

Maldives Coastal Characterization

Spatial and Temporal Characterization of Coastal Development and Infrastructure in the Maldives

Final Report

29th September 2022

Prepared for

Waitt Institute



Prepared by

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2 List of Abbreviations

BODC	British Oceanographic Data Centre
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
GEBCO	General Bathymetric Chart of the Oceans
GIS	Geographic Information system
IPRC	International Pacific Research Centre
MCAA	Ministry of Civil Aviation Authority
MED	Ministry of Economic Development
MECCT	Ministry of Environment, Climate Change and Technology
MMS	Maldives Meteorology Service
MMRI	Maldives Marine Research Institute
MNPPI	Ministry of National Planning, Housing and Public Infrastructure
MOFA	Ministry of Fisheries and Agriculture
MOT	Ministry of Tourism
MLSA	Maldives Land and Survey Authority
MPA	Maldives Ports Authority
NGO	Non-government organizations
NOAA	National Oceanographic and Atmospheric Administration
NBS	National Bureau of Statistics
SIGS	Small Island Geographic Society

3 Summary of the Report

This Final Report is the last deliverable of the Maldives Coastal Characterization project. The focus of the report is to highlight the outcomes and document all the activities carried out by SIGS in the implementation of the Maldives Coastal Characterization project. The report is prepared by Small Island Geographic Society (SIGS).

The team acknowledge the support and assistance provided by Ms. Robin Ramdeen - Program Director, Mr. Andy Estep, Science Director and Mr. Matt Paufve – Science Manager from Waitt Institute in guiding the team to achieve the overall objective of the project. Hon. Aiminath Shauna, Minister of Environment, Climate Change and Technology was instrumental in to gain access to the spatial database at Climate Change Department of the Ministry of Environment, Climate Change and Technology developed as part of the Climate Risk Screening for Mainstreaming Climate Change Adaptation into Development Activities and Policies in the Maldives by Asian Development Bank's (ADB) regional capacity development technical assistance (TA) Action on Climate Change in South Asia. The team also acknowledge the support and assistance provided by Mr. Moosa Zameer Hassan - Program Coordinator, Ms Maeesha Mohamed - Administrative Coordinator from Noo Raajje programme to implement the project activity in the Maldives as on track.

4 Introduction

4.1 General

The Noo Raajje Program is a partnership between Government of the Maldives and members of the Blue Prosperity Coalition. Small Island Geographic Society (SIGS) will serve as the lead consultant to Noo Raajje, a program being implemented in the Maldives by the Blue Prosperity Coalition (BPC) in partnership with the Government of the Maldives. The consultancy will focus on a Spatial and Temporal Characterization of Coastal Development and Infrastructure in the Maldives. The contract for the consultancy services was awarded to SIGS by Waitt Institute. The agreement between Waitt Institute and SIGS was signed on 1st March 2022. The work commenced on 30th March 2022 with initial discussions with Noo Raajje team and Waitt Institute.

This stakeholder consultation report describes the followings:

- Details of the consultation that were held with the relevant stakeholders who have spatial data on coastal infrastructure which is relevant to the project
- Details of the coastal spatial databases held at stakeholders
- Contact details of the person consulted at each stakeholder

4.2 Background

The Noo Raajje Program is a partnership between Government of the Maldives and members of the Blue Prosperity Coalition. The program is founded on three pillars of work: Marine Spatial Planning (MSP), Blue Economy (BE), and Sustainable Fisheries (SF). This project focuses on the MSP pillar to manage the ocean resources within the Exclusive Economic Zone (EEZ) of Maldives. Thus, the MSP process is required to take stock of the MSP's present and future conditions at global, regional, sub-regional, national and local scales to ensure inclusion of areas for prioritizing modelling process and to account for the uses and zones properly. The MSP process's expected outcomes are to produce a zoning map together with the associated legislation, policies, and regulations that will address future objectives such as defining zones for multi-use that prescribe permitted uses and restrictions.

4.2.1 Project Objective

This project is to study and characterize the spatial and temporal coastal development projects to create a spatial database of coastal structures and infrastructures. This includes natural and man-made structures. The overall approach of this project is to establish a geospatial database using existing data in various government and other agencies. Therefore, the project does not include collection of spatial raw data from the field.

