently waste oil is stored in 200 liter polyethylene containers or metal drum in the powerhouse premises. Waste oil has some demand for treating timber and timber based small fishing vessels. Although this is commonly practiced care has to be taken in handling waste oil as it contains low levels of carcinogens which may cause skin irritations and it is important to notify the buyers of the waste oil the risk involved.

Reuse of waste oil mixed with diesel fuel has been considered as an option for optimal usage of the waste oil. Although such mixing methods are available it has not been widely practiced as the viscosity of the mixed fuel doe not meet the specifications required by for the smooth operation of the engines. Such options may not be favored as it may reduce the life of the engines.

The best practical method for disposal of the waste oil would be to transport it to a site designated by MEEW to dispose waste oil and other hazardous material. However, such a place does not exist within the atoll. The nearest waste disposal site is located in Kulhudhuffushi which had a regional waste management site. The other option is to transport the waste oil to Thilafushi, the main municipal and hazardous waste disposal site in the country.

**Fire and other safety aspects**

Work safety aspects required by MEB have been incorporated in the design of the powerhouse. Suitable fire extinguishers will be installed. Sound level in the generator room is anticipated to be higher than required by MEB, therefore employees would be provided with ear protection devices such as ear plugs or headphones. Safety shoes would also be provided to the employees.

# Institutional requirements and environmental monitoring plan

The environmental impacts associated with this project are viewed in context of the fragile tropical environment of Maldives where some of the impacts can be regarded significant given the small size of the islands and sensitivity to adverse environmental impacts. The environmental impacts discussed will be systematically monitored and reported during construction and operation of the powerhouse in accordance with arrangements specified in the . The Project is designed to comply with the local construction standards, powerhouse/electricity operation and supply standards. With the design and operational specifications included in the contract document the project is expected to meet good environmental standards. Table 3 summarizes the mitigating measures, the monitoring requirements (e.g., parameters monitored), frequency of monitoring, and the parties responsible for compliance and implementation.

**Table 3 Environmental Monitoring and Management Plan.**

| ENVIRONMENTAL COMPONENT | PROJECT STAGE | PARAMETERS | LOCATION | FREQUENCY | STANDARDS | COSTS | RESPONSIBLITIES | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | IMPLEMENTATION | SUPERVISION |
| Terrestrial Vegetation loss | Construction phase | Felling of trees for constructing the powerhouse | Powerhouse plot | once | Identified in consultation with MEEW | Approx. USD 150.00 | Contractor | Consultant in association with MEEW |
| Air quality | Operation phase | Exhaust particulate matter | In the vicinity of the powerhouse | Twice a year | Identified in consultation with MEEW | Approx. USD 200.00 | environmental officer/consultant | Consultant in association with MEEW |
| Noise | Operation phase | Noise levels from the powerhouse | Vicinity of the powerhouse | Twice a year | Identified in consultation with MEEW and MEB | Approx. USD 200.00 | environmental consultant | Consultant in association with MEEW |
| Oil spillage/pollution | Operation phase | General housekeeping audits, Oil in groundwater/ soil | Powerhouse, fuel storage area, workshop | Twice a year | Identified in consultation with MEEW | Included in operation and maintenance costs, USD 200.00 | environmental consultant | IDC Powerhouse mamagemennt |

MEB/MEEW pay close attention at all stages of the project, to monitor and control environmental performance and to consult regularly with the responsible authorities and the community (e.g. powerhouse manager or relevant representative in IDC). The plant operations organization will include a specific person responsible for environmental management and monitoring, and training. Programs will include appropriate environmental management activities for all operational staff.

The institutional arrangement for environmental management and monitoring of the powerhouse is shown in figure 4.

