MULTIHAZARD RISK ATLAS OF MALDIVES

Geography—Volume I

MARCH 2020

ADB

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In this publication, "$" refers to United States dollars.
The maps presented in this atlas reflect airports based on 2017 data from the Civil Aviation Authority of Maldives.

On the cover: An aerial view shows 1 of 26 natural atolls that make up Maldives, which also includes nearly 1,200 small coral islands and some of the world's most beautiful beaches. Recognized as the seventh-largest in the world, the coral reefs and associated ecosystems of Maldives are key foundations for food security and means of livelihood. Yet, they are considered as among the most vulnerable to climate change (photo by Roberta Gerpacio).

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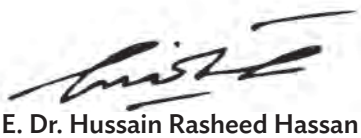
Foreword

Maldives is among the countries most vulnerable to the impacts of climate change as it is a small island nation with extremely low elevations. Maldives is also very vulnerable to impacts of rising air and sea surface temperatures and changes in rainfall patterns. Climate change impacts will therefore impose significant negative consequences on the Maldivian economy and society. Some of the priority vulnerabilities to climate change are land loss and beach erosion, infrastructure damage, degradation of coral reefs, and adverse impacts on water resources, food security, human health, and the overall economy.

Sustainable coastal resources management is of particular importance to Maldives, such that all regulations involving various development activities have coastal components. Despite the government's continued efforts in improving and sustaining coastal resources management, critical issues remain, such as the need for systematized coastal monitoring, clear definition of coastal boundaries and coastal development, enhanced regulatory and monitoring capacities for coastal resources protection, and sustainable long-term strategies on land reclamation and marine area protection. At a time when climate is rapidly changing and extreme weather events are frequently occurring, the critical roles that marine and coastal environments play in mitigating and adapting to climate change need to be sufficiently documented and properly recognized. It is therefore essential for Maldives to develop and establish a comprehensive digital database of marine and coastal ecosystem features and services that can be regularly monitored.

The *Multihazard Risk Atlas of Maldives* was developed through the project "Establishing a National Geospatial Database for Mainstreaming Climate Change Adaptation into Development Activities and Policies in Maldives" under the Asian Development Bank's regional knowledge and support (capacity development) technical assistance Action on Climate Change in South Asia (2013–2018). This five-volume atlas aims to promote the sustainable development of coastal and marine ecosystems and their various components, by enhancing the awareness of stakeholders on and enjoining them to address climate and disaster risks (including hazards, exposures, and vulnerabilities) to which ecosystems are exposed. The atlas presents spatial information and maps necessary for assessing future development investments in terms of their risks to climate and geophysical hazards.

The target audience of the *Multihazard Risk Atlas of Maldives* are the concerned stakeholders with current or planned development activities in the country, including public and private sectors, nongovernment organizations, research and academic community, development partner agencies, other financial institutions, and the general public. The atlas will also be a useful reference for other developing countries with similar geographical and environmental conditions, particularly small island developing states. It is envisioned that the atlas will significantly contribute to rendering important sector development investments more resilient to hazard-specific risk scenarios in the short, medium, and long terms.



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Acknowledgments

Government Ministries, Departments, and Agencies in Maldives
- Civil Aviation Authority
- Land and Survey Authority
- Marine Research Institute
- Meteorological Service
- Ministry of Economic Development
- Ministry of Education
- Ministry of Environment
- Ministry of Fisheries, Marine Resources and Agriculture
- Ministry of Health
- Ministry of National Planning and Infrastructure
- Ministry of Tourism
- National Bureau of Statistics
- National Disaster Management Center

International Institutions
- Manila Observatory
- Marine Spatial Ecology Lab, University of Queensland, Australia
- SANDER + PARTNER
- United Nations Development Programme

International Institutions in Maldives
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Abbreviations

BODC	–	British Oceanographic Data Centre
CAA	–	Maldives Civil Aviation Authority
GEBCO	–	General Bathymetric Chart of the Oceans
IHO	–	International Hydrographic Organization
IOC	–	Intergovernmental Oceanographic Commission
km^2	–	square kilometer
ME	–	Ministry of Environment
MED	–	Ministry of Economic Development
MLSA	–	Maldives Land and Survey Authority
MNPI	–	Ministry of National Planning and Infrastructure
UTM	–	Universal Transverse Mercator
WGS	–	World Geodetic System

Risk Mapping: Making the Invisible Visible

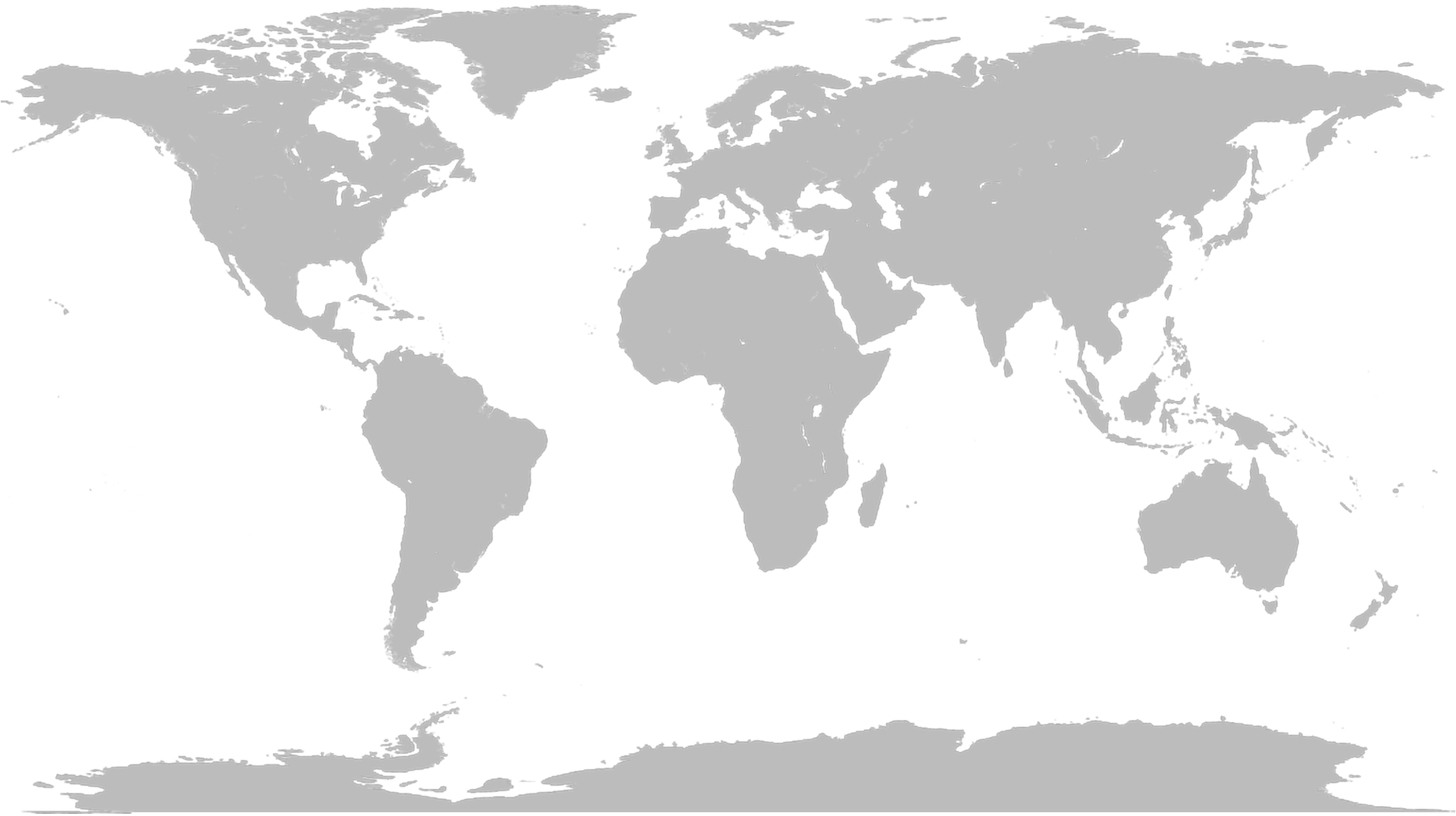
Maps have changed the way we see the world. By symbolizing the features of the earth and drawing its visible and invisible boundaries, maps give humans a wider perspective, which allows us to understand the patterns, trends, and interconnected components of our planet and see beyond where we have traveled. What used to be invisible to some became visible for all through maps.

At the global scale, the size of Maldives fades in comparison with its neighboring countries such as India and Sri Lanka. Sitting in the middle of the Indian Ocean, Maldives is barely visible but greatly vulnerable to natural hazardous elements, and it strives to overcome these challenges. People have lived in this beautiful nation for thousands of years despite limited land space and multiple hazards. However, their lives, livelihoods, and properties are becoming increasingly exposed to hydrometeorological, climatological, and geological hazards.

The *Multihazard Risk Atlas of Maldives* examines the often-unexplored networks of human and environmental paradigms, producing a compound picture of risk that hinders development. It compiles the maps generated for Action on Climate Change in South Asia: Establishing a National Geospatial Database for Mainstreaming Climate Change Adaptation into Development Activities and Policies in Maldives, an Asian Development Bank–Maldives Ministry of Environment technical assistance (TA) project.

The national and atoll-scale maps were produced to paint a clearer picture of climate and disaster risk in Maldives and can hopefully be useful in formulating action plans and policies and in communicating risk information toward averting economic losses and harm. They can become useful tools in visually comparing spatial and temporal variations, spotting interaction among layers, and in guiding possible development directions considering future climate scenarios in the context of the changing geography, demographics, climate, economy, and environmental conditions of Maldives.

This atlas is divided into thematic sections: geography, climate and geophysical hazards, economy and demographics, and biodiversity. A summary volume provides the highlights and key messages from the overall TA activities in Maldives. The main goal of this atlas is to capture often-unmapped factors shaping Maldives' contrasting picture of paradise in the midst of an evolving world, which generates natural hazards to the islands.



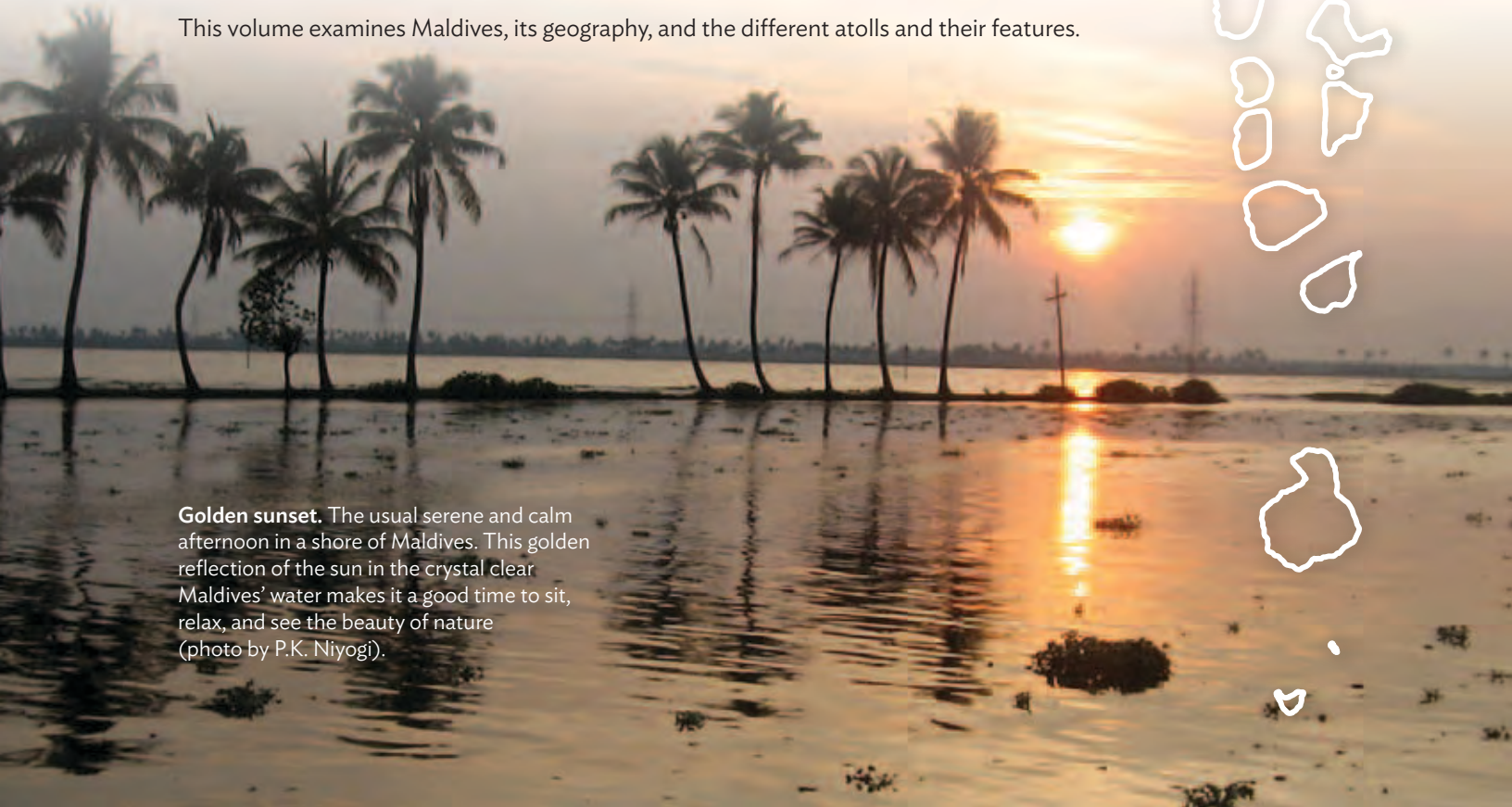
Map of the world. A map visualizing the different countries of the world (photo from Crates, World Map without Boundaries, Creative Commons).