4.2.2 Scope of Services

The project will study and characterize the spatial and temporal coastal development projects to create a spatial database of reclamation areas, revetments, borrow areas, dredging areas, impact areas, outfall pipes, channels, harbor basins, quay walls, seagrass removals, fill areas, jetties, breakwaters, overwater facilities, groynes, beach nourishments, coral propagation areas and current, wave and marine survey data from environmental impact assessments (EIA).

The project will require obtaining data from the ministries, relevant government authorities, and stakeholders. The project would likely require the manual classification and validation of features which would describe the coastal development and coastal infrastructure of the Maldives. The geodatabase developed as part of the project would contain metadata describing the type, date of installation, and geographic footprint of each feature that would describe the coastal development and coastal infrastructure of the Maldives. The SIGS would also digitize the coastal and marine development information that are in EIA reports which would be made available to the project from EPA. The dataset from EIAs would help to characterize the spatial and temporal coastal development of the Maldives.

4.3 SIGS Key Personnel for this project

This project was overlooked by Mr. Ahmed Jameel, Vice President - SIGS and lead by Mr. Faruhath Jameel (GIS specialist) with the assistance of Mr. Hamza Moosa (GIS analyst), Mr. Irsham Saudulla (GIS expert) and a dedicated team of GIS interns: Mr. Mohamed Anooof Shifan, Mr. Azeen Amjad Musthafa, Ms Aishath Basma, Mr. Nabeeh Shameem, Mr. Mohamed Kaif Raimoon Kammaldeen, Ms Holly Quinlan Watson Muecke, and Ms Aishath Yuha Mohamed.

5 Stakeholder Consultation

Stakeholder consultations were carried out with various stakeholders including stakeholders from the government, private sector and NGOs to determine the approach and broad institutional responsibilities in service provision in a particular sector related to coastal zone and resource use. Consultation was planned with government authorities and other organizations who are willing to share and provide the relevant data in the respective agencies for this project.

5.1 Consultation with Government Institutions

5.1.1 Ministry of Environment, Climate Change and Technology

Ministry of Environment, Climate Change and Technology carried out *Action on Climate Change in South Asia Climate Risk Screening for Mainstreaming Climate Change Adaptation into Development Activities and Policies in the Maldives* in 2017, this established a geospatial database on coastal and marine ecosystems as well as climate change at the Ministry of Environment Climate Change and Technology. The geospatial database was created with 629 layers of data. Hence, the Ministry was approached and consulted whether this database could be shared with the SIGS team to be used in this Maldives Coastal Characterization project.

A consultation meeting was held at the Ministry of Environment, Climate Change and Technology on 10th May 2022. H.E Ms Aminath Shauna, Minister of Environment, Climate Change and Technology met the SIGS team for the consultation. At the meeting, Minister Shauna noted that the Ministry of Environment would share the geospatial database on coastal and marine ecosystems database that was developed with the assistance of ADB within the project agreement with ADB. The Minister highlighted that the Ministry of Environment is a partner of the Noo Raajje program, therefore, will facilitate SIGS with any resources necessary for this Noo Raajje project.

Ms Aishath Aileen Niyaz, Director at the Climate Change Department of the Ministry noted that they will share the geospatial database on coastal, marine ecosystems and climate change with Noo Raajje after removing the demographic layer. Ms Aileen explained that information for the demographic layer was provided by the National Bureau of Statistics with a condition that it cannot be shared with any third party.



Figure 1: Consultation with Ministry of Environment, Climate Change and Technology

The SIGS team received a geospatial database on coastal, marine ecosystems and climate change from the Ministry of Environment, Climate Change and Technology in July 2022 . The geospatial database on coastal, marine ecosystems and climate change that was developed under the *Action on Climate Change in South Asia Climate Risk Screening for Mainstreaming Climate Change Adaptation into Development Activities and Policies in the Maldives in 2017* is a comprehensive database which provides most of the data required for the Maldives Coastal Characterization project.

