بسم الله الرحمن الرحيم

MINISTRY OF FINANCE
MALE'
REPUBLIC OF MALDIVES

TERMS OF REFERENCE

CONSULTANTANCY FOR DEVELOPMENT OF STORMWATER MANAGEMENT MASTERPLANS FOR MALE' CITY AND HULHUMALE'

MALDIVES URBAN DEVELOPMENT AND RESILIENCE PROJECT

Background

Maldives is an archipelagic nation made up of a collection of 26[1] atolls, consisting of 1190 islands, of which 358 are used for economic development and human settlement. The country's population of almost 428,000[2] reside in 195 islands. More than a third of the population reside in Malé, making it the fifth most densely populated island in the world and the remainder is dispersed across the many islands. The country is also urbanizing at an annual rate of about 4.2% with most of the growth taking place in the Male Region, thus resulting in higher density communities in this region.

Being a collection of islands most of which are tiny and low lying, the country is very vulnerable to climatic change issues and related challenges. Therefore, aside from the urgent need to address demographic pressures, risks to natural environmental and climatic related hazard are high. Government is in the process of developing a comprehensive regional development strategy towards the creation of sustainable, resilient and livable islands.

The cornerstone of the government's urban development plan revolves around 460 hectares of artificially created island close to the Capital Male, by name Hulhumalé. The Hulhumalé Master Plan developed in 2001 provides the long-term land use and development strategy for Hulhumalé. Phase 1 development is estimated to accommodate about 80,000 people most of who were expected to relocate from the City of Male to Hulhumalé. As of the end of 2017, over 50,000 people had settled in new developments in Hulhumalé. The design of the second Phase of Hulhumalé was structured to target another 160,000 people. The design has been completed and implementation of the provisions for infrastructure and social services started in Mid-2018. Contracts for 16,000 social housing units have been signed with private developers are complete for both Phases. Phase 1 social housing construction is almost completed and has been started in Phase 2. The Government of Maldives created a Special Purpose Vehicle in the name of Housing Development Corporation (HDC) and named it the "implementing entity/agency" for the development of Hulhumalé The Agency is in the process of planning and implementing the necessary urban infrastructure (water supply, sewerage, drains, roads, electricity, etc.) systems in Hulhumalé. While infrastructure for Phase 1 was developed on an as-needed basis, the required infrastructure for Phase 2 is being developed considering the future needs and in keeping with the policy of 'digging once for all required infrastructure'.

The Government of the Maldives has requested funds from the World Bank/International Development Association (IDA) to finance an urban development and resilience project. This new project, called

[1] Wikipedia
[2] Wikipedia estimate 2016

the Maldives Urban Development and Resilience Project (MUDRP) proposes critical new infrastructure (a sewage treatment plant, storm water drainage and rain water storage) and other investments to strengthen emergency preparedness and response in beneficiary cities and islands.

Existing Conditions/Technical Background

Malé

Malé city has been built on an island of approximately 2 km^2 only. Naturally the old city, being just about 1 km^2, was built on the highest parts of the island. This means elevations of 1 to 2 meter above sea level, or just a little higher, as 2.4 meter is the overall highest point of the whole Maldives. On the south and south-west side of the island several land reclamation projects have been executed in the past ten years, adding many hectares of land in various phases. The land reclaimed in the first phases has been used mainly for city expansion, and many public buildings like ministries, mosque, hospital etc. are located there. The more recently reclaimed area of 6 ha is presently used for harbour, ferry landing, industrial activities, storage of construction equipment, etc.

In general the reclaimed lands in the south and south-west in particular have been suffering from flooding, as stormwater from the higher, older city area comes down and can't be discharged quickly enough. Flooding depths are generally in the order of about 0.40 meter and create large scale traffic and business interruption. According to local sources they happen just about every year again, the most recent one was experienced in December 2018.