Paradise at Risk

In the middle of the Indian Ocean, southwest of India, lies a chain of atolls with islands forming a small low-lying island nation called Maldives. These tropical islands, emerging from corals and sprinkled across turquoise crystal calm waters caressing white sand beaches, paint a picture of a paradise.

The flatlands and surrounding seas form mangrove and aquatic ecosystems supporting the life of the communities that inhabit a tenth of the nation's total islands. These communities have witnessed the continuous formation and transformation of the islands as a product of natural tidal action eroding and depositing sand or of human hands reclaiming or dredging the land. They are also highly vulnerable to strong waves during storms or earthquakes (Waheed and Shakoor 2015). Moreover, a 1-meter high increase in sea level due to a warmer world (Khan et al. 2002) could inundate two-thirds of the country's land (Ahmed and Suphachalasai 2014). Rising seas could wipe away Maldives as most of its islands are less than 3 meters high (Khan et al. 2002). In addition, the natural biota in the islands might not be able to cope with the fast-paced development and could be displaced (ADB 2017). Geologic events and the changing climate pose a threat to the future of the islands and its inhabitants.

This volume examines Maldives, its geography, and the different atolls and their features.



Golden sunset. The usual serene and calm afternoon in a shore of Maldives. This golden reflection of the sun in the crystal clear Maldives' water makes it a good time to sit, relax, and see the beauty of nature (photo by P.K. Niyogi).

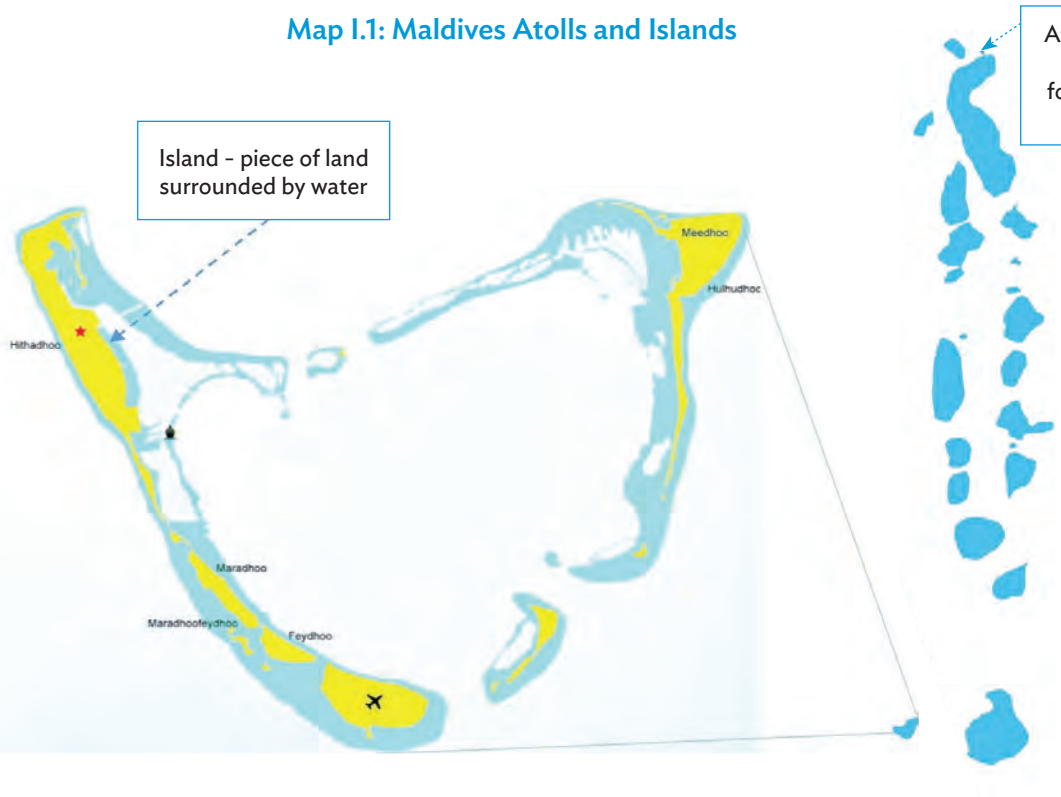
Geography of Maldives

Exclamation Point on the Ocean

Maldives sits like an exclamation point, marking the middle of the Indian Ocean and drawn vertically almost at the equator. Currently, there are about 1,900 islands forming 26 atolls scattered across 870 kilometers from north to south. Less than 200 islands are inhabited. These numbers might change in the coming years due to the dynamic shifts in factors shaping the island such as sea level and land reclamation. Islands rising up to 2.4 meters above mean sea level subtly punctuate the flatness of the sea.

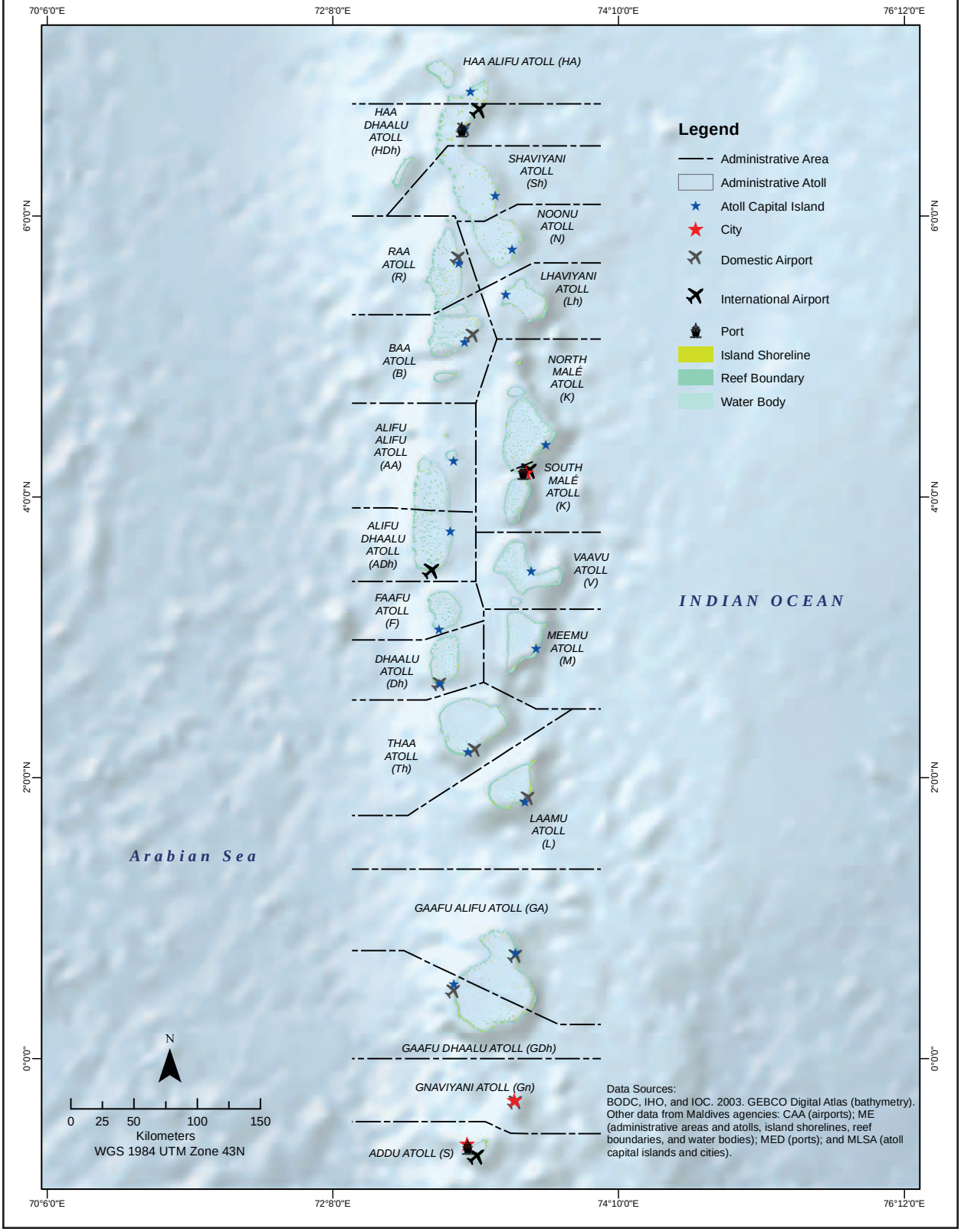
This volume explores the atolls, the transformation of the islands through land reclamation, and how the land is being managed.

Map I.1: Maldives Atolls and Islands

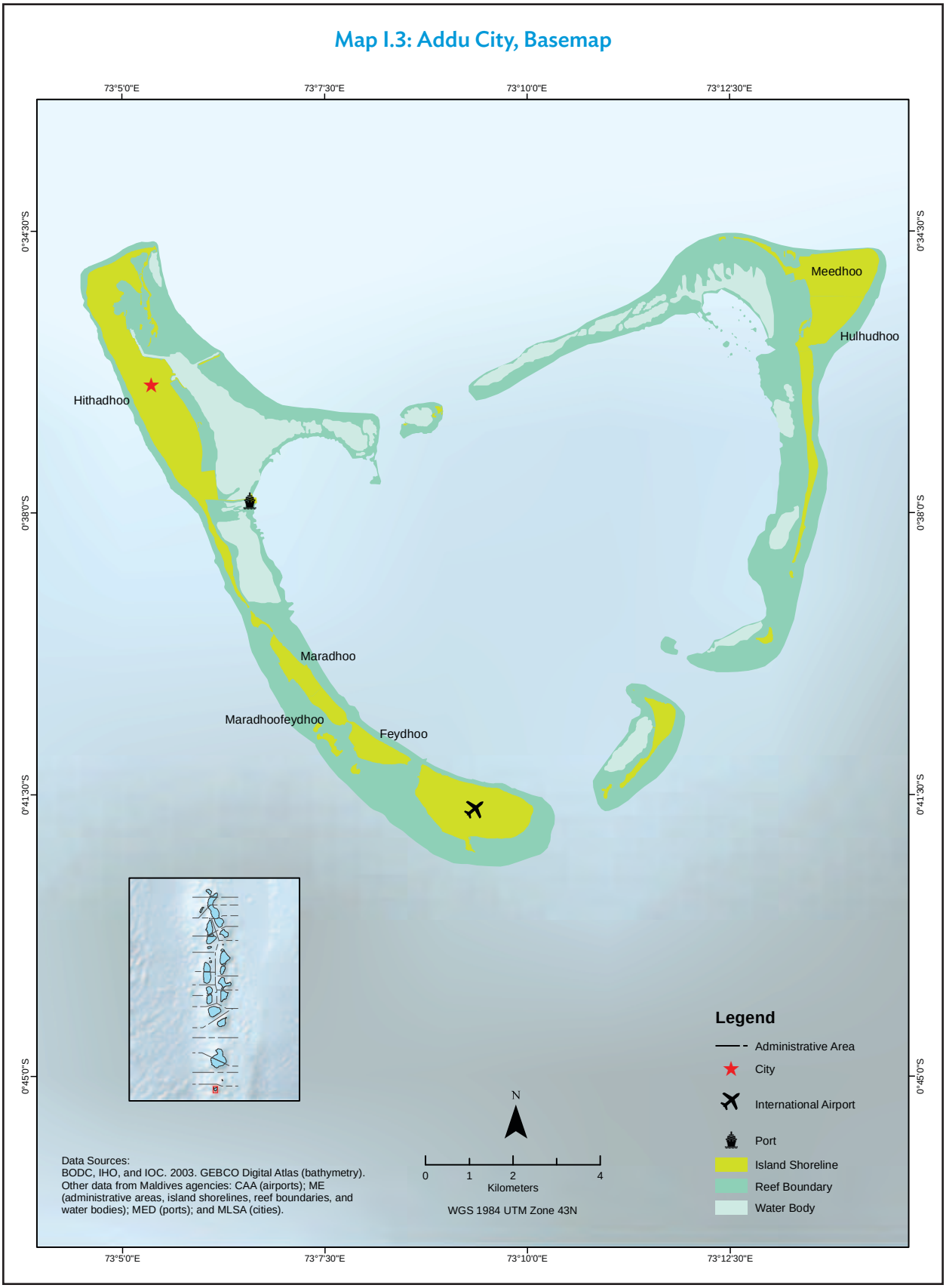


Source: Administrative area data from the Ministry of Environment, 2016.