Table 1: Details of meeting attendees

Official	Title
H.E. Ms Aimnath Sauna	Minister of Environment, Climate Change and Technology
Mr. Ajwad Musthafa	Permanent Secretary
Ms Aishath Aileen Niyaz	Director, Climate Change Department
Ilham Atho Mohamed	Senior Conservation Officer
Muhusina Abdhuh Rahman	Senior Conservation Officer

5.1.2 Ministry of National Planning, Housing and Infrastructure

A consultation meeting was held at the Ministry of National Planning, Housing and Infrastructure on 7th July 2022. Mr. Mohamed Imad, Chief Project Executive from Department of Planning met the team. Minister of National Planning, Housing and Infrastructure, H.E. Mohamed Aslam was planned to participate at this meeting but was unable to attend.

At the meeting, Mr. Mohamed Imad noted that the Maldives Land and Survey Authority under the Ministry of National Planning, Housing and Infrastructure has made public a number of GIS shape files from the National GIS (NGIS) database. As a result, the Noo Raajje team could use these data layers under the contract they have with the Ministry of National Planning, Housing and Infrastructure.



Figure 2: Consultation with Ministry of National Planning, Housing and Public Infrastructure.

Moreover, these layers of interest from the NGIS would help the SIGS team in the Maldives Coastal Characterization project in populating the GIS on the spatial and temporal characterization of coastal development and infrastructure in the Maldives.

Table 2: Details of MNHPI attendees

Official	Title
Mr. Mohamed Imad	Chief Project Executive / Planning Department

5.2 Consultation with Private Sector

5.2.1 Water Solutions Pvt Ltd

The SIGS team met with Water Solutions on several occasions to discuss the Maldives Coastal Characterization project. Water Solutions participated at the workshop organized by the Ministry of Environment in 2016/17 where an extensive data base on coastal, marine ecosystems and climate change was developed with the technical assistance from ADB. As result, Water Solutions was able to brief the SIGS team about the database.

Table 3: Details of Water Solutions attendees

Official	Title
Mr. Abdul Aleem	Director
Mr. Mohamed Affan Shakir	Offshore Surveyor
Mr. Zahy Zuhair	Technology Officer
Mr. Hamdulla Shakir	Surveyor – Terrestrial
Mr. Ibrahim Faiz	Senior Environmental Consultant
Ms Yumin Naseem	Environmental Consultant
Ms Juma Ahmed	Assistant Environmental Consultant
Ms Fathimath Azzath Faheem	Office Manager

5.3 Consultation with Non-Governmental Organisation

5.3.1 Eco Care Maldives

The team met with Mr. Maeed Zahir, Advocacy Director of Eco Care Maldives. Eco-care Maldives, a non-governmental civil association working for the protection and conservation of the environment of Maldives. Mr. Maeed noted that Eco-care Maldives is currently focusing on advocacy work and hence the organization does not have any databases such that it could be used by the project for the development of the spatial characterization of coastal development and infrastructure in the Maldives.

Table 4: Details of Eco Care Maldives attendees.

Official	Title
Mr. Maeed Zahir	Advocacy Director

6 Methodology

The EIA reports at the EPA have a wealth of information on the coastal development projects and built environment of the islands of Maldives. Therefore, the EIA reports were obtained from the EPA and then were categorized and compiled into a single geodatabase. Data of interest from these EIAs were extracted and then digitized using a GIS software (ArcGIS Pro).

Maps in the EIAs with features of interest such as proposed reclamation areas, shorelines, coastal protection structure were imported into ArcGIS Pro and then correctly georeferenced.

However, some of the maps and diagrams present in the EIAs did not exhibit any coordinate system references or grid information, that can be used to geo-reference the map. The only way to use these maps were to manually georeference the maps to a basemap (imagery) available in the ESRI living atlas on ArcGIS Pro. The accuracy of this method will limit the use of the data in small scale maps where the scale is greater than 1:10000.

Moreover, information from graphs/tables/photos from surveys carried out and presented in the selected EIAs were also attached to digitized features. For example, available benthic data, water quality data and photos from marine surveys have been added/attached to the digitized point features of that feature class.