The existing drainage system of Malé was constructed about twenty years back. The system includes gutters installed along the whole length of all the paved roads (about 60 km), covered by concrete grids or steel gratings. The rainwater is all collected in these gutters and flows through cross-pipes to underground soak pits, installed every 6 meters in the middle of the roads. Consequently the water is supposed to infiltrate into the ground. It is however doubtful if this system is still functioning well, as sources complain about clogged grids and/or gutters, broken pipes, and possibly soak pits where infiltration may be hampered due to a process of natural sealing.

The existing roads in Malé city are all paved, mostly using interlocking paving blocks (about 57 km of roads) or asphalt-concrete (about 3 km). However, on basis of field visits and inspection, there is serious doubt if the street paving still allows direct infiltration, since most of the space between paving blocks seems to be clogged by dust and/or by natural sealing.

From 2014 through 2018 in 4 different phases a number of 15 pumping stations (*Annexed)* has been installed, pump collection chambers were built, and street gutters in the low laying reclaimed areas were connected. Nevertheless, based on the flooding of December 2018, this apparently is not sufficient to mitigate flooding resulting from extreme rainfall events.

One of the issues in the Malé drainage is that 20 years ago the city had a much lower population, there was a significant area of unpaved land, and rainwater collected from most of the roofs was either stored or released to unpaved areas instead of draining it on to the roads. Due to the rapid urbanization in the past decades the area of unpaved land has been reduced substantially. In addition, due to a lack of space people have stopped the rainwater harvesting and storage practice, and presently all water from the roofs gets drained to the streets through water spouts.

The large area of newly reclaimed land, with an elevation lower than the natural land c.q. the old city, accumulates all the flood waters and gets heavily flooded even with relatively light intensity rains. As mentioned above, the series of pumping stations installed between 2014 and 2018 hasn't solved the problem of flooding during high intensity rains.

Limitations to the system are: the present size of the gutters can not be increased due to the limited space in the streets, occupied with other utility lines, electricity, telephone, sewer lines etc. The same basically applies to the gravity pipes that were installed to connect the gutters and the collection chambers to the pumping stations: no space to increase the size. Finally, the rainwater spouts from the roofs can not be connected to the sewer network due to the limited capacity of the system. Moreover, the design approach was based on a separate system for drainage and sewerage.

Another potential problem observed may be the calcareous characteristics of the (sub)soils and the large amounts of crushed shells used in the construction business. This material has a tendency for clogging the spaces between the interlocking paving blocks on the roads, and also creates a kind of natural sealing that may reduce the infiltration capacity of open fields as well as in the soakpits. Even open areas in Hulhumalé, reclamed just a few years ago, seem to show a tendency of natural sealing already, and consequently the infiltration capacity of the sand layers below is reduced significantly.

Hulhumalé

To address hazard risks, government is focused on creating safer islands to protect widely dispersed populations in case of a natural disaster or adverse events due to climate change. The corner stone of government plan is the reclamation of Hulhumalé. Hulhumale is a newly reclaimed land that consists of two phases; phase 1, a 188 ha area where the housing and infrastructure development has completed to a significant extent, and phase 2 a 240 ha area, where the infrastructure development is still taking plance.

In the old times, about 40 to 50 years ago, many (most) of the households in the Maldives had their own private system of rainwater collection and storage, in pots, barrels, tanks or cisterns. This also applied for Male city, when piped water supply wasn't common yet. And specifically it applied for the outer islands. Unfortunately in Male city this practice has more or less disappeared because of land pressure, increasing population and the density of buildings and infrastructure. As a result presently the water supply system is dependent on the relatively expensive desalination of water.

According to local sources on various islands pilots for rainwater harvesting are in progress or have been executed. Regulations in the Maldives tell that on the 'outer islands', in order to save on expensive desalinated water, the water supply should be covered by at least 25% rainwater harvesting. The collected water does not qualify for drinking water, but can be used for all other purposes like laundring, flushing toilets, watering gardens or parks, etc.