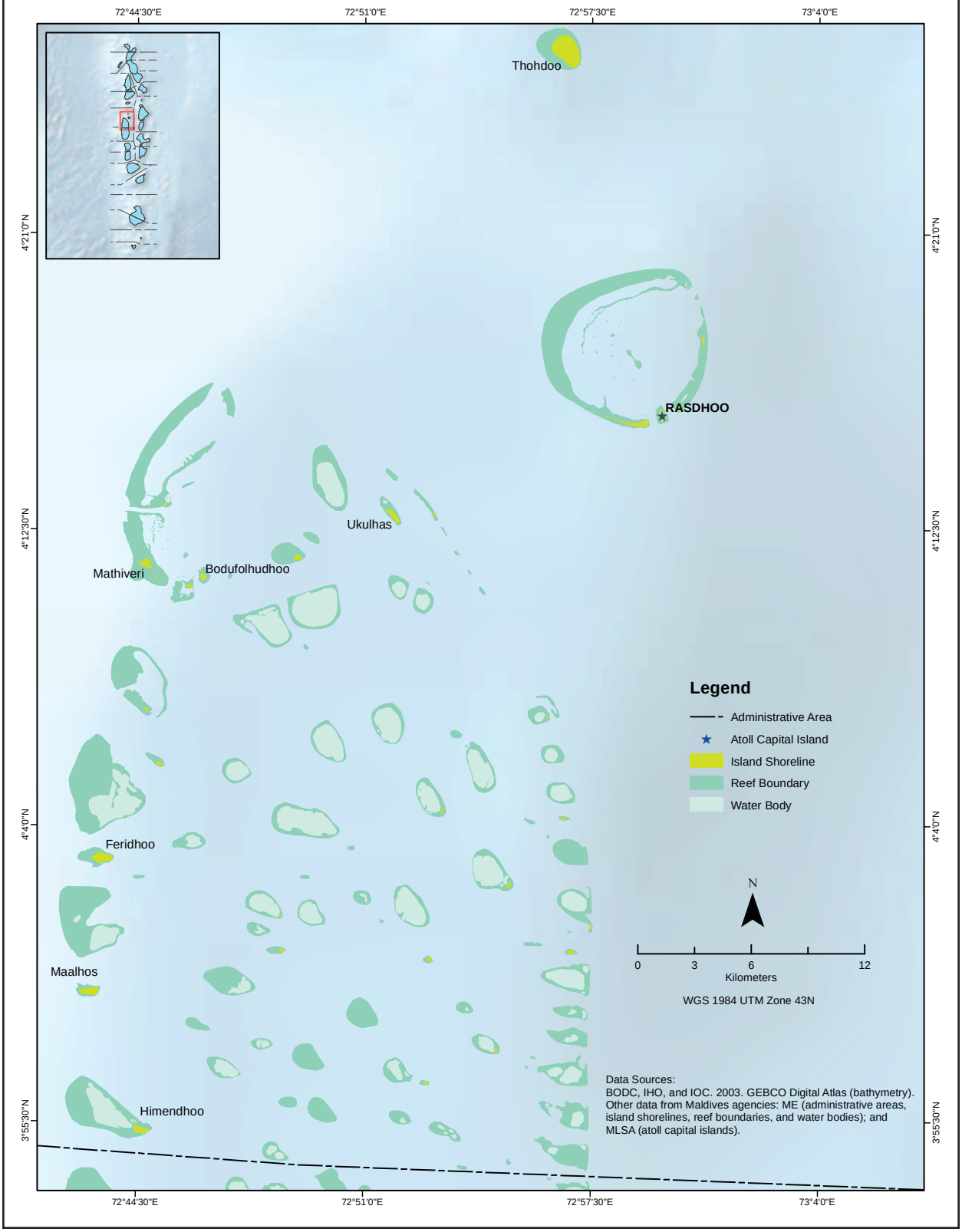
Map I.2: Maldives, Basemap



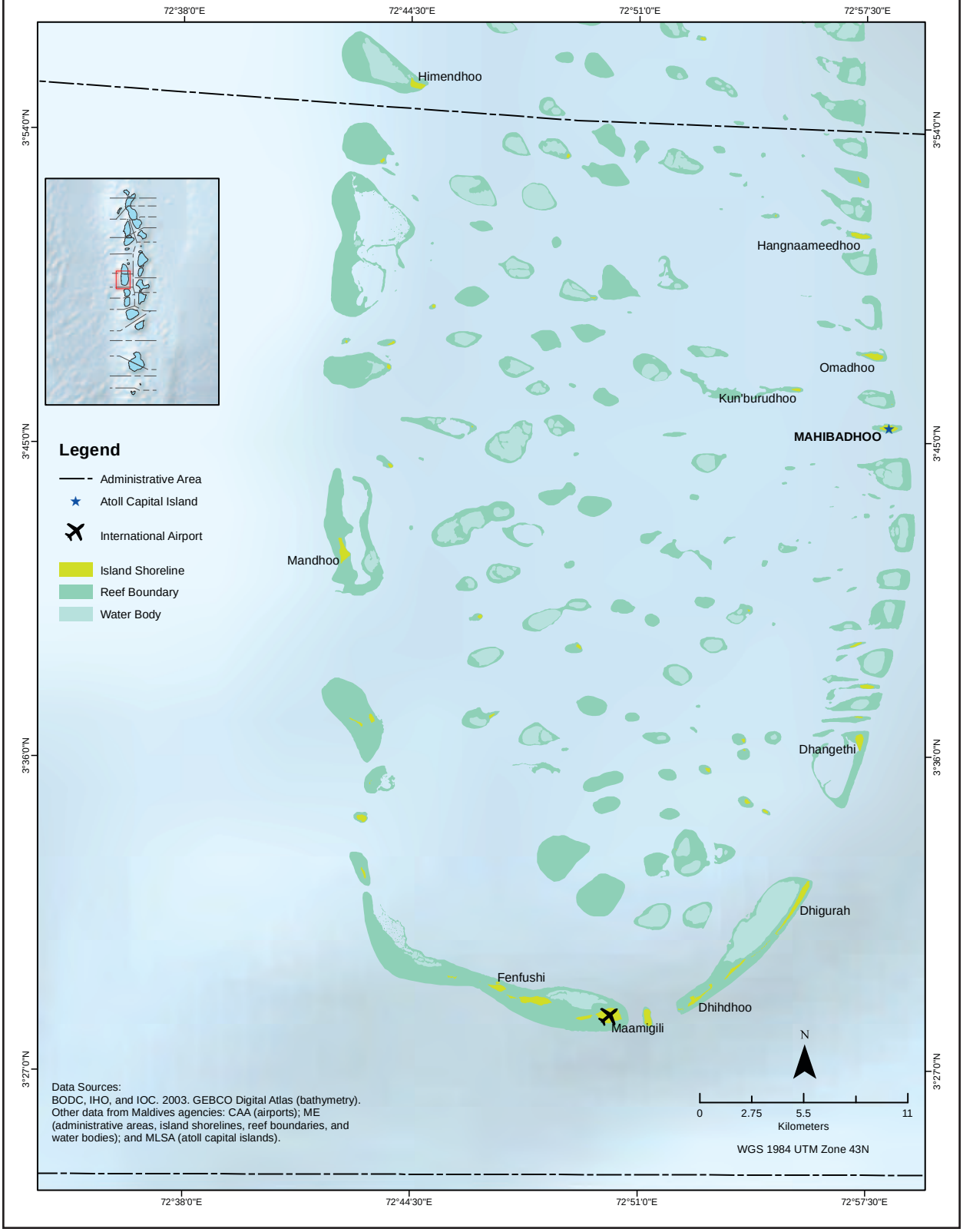
Map I.3: Addu City, Basemap



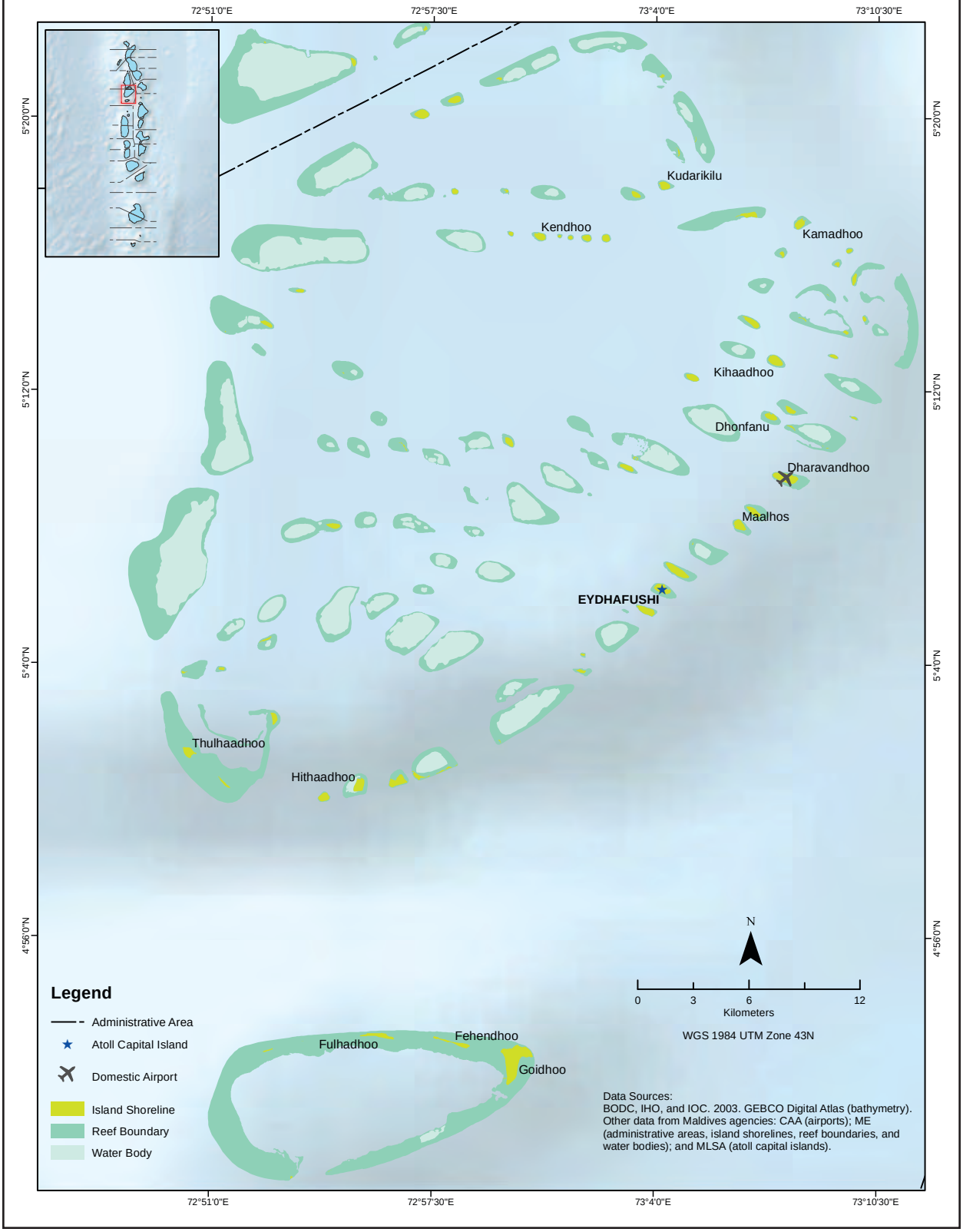
Map I.4: Alifu Alifu Atoll, Basemap



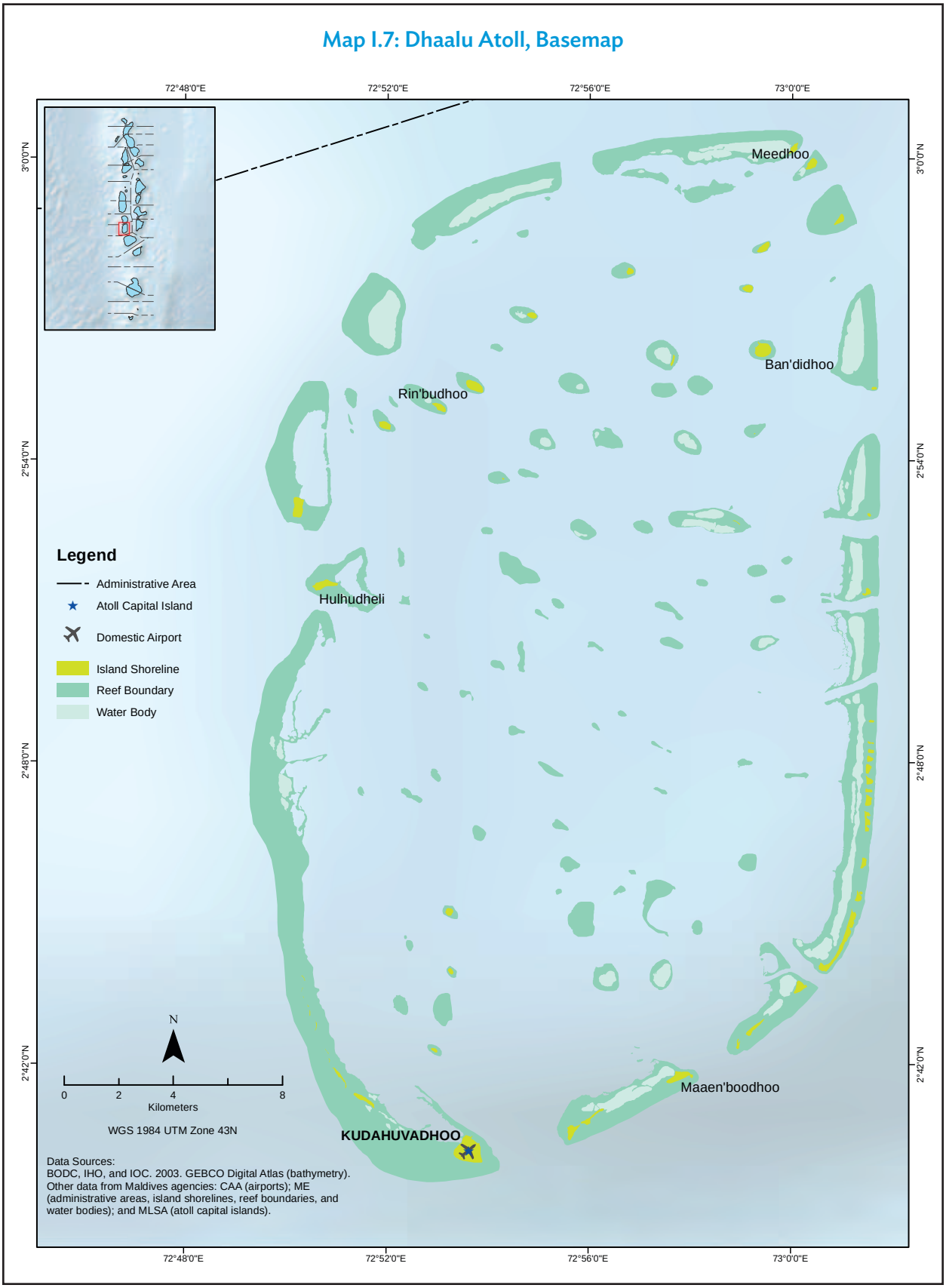