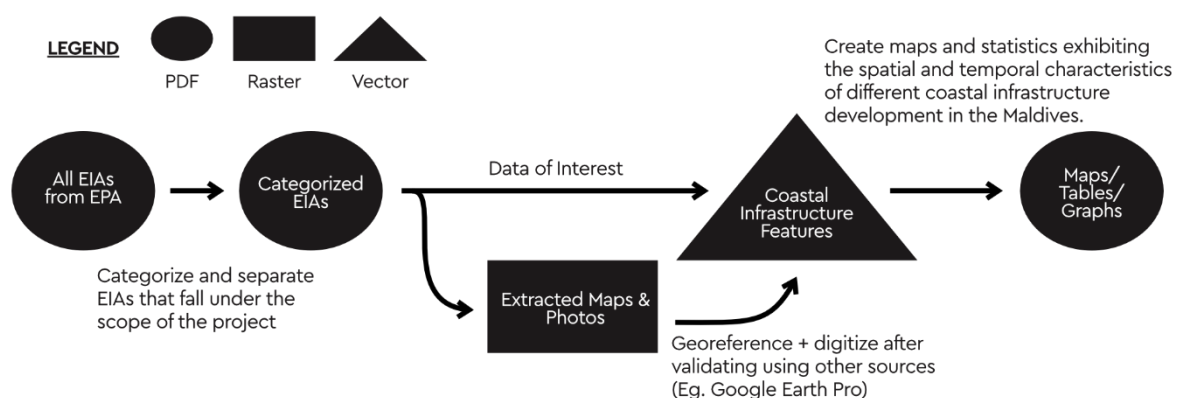


Figure 3: MCC methodology workflow chart

In addition, coastal infrastructure visible on the ESRI living atlas basemap were also digitized and compiled to a separate data set.

7 Results

Table 5 – Summary table of coastal development EIAs digitized per category per year.

		Category						
		Dredging and reclamation	Coastal protection	Coastal modification	Beach nourishment	Harbor development	Resort development	Other
Year	2007	4	3	1	0	1	6	0
	2008	3	5	0	0	31	17	1
	2009	2	2	3	0	4	10	0
	2010	9	2	5	1	15	13	0
	2011	7	3	4	2	15	13	8
	2012	1	5	2	0	9	18	0
	2013	17	1	12	0	21	20	0
	2014	11	9	6	4	21	32	7
	2015	10	18	2	0	33	16	2
	2016	7	12	3	1	9	0	0
	2017	5	7	2	0	10	0	0
	2018	3	5	2	0	9	3	0
	2019	4	2	4	2	3	19	5
	2020	7	3	2	1	13	10	0
2021	4	3	1	0	1	6	0	
	Total	94	80	49	11	195	183	23

7.1 Summary list of number of features digitized using ESRI basemap imagery.

- Overwater facilities (8263)
- Revetments (709)
- Quay walls (313)
- Jetties (1057)
- Groynes (1056)
- Breakwaters (1938)
- Harbor basins (395)