Hulhumalé new urban center may not be considered an 'outer island', but there certainly seems to be potential for the implementation of rainwater harvesting. Large apartment buildings, warehouses, public offices, as well as sport fields, parks and playgrounds may offer potential for such collection of rain water. In addition, also people living in single private houses could be encouraged to install rainwater harvesting systems.

For storage of the collected water the options may be: tanks or cisterns for private buildings, while large retention basins, surface or underground, may be an option for public places. One of the problems of surface water basins, however, is the high loss due to evaporation. For underground basins it should be realized that concrete in the Maldives is expensive, and the same applies for steel tanks, while also the aggressive corrosive climate plays a role in that respect.

Another option is the use of the groundwater system itself, i.e. the fresh water lens floating on the saline lower layers in Hulhumalé (ref. Ghyben-Hertzberg, groundwaterformulas). There is some fear, however, that the quality of the fresh groundwater may be endangered by pollutants, or be influenced by the saline water from below and/or the seaside. Specifically construction activities may cause a break-up of the fresh water bell and intrusion of saline water.

Nevertheless, with an annual average rainfall of almost 2000 mm, and the area of Hulhumalé being almost 4.5 km2, a total volume of 9 million m3 good quality water is received with a potential for harvesting a considerable proportion of it. However, due to evaporation losses this volume will be reduced by about (at least) 50%. If only used for domestic use, with a projected population of 250,000 capita, this would still be an annual volume of 18 m3 per year, or about 50 liter per capita per day! Certainly worth exploring the feasibility and options to be captured and utilized.

Green fingers are planned across island per the Green and Blue Plan of the Urban Design Masterplan in Hulhumale'. These green fingers are to be fitted with water reservoirs which collect high volume of rain water in monsoon rains.

Objectives

The specific objective of the subject component is: '' development of a stormwater management Masterplans for Malé and Hulhumalé cities''.

The current objective of the Government is to find a way to manage storm water during heavy rains and to reduce the urban flooding problems resulted mainly by the inadequate drainage infrastructure.

An additional objective is to explore the feasibility to harvesting and storing of rainwater for later utilization such as landscape irrigation, exterior washing, fire fighting etc.

Tasks

The following specific tasks are foreseen for the subject Masterplan and pre-feasibility study:

Task 1: Assessment of the existing and planned storm-water drainage system in Malé and Hulhumalé; its (mal)- functioning stormwater drains; detailed inventory of the locations, traces and dimensions of the manholes, gutters, green verges, cross-pipes, soak-pits, etc.

Task 2: Assessment of the system of pumping stations in Malé city and their (mal)-functioning (locations, size, and capacity of the pumps, location and sizes of the collection chambers, location, trace and dimensions of the gravity pipes, etc.);

Task 3: Assessment of the possibility for repairs and/or renovation of the system. If in any way possible, an action plan should be made of required immediate and no-regret repairs and improvements to the system on basis of the inventory above.

Task 4: Assessment of flooding hotspots, locations, depth and duration of flooding, causes of flooding, bottlenecks in the system, etc.; assessment of actual or potential damages, primary and secondary, traffic and business interruption, etc.

Task 5: Collection and analysis of available meteorological/hydrological data (rainfall, evaporation); since Velana airport is the only station nearby, it can/must be assumed that the data from this station are representative for Malé and Hulhumalé city as well; assessment and selection of rainfall events (design storms, amount, shape, duration) for system design, as related to the required level of protection (probability of once per 2, 5, 10, 25, 50 years);

Task 6: Development of a dense, high resolution digital elevation model on a grid equal to or smaller than 2m x 2m; based on LIDAR or ground surveys (using whatever most technically feasible technology) and covering the whole catchment that will be part of the drainage masterplan. The consultant should first evaluate the available data. For example, Hulhumalé being a newly reclaimed land, Housing Development Corporation would have robust survey data that can be used as high resolution elevation data for modeling.