Map I.5: Alifu Dhaalu Atoll, Basemap



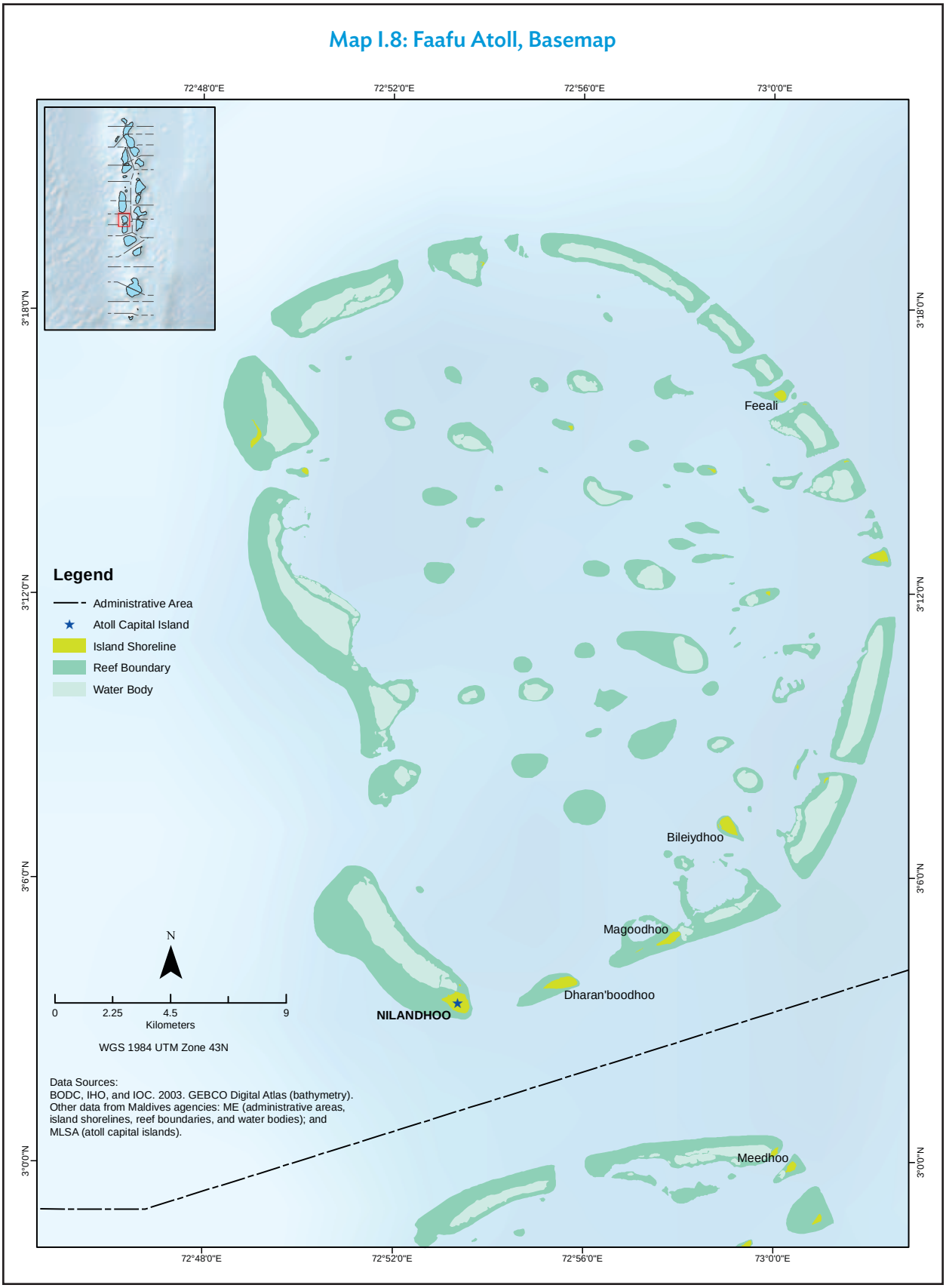
Map I.6: Baa Atoll, Basemap



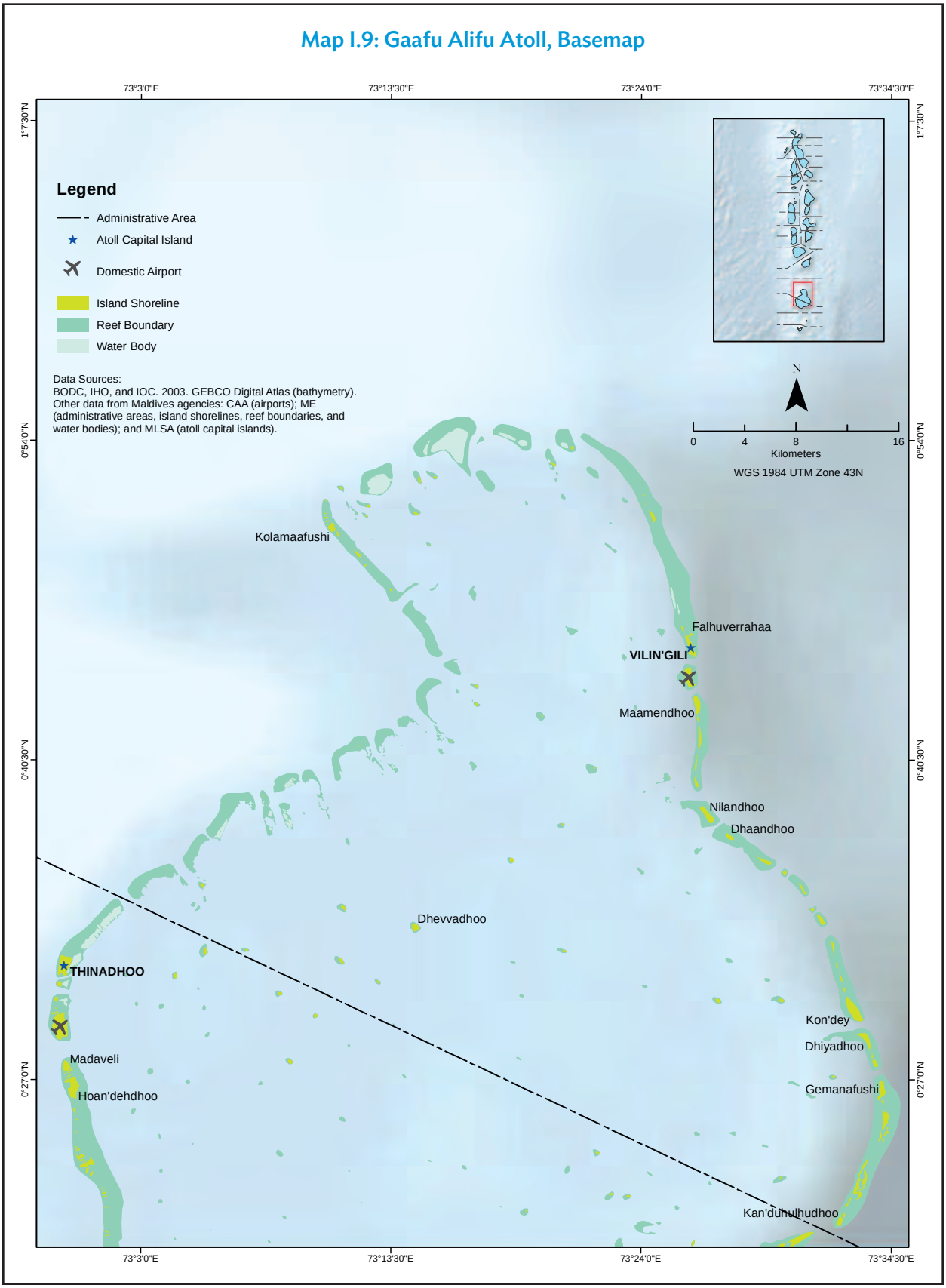
Map I.7: Dhaalu Atoll, Basemap



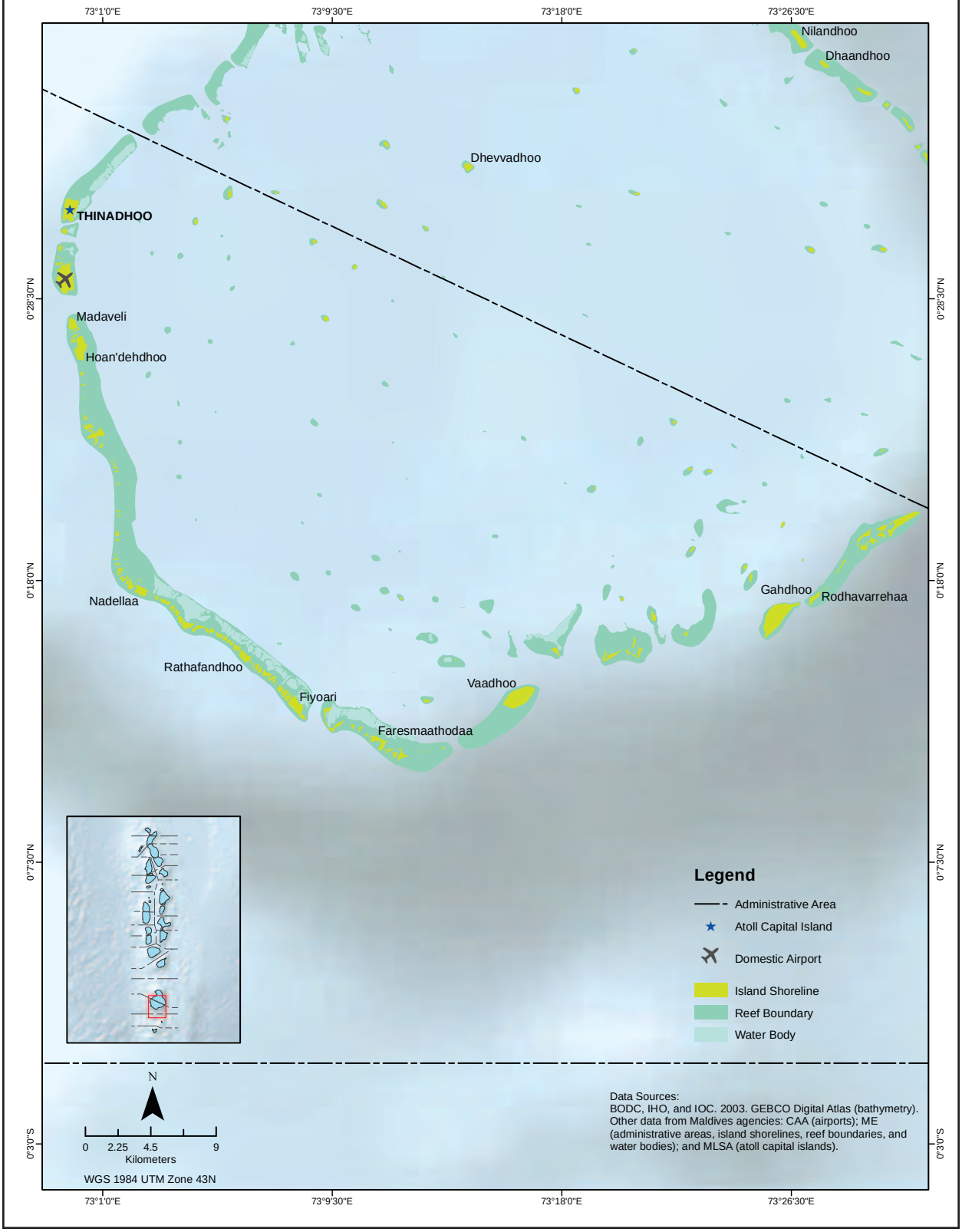
Map I.8: Faafu Atoll, Basemap