7.2 Maps

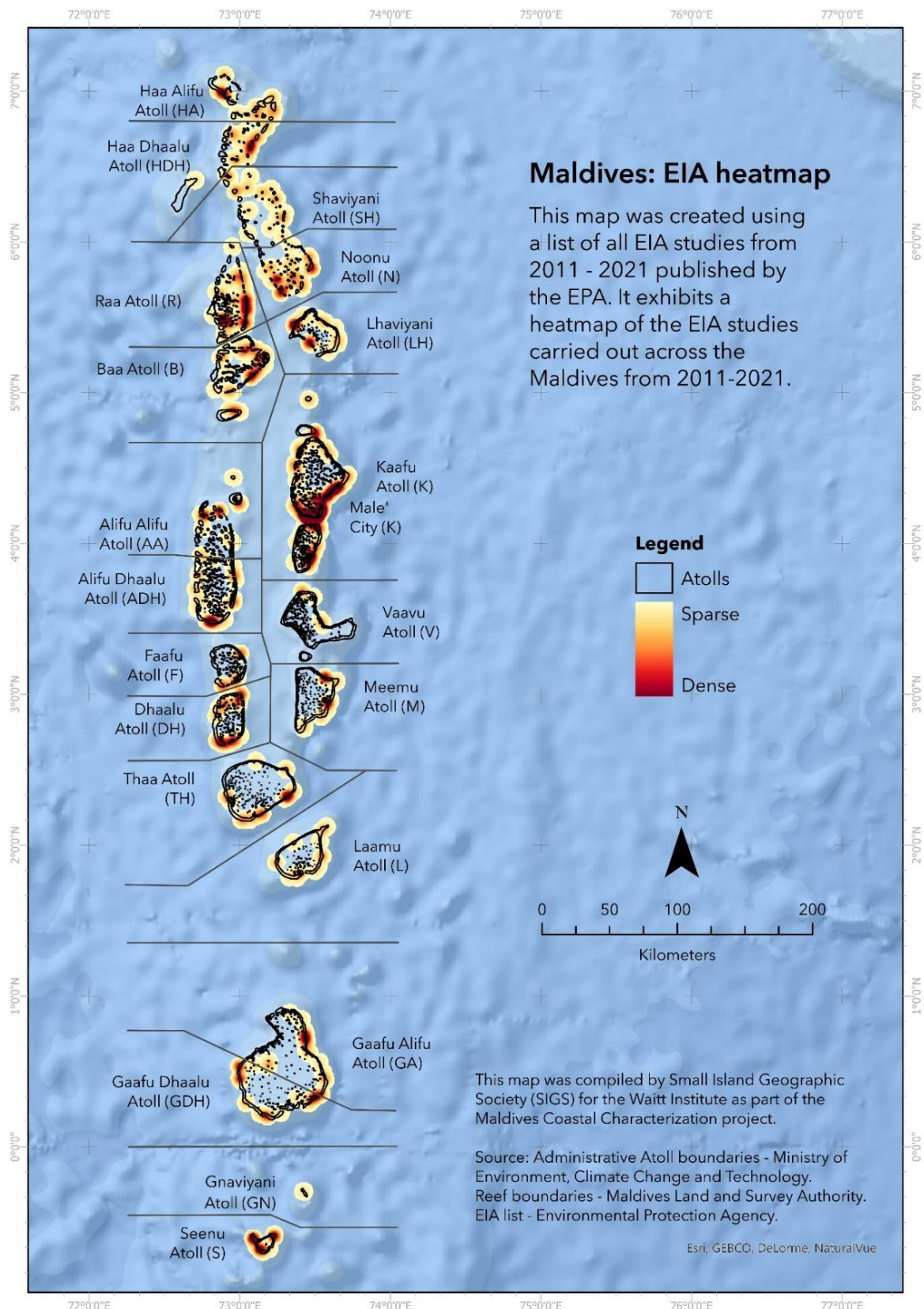
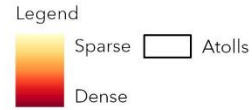


Figure 4: Heatmap exhibiting the density of EIA studies in the Maldives from 2011 – 2021

Heat map series: Coastal Development EIA studies per year 2006 - 2021



This map was compiled by Small Island Geographic Society (SIGS) for the Waitt Institute as part of the Maldives Coastal Characterization Project.

Source: Administrative Atoll Boundaries - Ministry of Environment, Climate Change and Technology.
Reef boundaries - Maldives Land and Survey Authority.
EIA list - Environmental Protection Agency