Task 7: Set-up of a modelling system for Malé and Hulhumalé city urban drainage network; based on improved data and info regarding meteorology/hydrology, existing dimensions, elevation information (as mentioned above), etc. For Malé this would require a review of the functioning of the present drainage network and calibration of the model; the next step will be testing the efficiency of potential repairs/renovation (if relevant) as well as potential measures. Use of free and open source models is preferred. If this is not possible the Consultant has to justify why it is not feasible;

Task 8: Investigate the potential application and feasibility for the introduction of Sustainable Urban Drainage Systems (SUDS) for Malé and for Hulhumalé in particular; in this respect potential types of SUDS are:

- **green roofs**, for temporary collection and storage of storm water, to catch the rainfall and delay the runoff, reducing the flood peak; typically relevant for larger buildings, government offices, industries, sport complexes, etc. It should also be realized that green roofs will allow increased evaporation, which also will benefit drainage reduction;
- **retention basins**, green areas, sport fields, play grounds, or parking lots, for temporary storage of storm water: idem to delay direct run-off and shave off the peak of the flood waters. When/if no options for retention basins can be identified, such as in heavily populated districts in Malé, sub-surface storage could be a solution, for instance below sport fields or parks. Taking into account that in Malé the ground conditions are difficult, the groundwater-table is high, and the saline climate is quite aggressive (corrosive), closed steel tanks or concrete basins may be necessary, resulting in relatively high costs.
- use of **(semi)-permeable pavement**, to enable infiltration of storm water to the ground water system, shaving off the flood peaks, and storing water for the dry season; this

can be applied on parking lots, yards, playgrounds, minor roads, or wherever no solid pavement is really required;

- The use of **infiltration trenches**, infiltration pits, etc.; basically with the same function: delay the run-off, shave off the flood peaks, and store the water for later.
- **Rainwater harvesting**, see next point, may be combined with green roofs (see above), or direct capturing from concrete, zinc, or steel roofs;

Task 9: Investigate the potential for (re)introduction of rainwater harvesting, either small scale, at household level with private tanks or cisterns, or large scale on public buildings, apartment complexes etc., in large tanks and/or underground retention. Detail a strategy to promote rain water harvesting in Hulhumalé, program and incentives to popularize rain water harvesting.

Task 10: Investigate the options for collection of rainwater from surface areas, playgrounds, parking lots, sport fields, etc., with storage in tanks, or retention basins, surface or underground, or directly into the groundwater system

Task 11: Assessment of geo-hydrological conditions, extent and characteristics of the aquifers, spatial and temporal variation of groundwater levels, extent of fresh water-lens system, groundwater pumping rates, investigation of the actual infiltration capacity of the ground surface in Malé and Hulhumalé, and its potential reduction by natural sealing, clogging by waste or crushed shell-dust, etc.; (this may require fieldwork); specification of additional field investigations for feasibility phase.

Task 12: Investigate potential measures to increase flood resilience, flood proofing, etc for extreme events.

Task 13: Prepare Masterplan for the stormwater management of Malé and Hulhumalé. The Hulhumalé will focus more on harvesting and storing rainwater, and Malé to the best possible extent. Develop a program to implement the plan including detailing short-, medium- and long-term options to implement the plan.

Task 14: Develop terms of reference to engage an agency to detail and implement the medium and long term plan.

Task 15: Develop approach to implement short term plans.

Task 16: Design an overall public participation and education program for introduction of the water conservation, sustainable use of the water sources and responsible behaviour with regard to the overall water related environment, water use, solid waste disposal, etc.

Task 17: Optional: Investigate the possibilities for setting-up a Flood Early Warning System for Malé and Hulhumalé city, mainly along the lines of flash flood guidance based on rainfall forecasts.