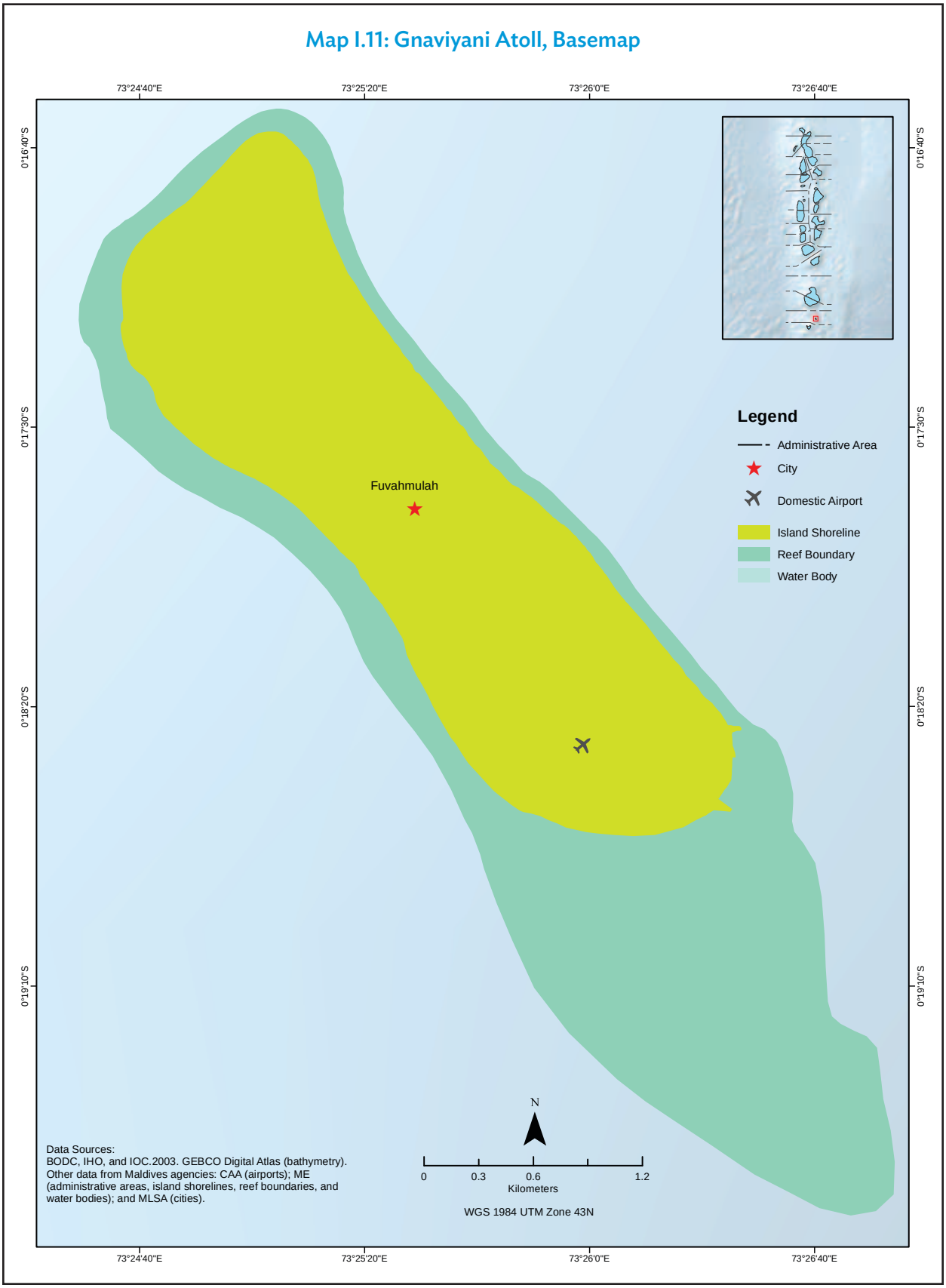
Map I.9: Gaafu Alifu Atoll, Basemap



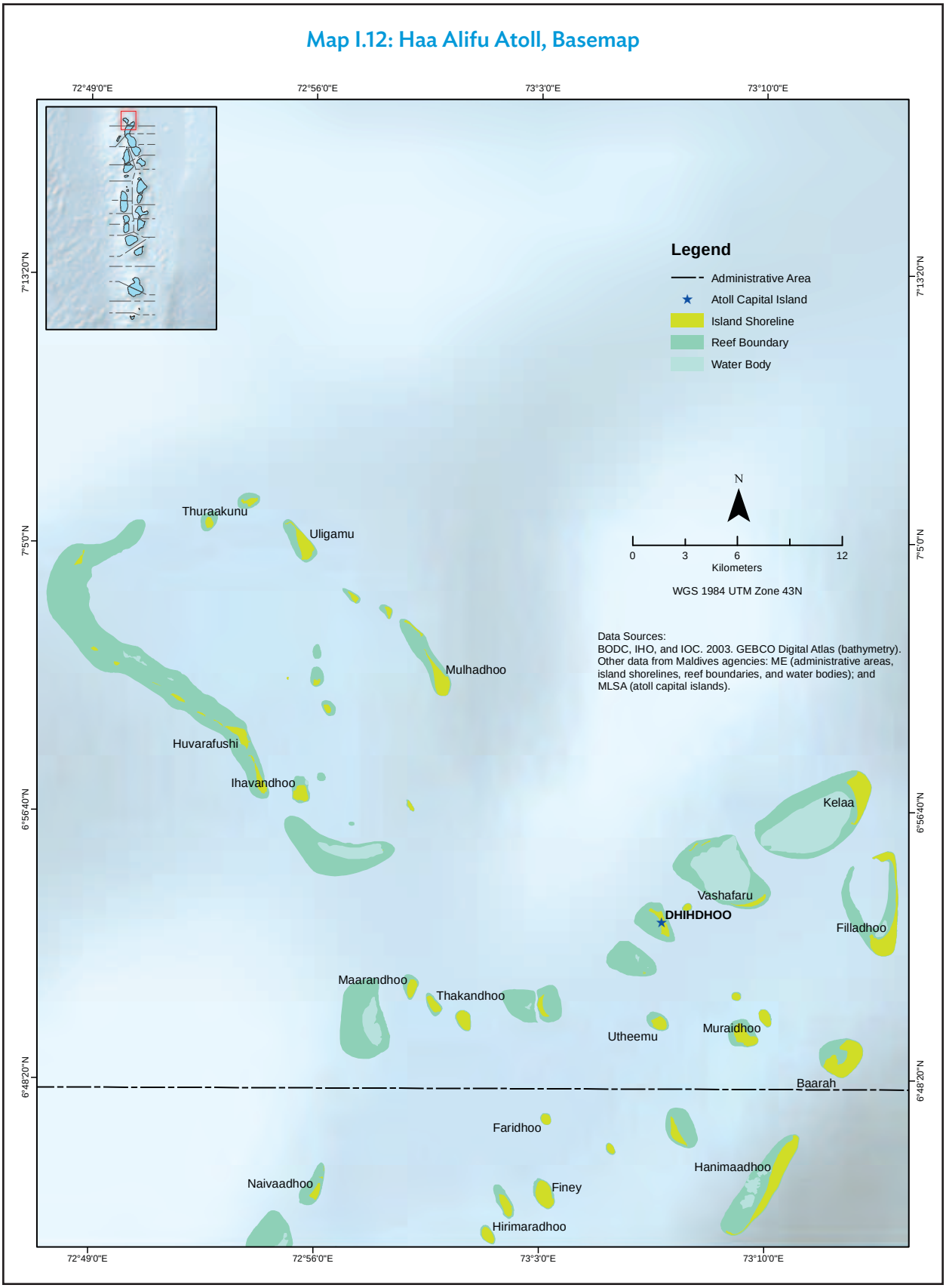
Map I.10: Gaafu Dhaalu Atoll, Basemap



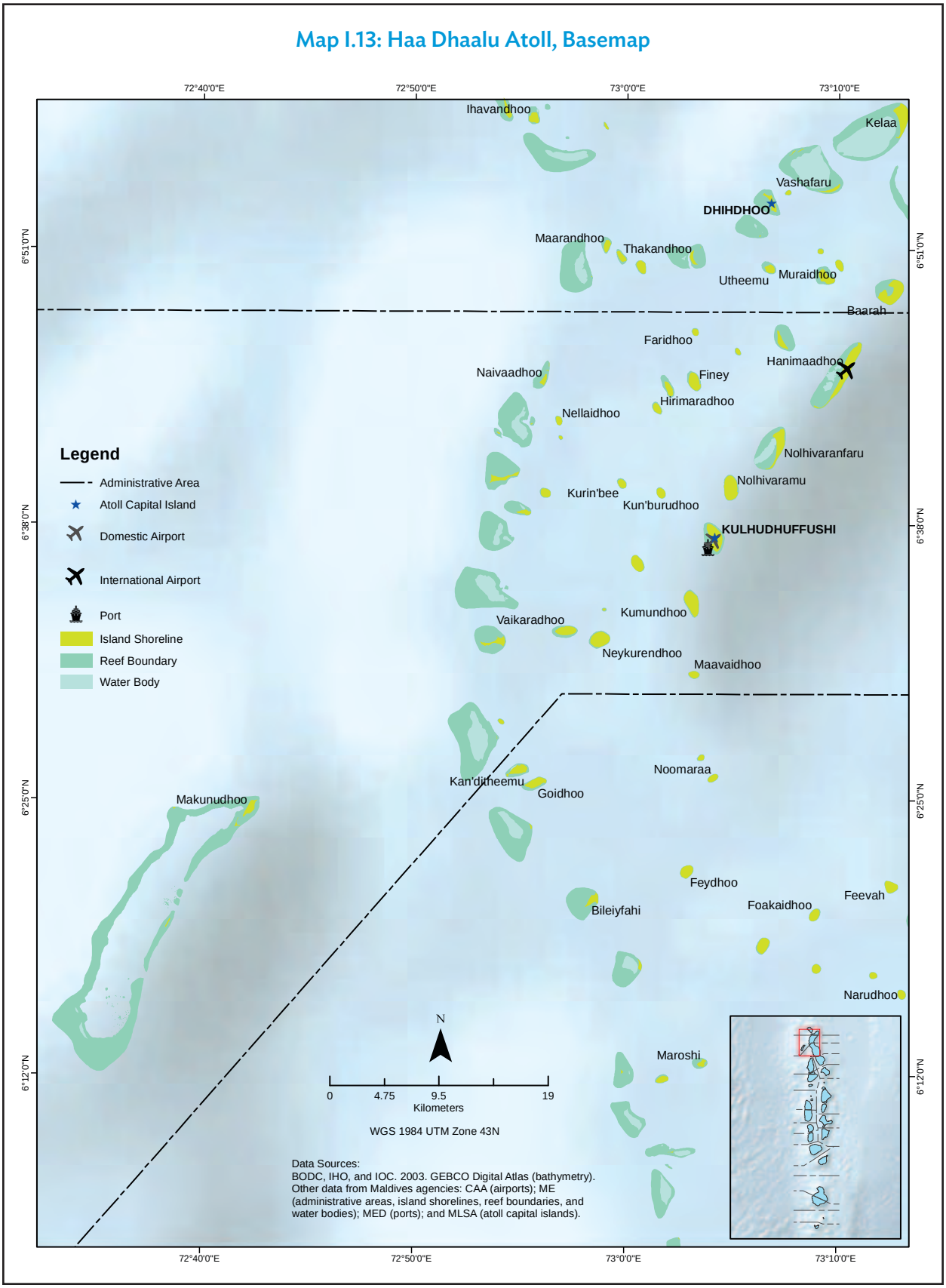
Map I.11: Gnaviyani Atoll, Basemap



Map I.12: Haa Alifu Atoll, Basemap