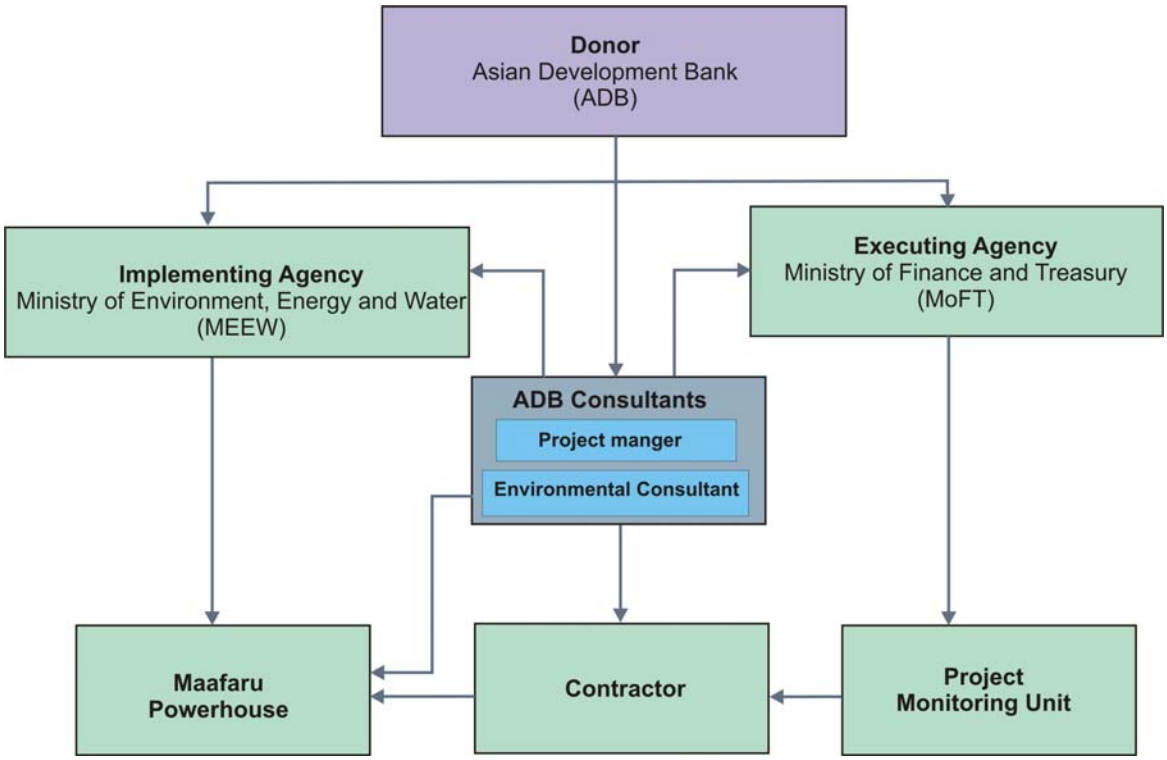


**Figure 4 Institutional arrangements for the implementation of the proposed project**

# Public consultation and information disclosure

The design for the powerhouse, equipment and services provided under the project has been consulted and approved by Maldives Electricity Bureau (MEB) and MEEW. Environmental consultations during for the IEE were carried out with the relevant stake holders including island communities and other relevant agencies. The main purpose of these consultations were to discuss the ADB requirement for IEEs and its objectives of setting the baseline for the project sites and confirming which environmental category the project belongs to with respect

to both the Governments and ADB regulations. The full list of those met and consulted is in Appendix 1.

The Island Development Committee (IDC) and key senior citizens including Women Development Committee representatives from the island has been briefed on the environmental consideration required by the project. Detailed description of the each component of the project was presented to the community to get their feedback and perception on the overall project. In addition, the group was asked their environmental concerns in general as well as any related to the project.

Among the issues which were raised in consultations, apart from the state of the electricity and the need for improved electric supply system, those that aroused the most concern were state of the groundwater and waste management. Groundwater has been contaminated seawater during the tsunami flooding which was substantial. Many feel that the groundwater is becoming less saline which is slow but steady. Good precipitation is likely to improve the quality of the groundwater, at least the salinity.

Solid waste management was highlighted by the IDC as the second serious problem. There is currently no waste management site designated to dispose the waste. As the island is relatively large and no designated site established waste is disposed where ever convenient in the fringes of the housing area. However most organic waste (food and fish waste is always either buried or disposed to the shore. This has created proliferation of the seagrass in the near-shore lagoon. The community folks largely complained this as a nuisance slowly making the previously turquoise lagoon shallow and ugly.

Sewage disposal is through septic tank systems where each household has a system. The effluents from the sewage system slowly drain to the groundwater. In small quantities the groundwater or the soil has the ability to purify the effluents from the contaminants. The extent of contaminants in the groundwater from the sewage disposal is unknown. Some of the key informants feel that groundwater is contaminated in some area. However, in general the groundwater is reported free from sewage related contaminants.