Task 18: Prepare storm water drainage network using an integrated gravity flow and pumping stations

Project Structure

The project will be structured into two phases.
The first phase within the Masterplan study will be the assessment and pre-feasibility type of activities, as decsribed in the tasks 1 to 18 above. The second phase will focus on feasibility and detailed design level activities. Contents of that phase will depend on the results of the first phase and therefore can not be specified here in detail. In principle the activities will include feasibility and design of selected measures, both technical and financial feasibility, specification of technical details, implementation plan, institutional setting, etc. Selected measures will be tested on their effectiveness using the model developed, as far as relevant. **Both Phase I and II will be lump-sum contracts. For the Phase I detailed Technical and Financial Proposals to be Provided by the eligible firms. For Phase II activities, the firms should provide evidence of availability of key staff that the firm proposes for Phase II and the 'Remuneration Rates of Key Staff" which will apply for the Phase II activities. For Phase I, staff costs and reimbursable costs to be provided seperately. Phase I contract will be first awarded, and the Phase II will be negotiated once all the information is available, and the ToR is reviewed and finalized by the Government. It will be fully contingent upon the Phase**

I performance of the selected firm and the requirements that arise from Phase I, and the MNHPI will have full descretion to decide whether the Phase II contract is awarded to the same consultant or go for a new selection based on the requirements/needs and performance of the consultant during Phase I.

Required Specific Expertise

The required expertise will be as follows:

a. **Urban drainage specialist/Engineer (cum team leader):** responsible for the overall team coordination, conceptual design of urban drainage systems, including SUDS, rainwater harvesting and storage type of works, evaluation of the hydraulic/hydrological performance of the system, and preparation of the Masterplan; at least 20 years of experience in the subject field, Masters Degree in civil engineering, familiar with the design of small urban drainage structures, SUDS, etc.; estimated input 12 months;

b. **Structural Engineer:** responsible for all aspects of engineering and to provide input for the Urban Drainage Specialist.; at least 20 years of experience in the subject field, Masters Degree in civil engineering, familiar with the design of small urban drainage structures, SUDS, etc.; estimated input 4 months;

c. **(Geo)hydrological specialist**: responsible for the collection and analysis of rainfall, climatic and ground-water data, assessment of rainfall events/design storms, analysis of geo-hydrological conditions of the island, assessment of the extent of the fresh water-lens system, the potential for groundwater storage, infiltration capacity of the soil, etc.; at least 20 years of experience in the subject field; Masters Degree in civil engineering/ hydrology, estimated input 4 months;

d. **Hydraulic modelling specialist:** responsible for the set-up of the mathematical hydraulic model of Malé city and its operation; model calibration, preparation of modelling scenarios; advantageous to be able to handle GIS; testing of the performance of specific measures and the overall drainage system; at least 20 years of experience in the subject field; Undergraduate Degree in civil engineering/ hydrology. estimated input 4.5 months;

e. **Finance Specialist**: (conceptual) estimate of the costs of specific measures for urban drainage and water storage, and overall estimated costs for implementation of such project; at least 10 years of experience in the subject field; Masters Degree in Finance or economics, estimated input 2.5 months;

f. **Communication/Public Participation specialist**: responsible for collection of information about public awareness, willingness to participate and willingness to pay, inform the population about possible plans for urban drainage, flood resilience, RWH and storage, set-up community information workshops, etc.; at least 10 years of experience in the subject field; Undergraduate degree in Mass Communication, Journalism or any other relevant field; estimated input 3 months;

g. **Draftsperson**: drafting of conceptual design drawings; at least 10 years of experience in the subject field; Undergraduate Degree in Architecture; estimated input 4 months;

h. **Any additional specialist as required**.

Remark: For the second phase more and/or different expertise might be required. This can only be specified after phase 1, when the selection of measures will be clearer.