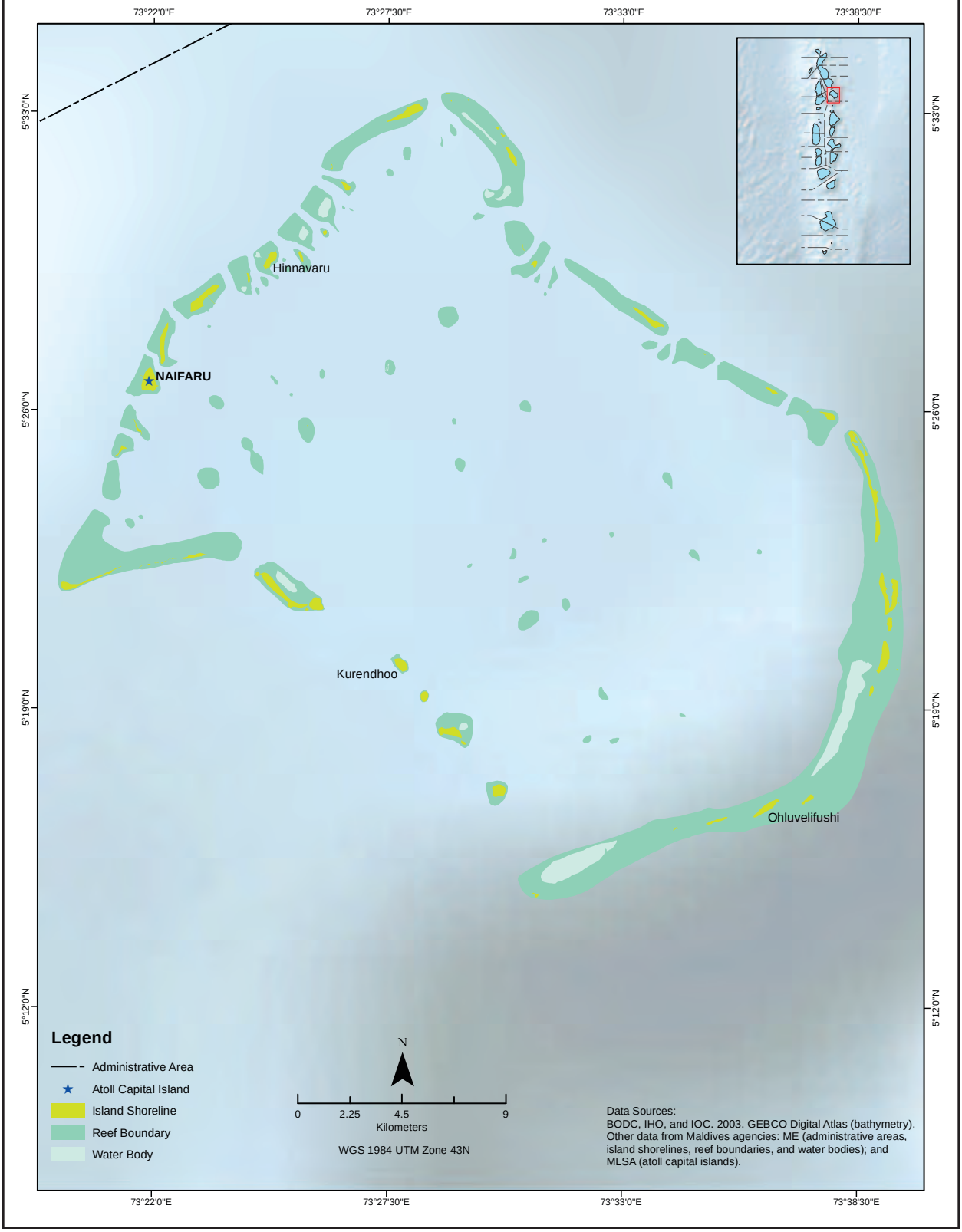


Map I.13: Haa Dhaalu Atoll, Basemap

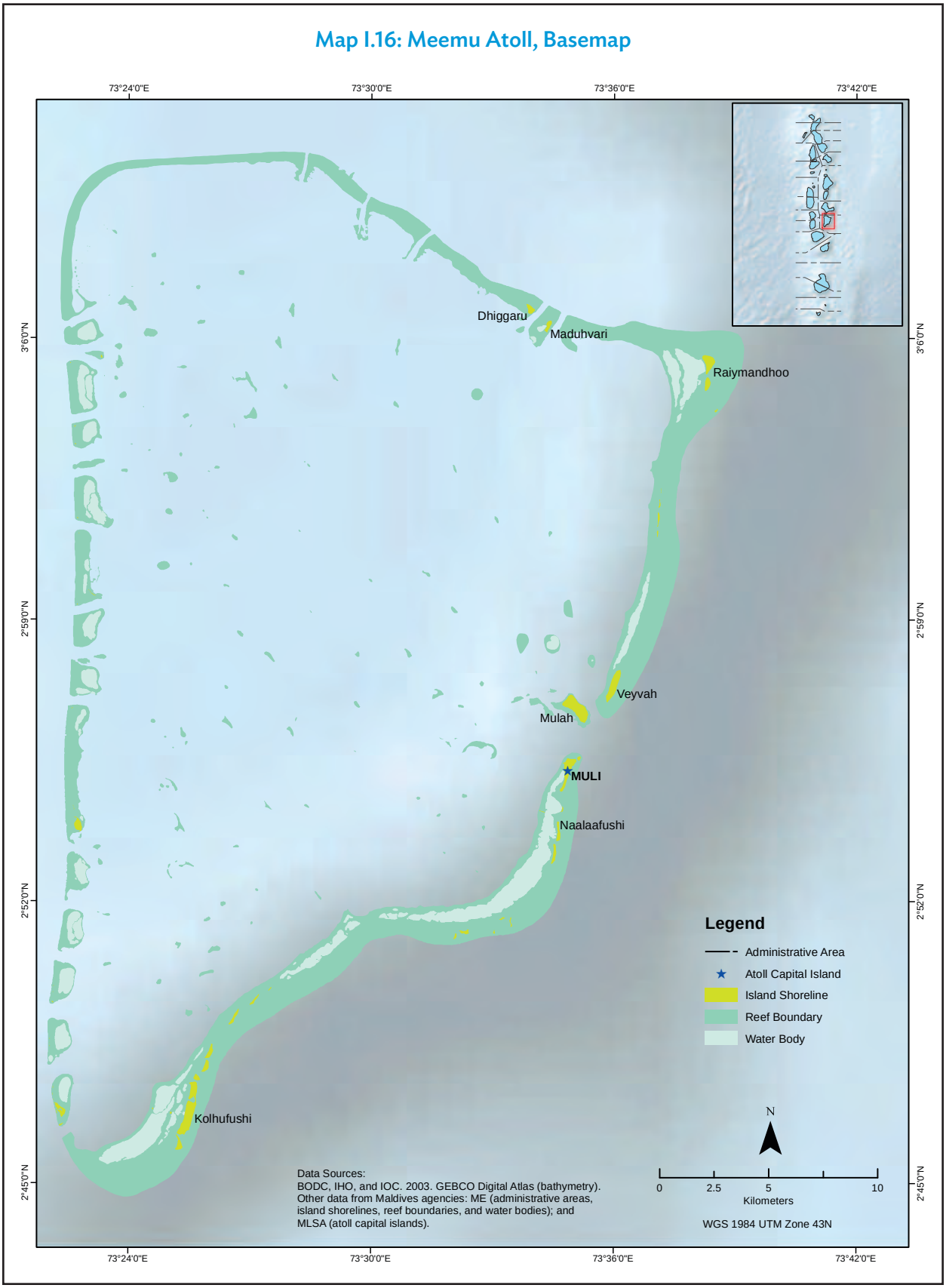


Map I.14: Laamu Atoll, Basemap

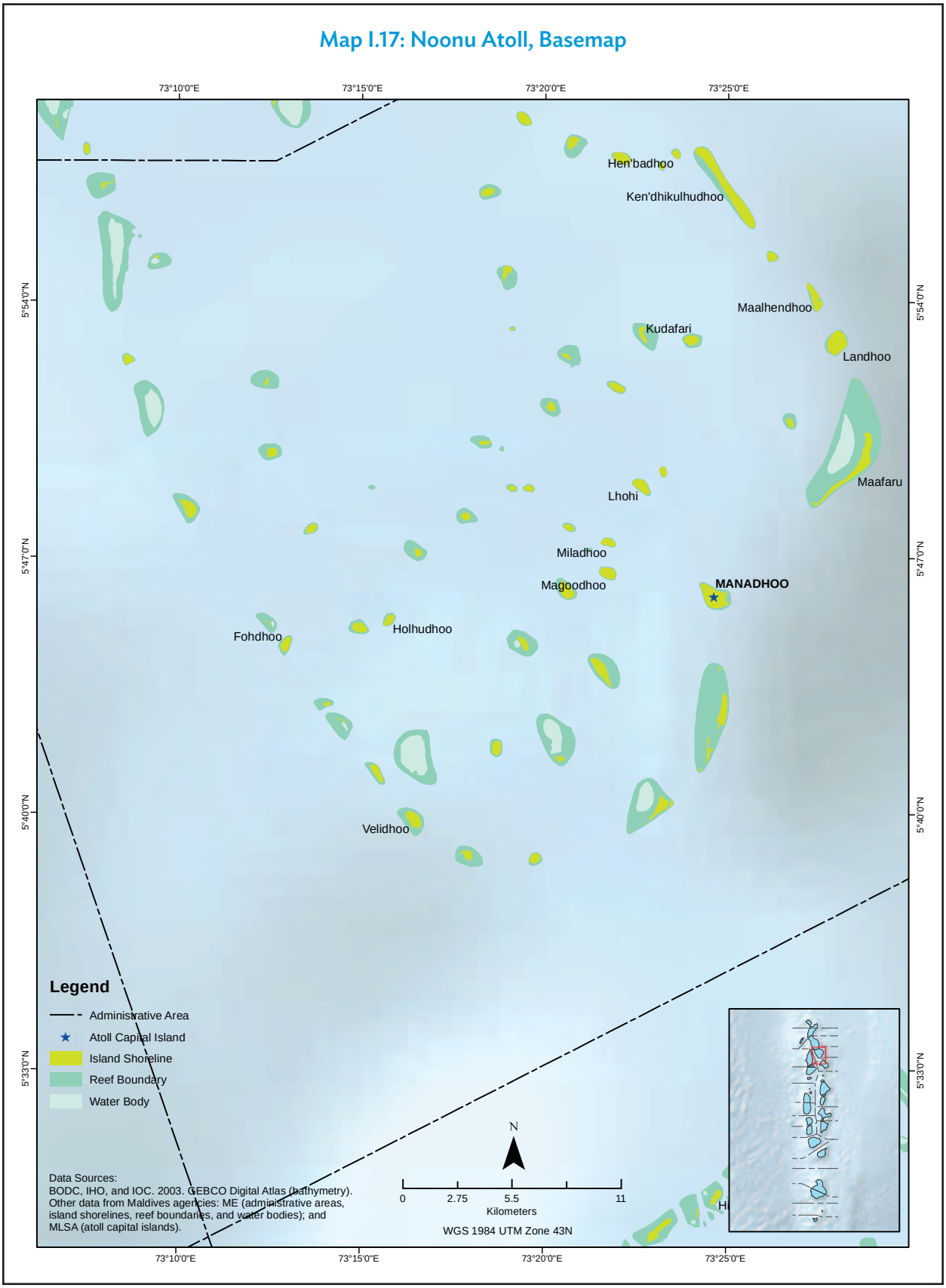
Map I.15: Lhaviyani Atoll, Basemap



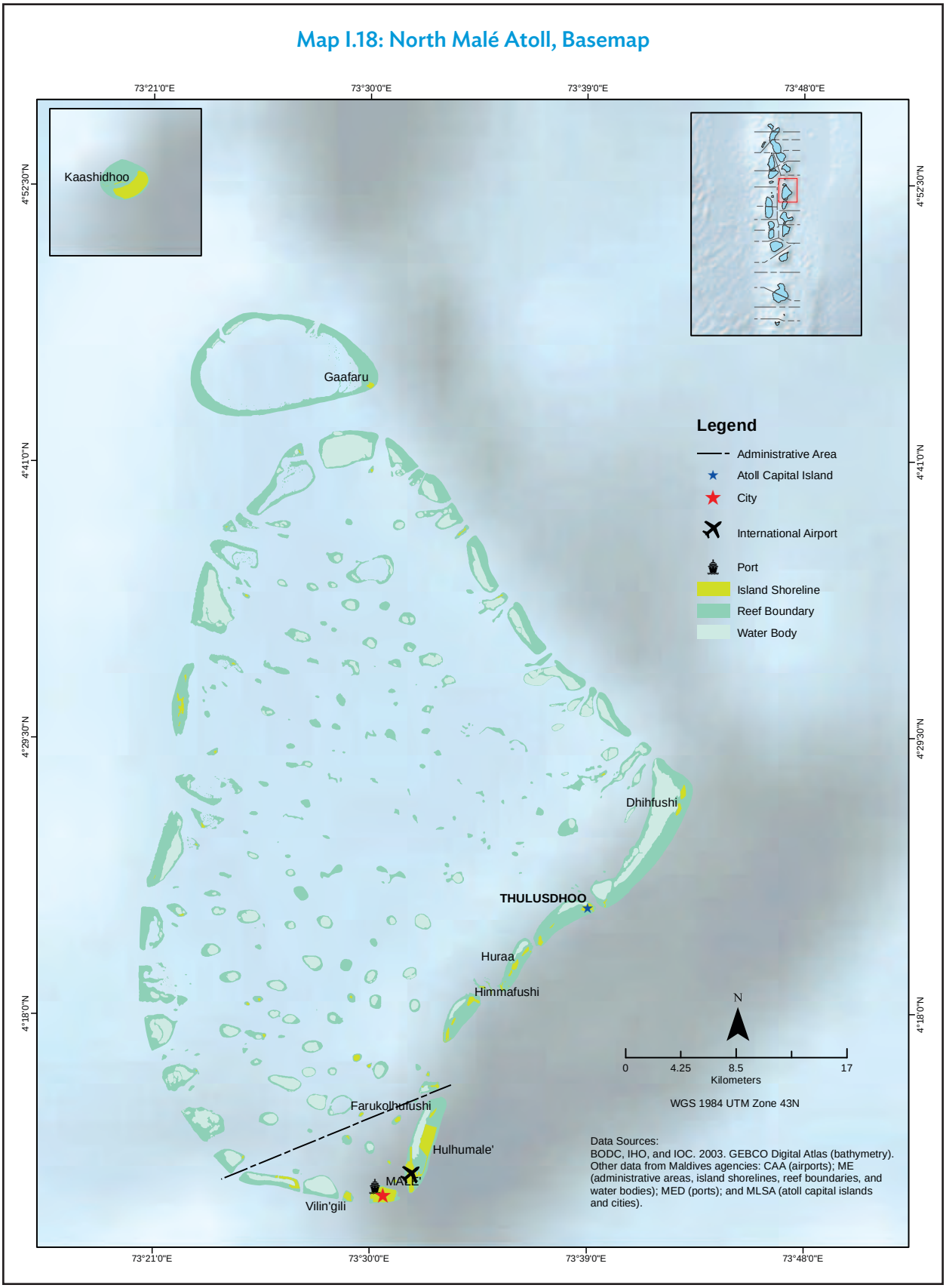