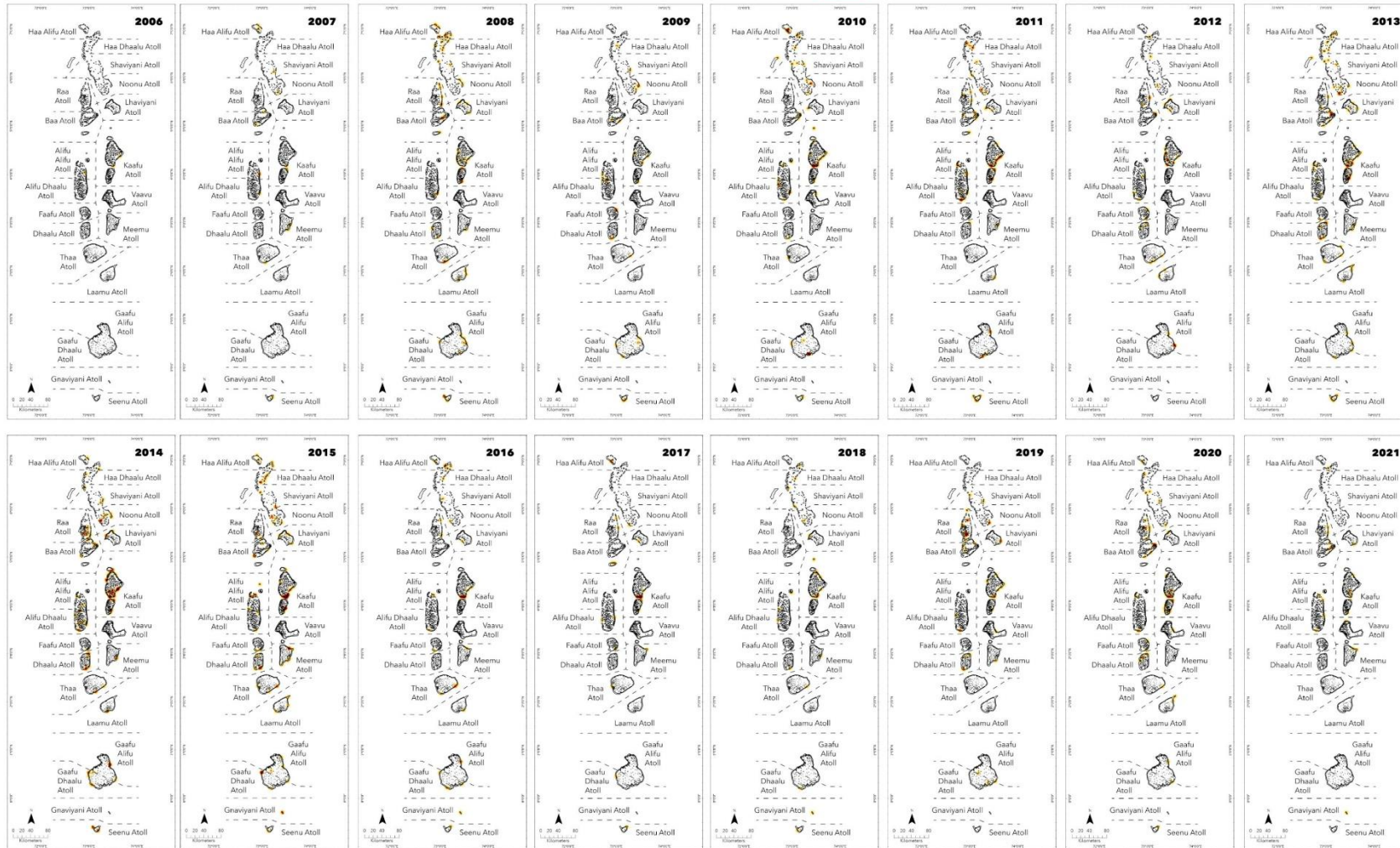


Figure 5: Heat map series of coastal development EIA studies in the Maldives from 2006 - 2021