Roles of the Government

On behalf of the Government of Maldives, The Ministry of National Planning,Housing and Infrastructure (MNPHI) is supposed to support and facilitate the project. The Director General Infrastructure of MNPHI will be the Project Director. The MNPHI will be responsible for:

a. Guidance of the project and internal coordination between the relevant parties: Ministry of Finance (MoF), Ministry of National Planning, Housing and Infrastructure (MNPHI), Maldives Meteorological Service, Maldives Water and Sewerage Company (MWSC), National Disaster Management Authority (NDMA), Maldives Land & Survey Authority, etc.
b. Coordination between the consultants and related parties;
c. Communication with direct stakeholders;
d. Provide/arrange access for any required reconnaissance visits and/or field work;
e. Provide local support, inputs, and expertise to the consultants;
f. Provision of all required data and information free of any charges to the consultants;
g. Provide office/working space with desks, WiFi and support services;
h. Organize and execute field surveys or measurement activities for additional data needs;
i. Timely review of and commenting on deliverables (reports/drawings).

Deliverables, Time Schedule, and Payments

Specific deliverables will be:

I. Inception report, after 1 month of signing contract: first impressions of the field conditions, short description of the project approach, refined time schedule and project inputs, specification of additional data collection and/or field surveys; The inception report should clearly mention the analytical approach, data, models and assumptions made during the development of the storm water master plan.
II. Interim report, after 4 months of signing contract: update of the project approach and time-schedule, presentation of initial relevant results and observations, etc.
III. Draft Final Report, after 9 months of signing contract, consisting of:
    - ✓ Design of the overall Stormwater management Masterplan, including:
    - ✓ Description of the existing drainage system and its functioning;
    - ✓ Description of the pumping stations, locations, capacities and their functioning;
    - ✓ Description of flooding problems, locations, frequency, hotspots, depth and duration of flooding;
    - ✓ Description/results of the meteorological/hydrological data collection and analysis; presentation of typical rain events, design storms and frequencies (2, 5, 10, 25 and 50 years)
    - ✓ Description of the potential for the application of SUDS;
    - ✓ Description of the options for flood resilience improvement and typical measures;
    - ✓ Description of the options for large-scale storage of the collected rainwater (tanks, retention basins, groundwater), potential locations, and description of structural measures for storage;
    - ✓ Description of the potential for rainwater harvesting from the ground surface, storage options, locations, volumes, etc. and structural measures for capturing and storage;
    - ✓ Description of the infiltration capacity and potential future changes of the soils in Malé and Hulhumalé city, and the effect on urban drainage;

- ✓ Description of the options for small-scale rainwater harvesting for private households, level of public support, willingness to participate/pay, etc.; and description of structural measures for collection and storage;
- ✓ Description of costs related to the various measures mentioned above;
- ✓ Description of the public participation and communication activities executed during the feasibility study, and a conceptual design for further communication, education and participation with stakeholders.

IV. Final report, after 12 months of signing contract. Contents as above, but including response and comments from the Maldives Government and the World Bank.

For the second phase no detailed ToR or Project contents cannot be specified now, but it is estimated that the second phase will also need a project duration of about 12 months.

Time schedule and inputs:

	1		2		3		4		5		6		7		8		9		10		11		12		MM
TL	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	12.0
SE					- - -	- - -	- - -	- - -			- - -	- - -		- - -	- - -										4.0
GH		- - -	- - -				- - -	- - -		- - -	- - -		- - -	- - -											4 .0
HM		- - -	- - -				- - -	- - -		- - -	- - -			- - -	- - -	- - -									4.5
FS											- - -	- - -	- - -		- - -	- - -									2.5
PP		- - -	- - -									- - -	- - -			- - -	- - -								3.0
DP			- - -					- - -			- - -	- - -	- - -			- - -	- - -	- - -							4.0

Payments:

Payments are/will be connected to the deliverables:

a) Advance payment, after signing of the contract: 10% of project sum;
b) First payment, after approval of the Inception report, i.e. 2 months after start: 10%
c) Second payment, after approval of the interim report, 5 months, 30%
d) Third payment, after approval of the draft final report, 9 months, 30%
e) Final payment, after approval of the final report, 12 months, 20%.