Map I.16: Meemu Atoll, Basemap



Map I.17: Noonu Atoll, Basemap



Map I.18: North Malé Atoll, Basemap



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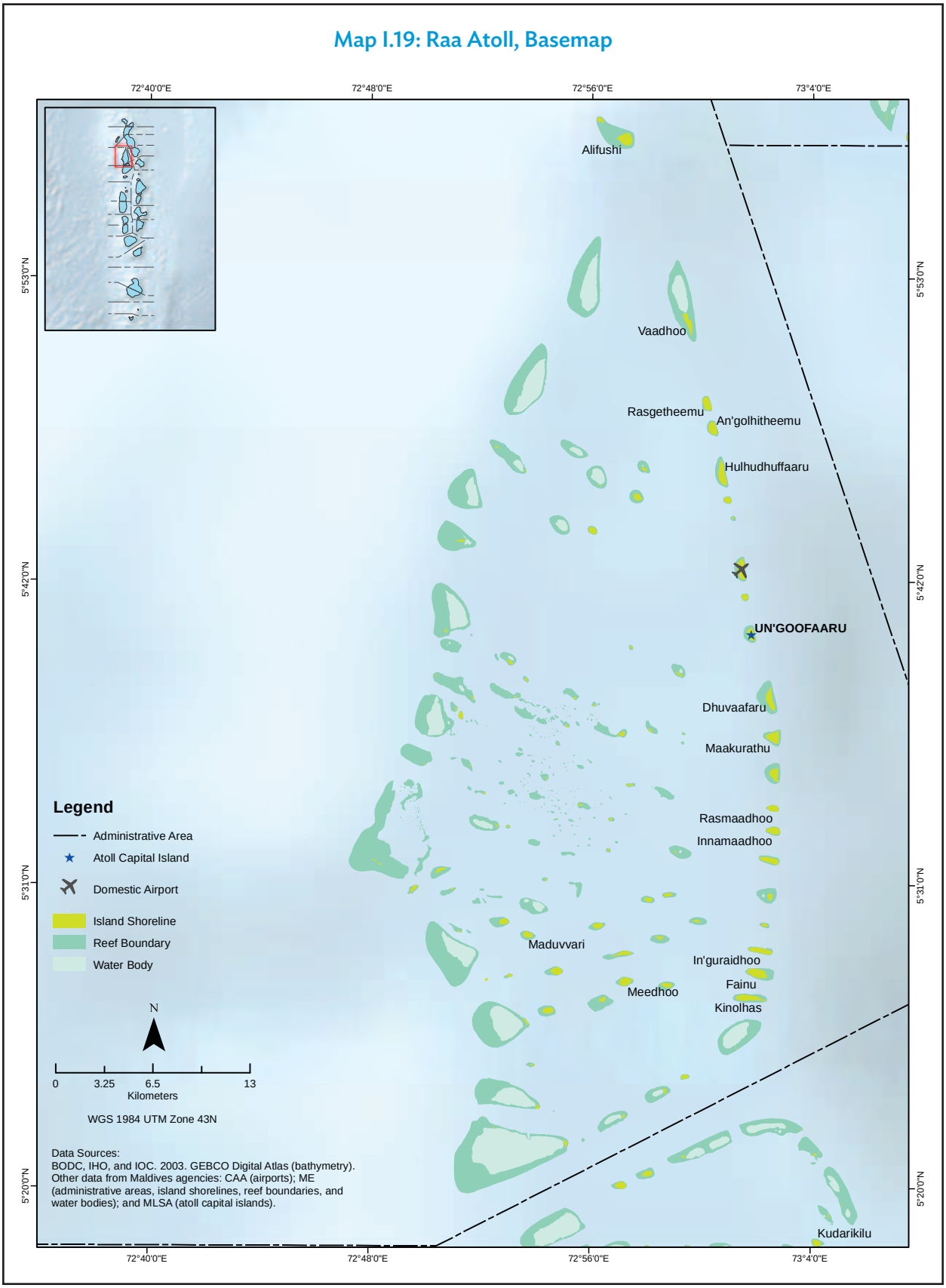
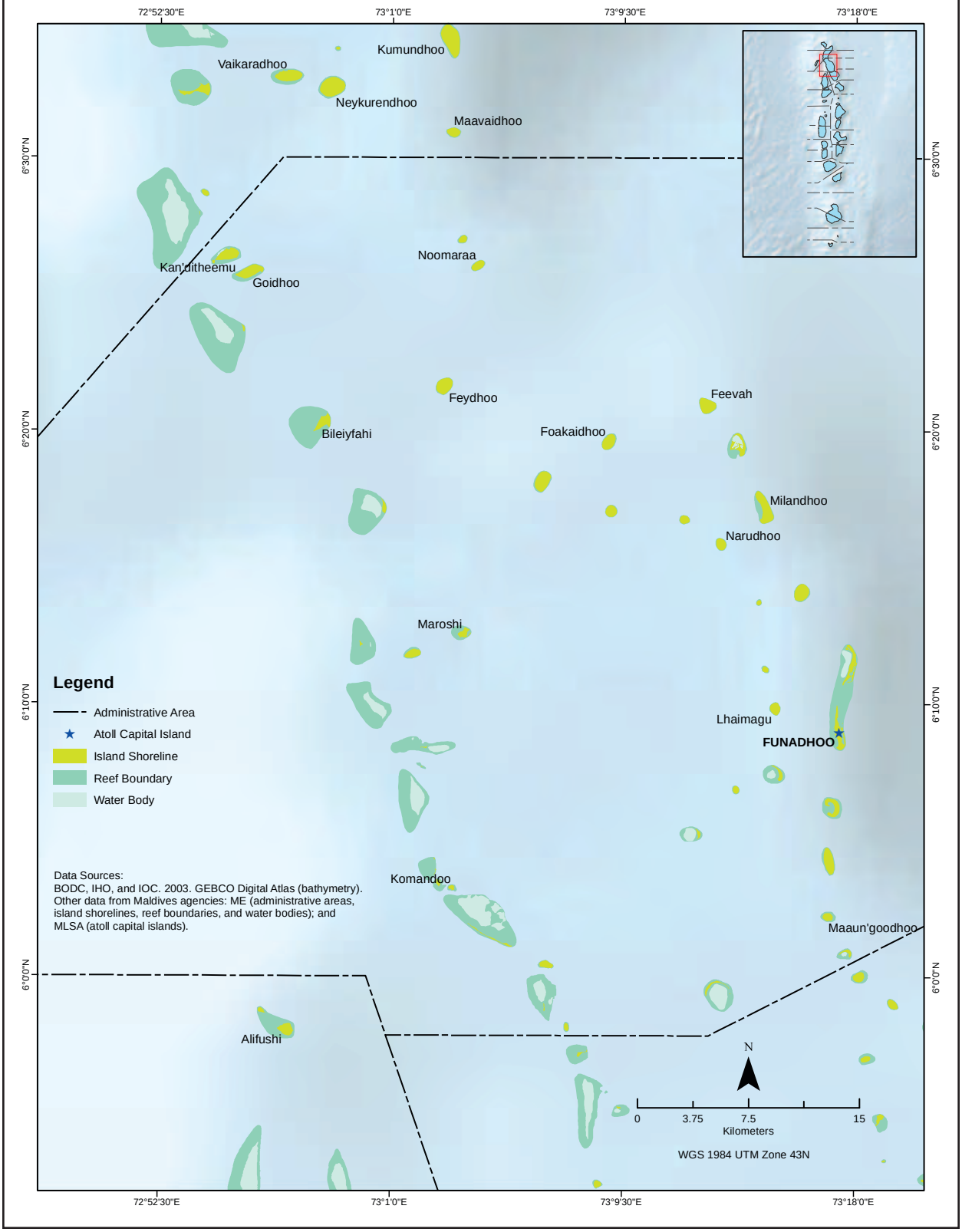
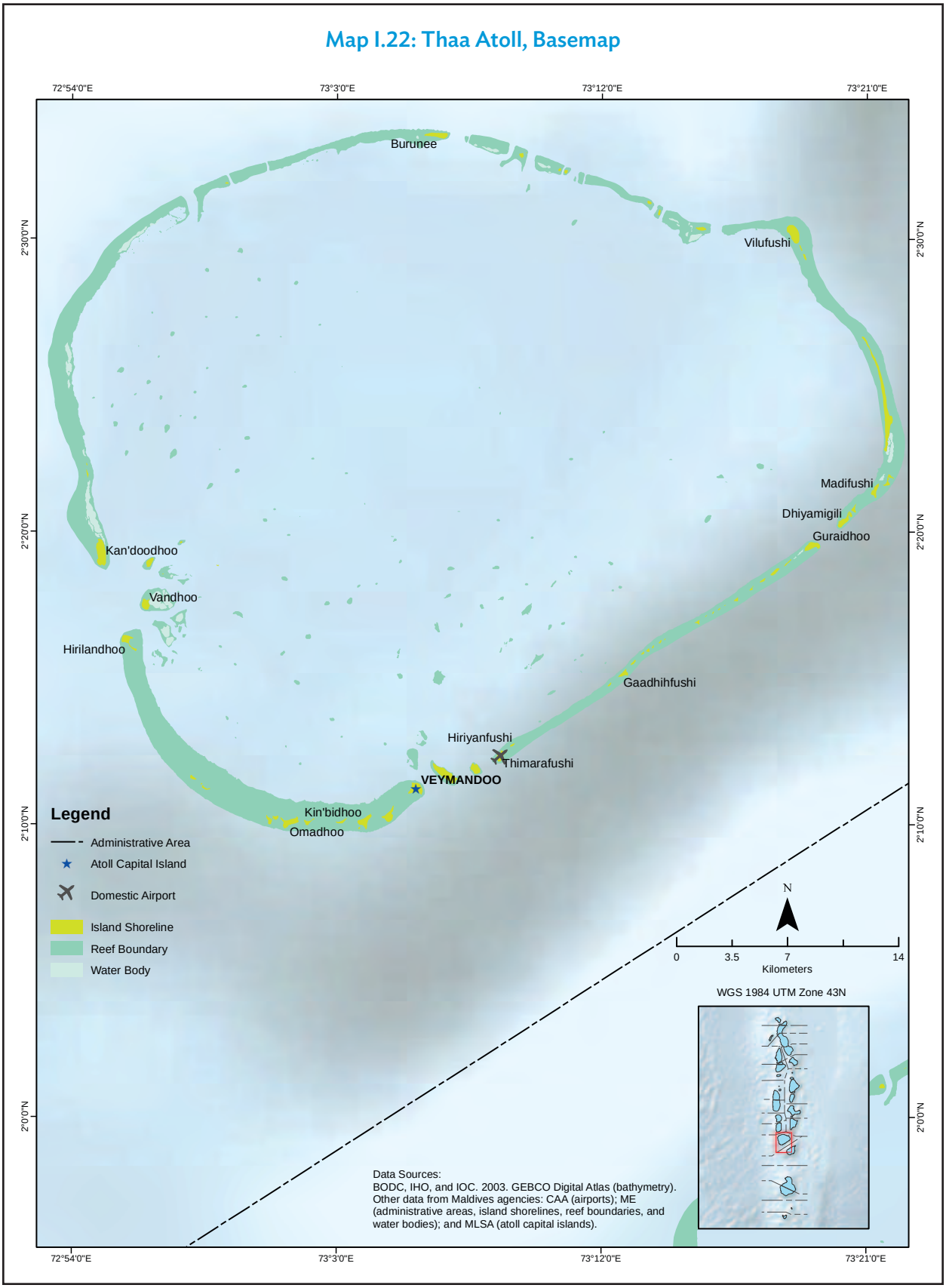