Unlike other islands coastal erosion has not been raised as a serious issue. The main reason for this is likely to be related to the population density where the village is more or less centrally located on the island. Community infrastructure is thus not threatened by the encroachment of the sea which leads to erosion. Although erosion is not reported severe some erosion is reported on the northern end of the island.

These concerns and other points of view of the community and the environmental issues associated with the project and its components have formed the basis of this IEE, supplemented as necessary by the consultants' own observations and knowledge on the environmental issues in the Maldives.

Public consultation would be made as part of the public information and disclosure process as required by MEEW. As soon as the report is approved by the relevant authorities ADB and

MEEW, it would be available to the key stakeholders involved in the project for comments.

The report would be published in ADB website: www.adb.org
It would also be made available at MEEW website; www.environment.gov.mv
Also it would be provided, at least for perusal, to those who request it.

# Findings and recommendations

This IEE report confirms that all the significant adverse environmental impacts associated with the new powerhouse with fuel storage facility and its operations in Maafaru can be satisfactorily mitigated.

Then project will an overall positive impact on the environment as the efficiency of the diesel powered electricity supply would be improved through decommissioning of the old engines and installment of the 3 new DEG sets with renovation of the distribution network. This new improved power generating system with its efficiency would also reduce the fuel and other electricity related losses.

Noise levels would be reduced through the installment of the chimney in the new powerhouse. In addition to the noise, emissions would also be reduced and controlled by the settlement of carbon in the chimney walls and floor as as the exhaust fumes pass though the chimney.

Fuel storage and handling efficiency would be improved through the implementation of the project. Accidental fuel spill can be retained and safely handled through the installment of the fuel retainer wall around the fuel tanks.

In addition to these mitigation measures powerhouse staff would be trained to safely operate the engines and electric system according to the specifications of the systems and powerhouse operation procedures outlined by MEB. Moreover the powerhouse manager would be trained by the contractor/consultant to follow and monitor the environmental monitoring and mitigation measures discussed in the environmental monitoring plan.

# Conclusions

The finding of this IEE, after the assessment of the existing environmental conditions at the project site, environmental impacts associated with the proposed activities confirms that the impacts identified can be controlled and minimized provided all the environmental measures and monitoring procedures are followed.

# Appendices

**Appendix 1 List of people met**

| | | |
|---|---|---|
| Mr.Zahid Jameel | Team Leader /ADB consulting Team. | |
| Mr.Adnan Ibrahim | Socio Economist/ADB consultant. | |
| | | |
| Mr.Mohamed Adam | Acting Island chief | Maafaru Island. |
| Mr.Abdul Sattar Ali | Acting School Headmaster | Maafaru Island. |
| Mr.Mohamed Hasan | Primary Teacher | Maafaru Island |
| Mr.Hassan Mohamed | Fisherman | Maafaru Island |
| Mr.Umar Aboobakuru | IDC Member | Maafaru Island |
| Mr.Ibrahim Manik | Senior figure of Island | Maafaru Island |
| Mr.Mohamed Yoosuf | Businessman | Maafaru Island |
| Mr.Mohamed Aboobakuru | Fisherman | Maafaru Island |
| Mr.Ibrahim Dhaaoodh | P/H Engineer | Maafaru Island |
| Mr.Hameed Abdulla | Fisherman | Maafaru Island |
| Mr.Mohamed Abdulla | Fisherman | Maafaru Island |
| Mr.Ahmed Naseer | Businessman | Maafaru Island |
| Mr.Ibrahim Abdulla | IDC Member | Maafaru Island |
| Mr.Ali Hussein | IDC Member | Maafaru Island |
| Mr.Mohamed Aboobakuru | IDC Deputy President | Maafaru Island |
| Mr.Sameer Ali | Businessman | Maafaru Island |
| Mr.Abdulla Ibrahim | Fisherman | Maafaru Island |
| Mr.Abdul Ghanee Abdulla | Fisherman | Maafaru Island |
| Mr.Naseer Ibrahim | Fisherman | Maafaru Island |
| Mr.Hussein Umar | Carpenter | Maafaru Island |
| Mr.Abdul Raheem Mohamed | Carpenter | Maafaru Island |
| Mr.Musthafa Adam | P/H Engineer | Maafaru Island |