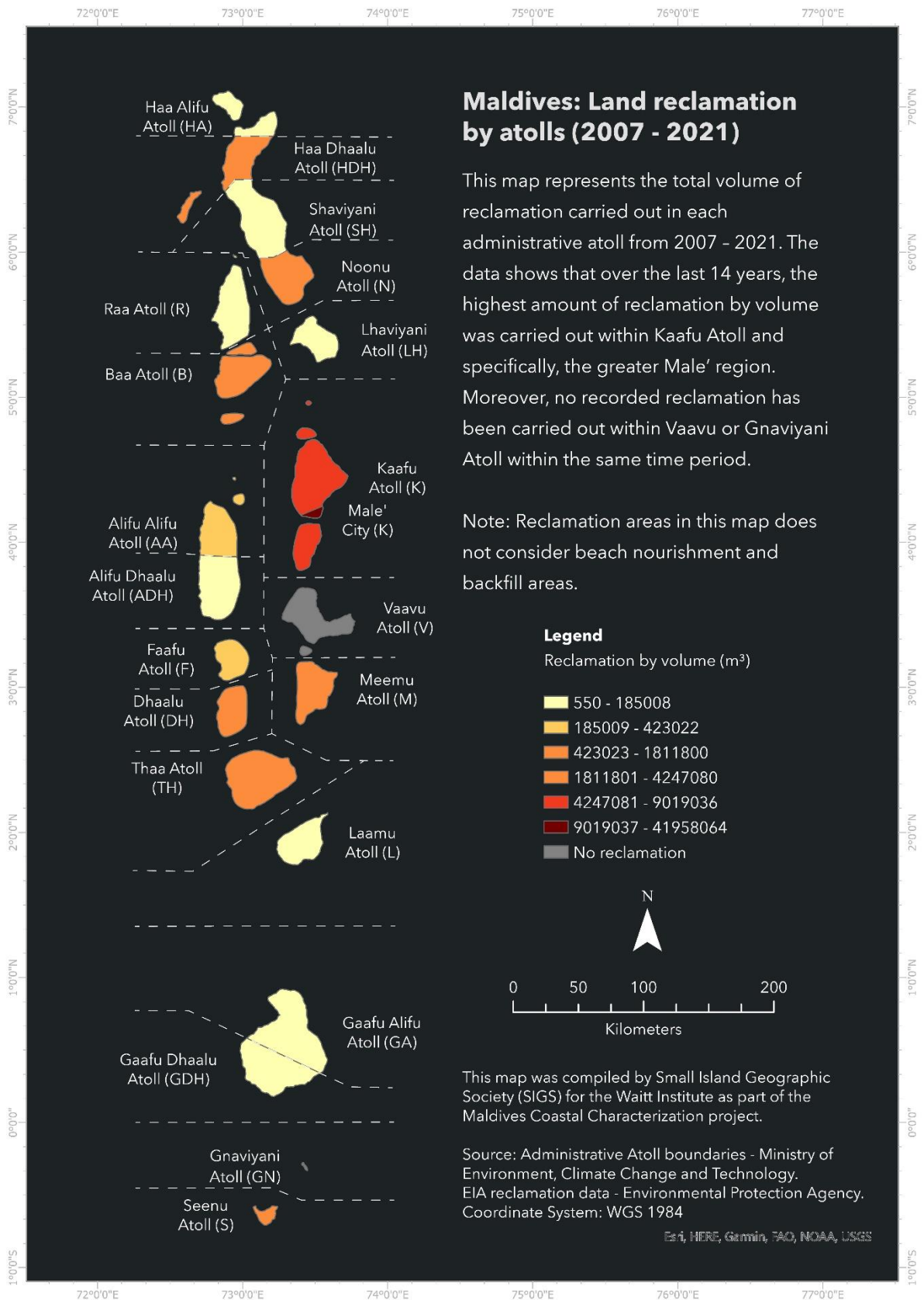


Figure 6: Map showing footprint of land reclamation in the Maldives from 2007 -2021 by administrative atolls

Coastal Development EIA heat maps per category from 2006 - 2021



This map was compiled by Small Island Geographic Society (SIGS) for the Waitt Institute as part of the Maldives Coastal Characterization Project.

Source: Administrative Atoll Boundaries - Ministry of Environment, Climate Change and Technology.
Reef boundaries - Maldives Land and Survey Authority. EIA list - Environmental Protection Agency

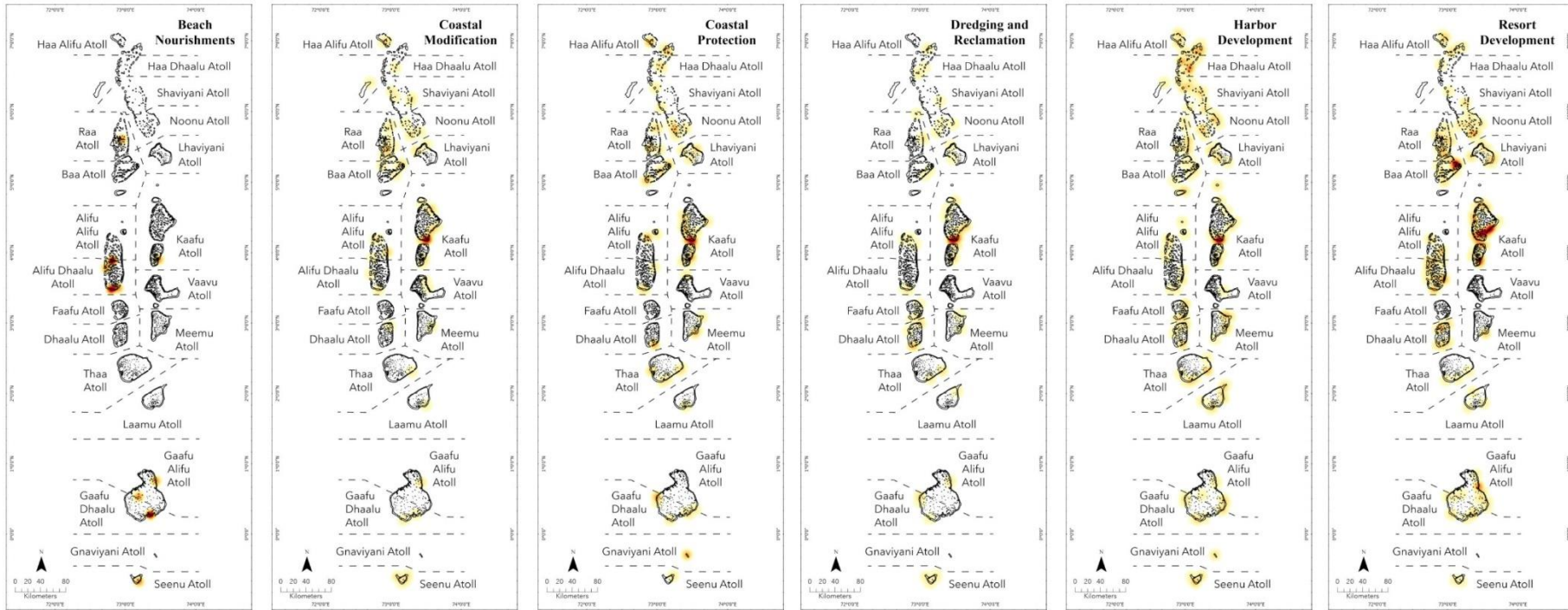


Figure 7: Heat map series of coastal development EIAs per category from 2006 - 2021

This map series represents the patterns of coastal development EIA studies for the selected categories across the Maldives from 2006-2021

8 Limitations

8.1 Spatial

The data compiled for this project is limited to and only recommended to be used above scales 1:10,000. This is due to variability in accuracy of the digitized features because of the inconsistency in EIA and base map quality.

8.2 Temporal

Developments prior to 2007 are not represented in the geodatabase.

8.3 Data in the EIA Reports

General limitations of the data from the EIA reports used include missing information, corrupt files, low quality maps, incorrect and lost survey results. Similarly, some coastal infrastructure that have been built as proposed on EIA reports are not spatially accurate in terms of position, scale and in some cases, the number of structures. Therefore, some of the layers and features digitized from the information extracted from the EIAs reports will have specific limitations when it comes to data usage.

Features digitized from EIA reports published in the year 2021 may differ to the actual infrastructure built or being constructed as the digitization was relied on solely the proposed concepts in the EIA reports published by EPA. This is also the case for features that could not be cross-checked due to dated base map imagery, satellite imagery with high cloud cover and low-quality maps.

Table 6: Limitations of specific features in the MCC geodatabase.

Feature	Feature specific limitations
Marine survey points (m_survey)	Different survey methods and classification of marine data in EIA reports could lead to inconsistent outcomes in classification and percentages/values of benthic and water quality data.
Impact areas (impact_area)	Some EIA reports did not specify and grade the impact areas in terms of severance.
Wave data (wave) and current data (current)	Wave and current data digitized was only for the information recorded on that specific date/tide hence would not account for diurnal/seasonal changes.
Overwater facilities (ow_facility)	Difficult to visualize separate point features at the recommended 1:10,000 scale due to the cluster like placement of the infrastructure.
Borrow areas (borrow_area)	Some EIA reports showed general borrow areas rather than specific ones from which material was extracted for the proposed reclamation and beach nourishment projects. Therefore, the volume specified in the EIA may not be compatible to the area calculated in the digitized features.

Jetties (jetty)	Unable to determine the purpose of some jetties due to multi-purpose usage and/or the lack of a mentioned purpose in the EIA reports.
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9 General findings

- More categories such as sewerage and waste management should be introduced to the database due to the increasing frequency of EIAs regarding these types of projects.
- Recognition of missing or undocumented developments.
- Variation in procedures/structures/classifications used by different consultants for similar projects.

10 Building upon project findings

- Keep updating the geodatabase.
- Identification of sources leading to information on coastal development data prior to 2007 gives incentive for further research. For example, the first edition of Maps of Maldives published by Water Solutions Pvt Ltd exhibits that 89 resorts developments were present by 2008.
- This project also provides an opportunity to improve the EIA procedures/framework practiced in the Maldives.