Map I.20: Shaviyani Atoll, Basemap

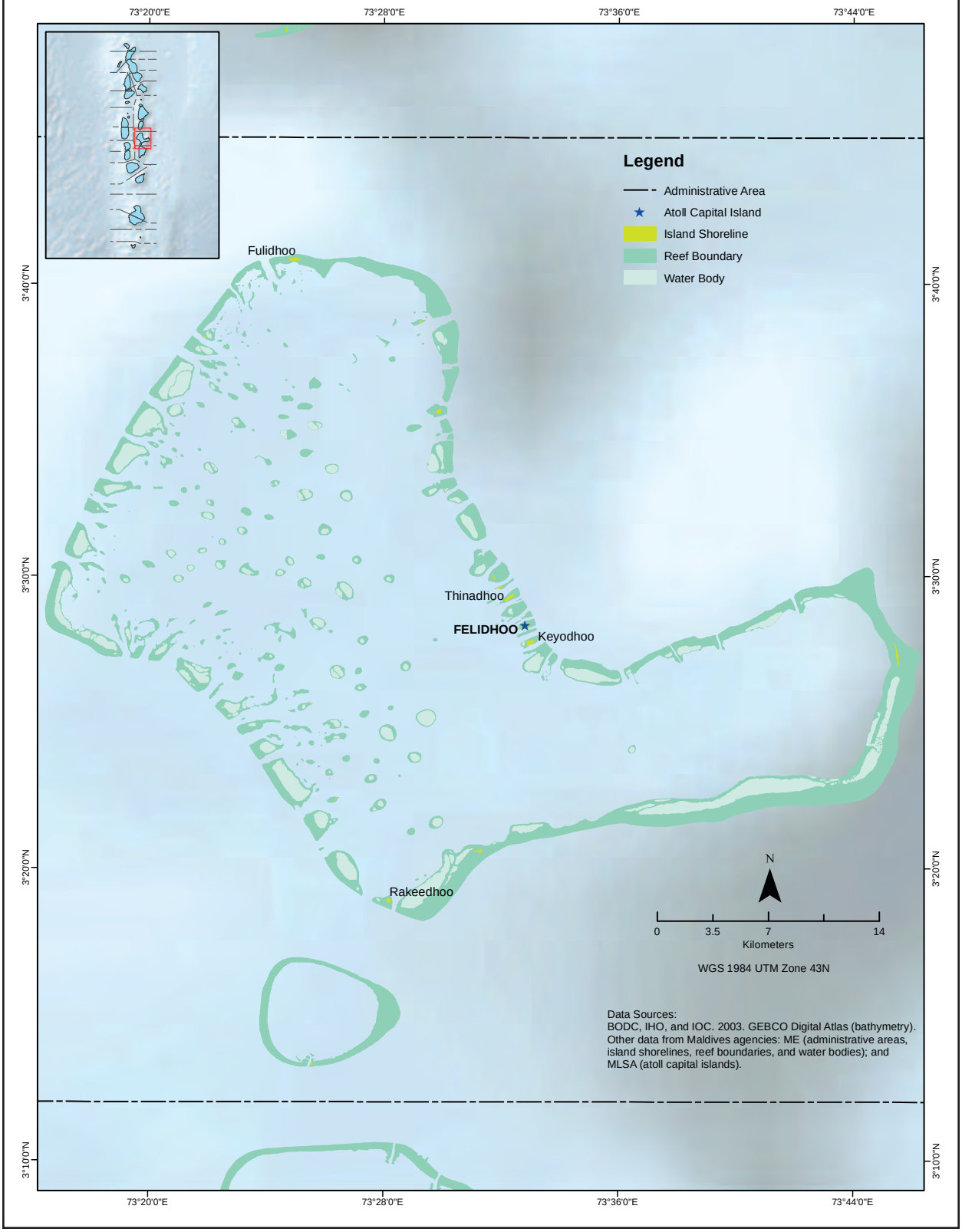


Map I.21: South Malé Atoll, Basemap

Map I.22: Thaa Atoll, Basemap



Map I.23: Vaavu Atoll, Basemap



Dynamic Geography

The natural geographic formation of Maldives presents challenges in urban expansion and development. Limited dry land combined with urban growth requires measures to maximize the available space for multiple activities. One mode of urban expansion is land reclamation. Land reclamation has become part of the development in the country and a solution to the limited available land, transforming the islands over the years to accommodate more human activities. Land reclamation is noticeable in the straightened coasts of Thinadhoo Island located in Gaafu Dhaalu Atoll (Map I.24). Other locations of land reclamation in Maldives are listed in Table I.1 and shown in Map I.25.

Table I.1: Islands with Reclamation

Atoll	No. of Islands with Reclamation	Islands with Reclamation
Haa Alifu	1	Dhidhoo
Haa Dhaalu	1	Kulhudhuffushi
Addu City	2	Hithadhoo
		Feydhoo
Alifu Alifu	2	Bodufolhudhoo
		Rasdhoo
Alifu Dhaalu	2	Dhihdhoo
		Maamigili
Faafu	2	Magoodhoo
		Nilandhoo
Laamu	2	Gaadhoo
		Kunahandhoo
Lhaviyani	2	Hinnavaru
		Naifaru
Noonu	2	Maafaru
		Vavathi
South Malé	2	Gulhi
		Maafushi

continued on next page

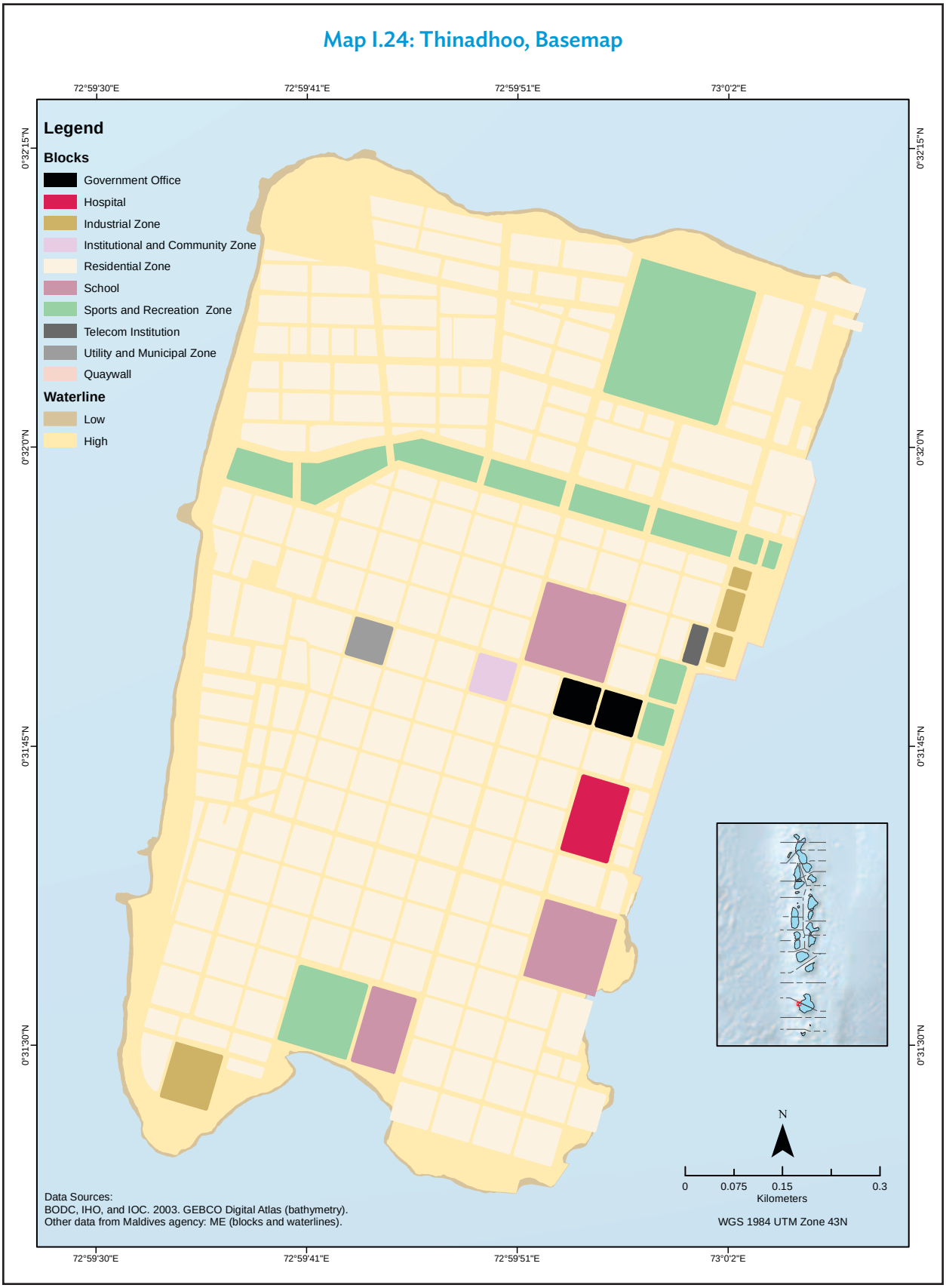
Table I.1 *continued*

Atoll	No. of Islands with Reclamation	Islands with Reclamation
Dhaalu	3	Kudahuvadhoo
		Maaen'boodhoo
		Meedhoo
Gaafu Alifu	3	Kolamaafushi
		Falhuverrahaa
		Dhaandhoo
Baa	4	Dharavandhoo
		Eydhafushi
		Thulhaadhoo
		Fares
Gaafu Dhaalu	4	Hoan'dedhdhoo
		Thinadhoo
		Faresmaathodaa
		Rodhavarrehaa
Meemu	4	Dhiggaru
		Maduhvari
		Muli
		Naalaafushi
Shaviyani	4	Milandhoo
		Funadhoo
		Komandoo
		Maroshi
Thaa	6	Vilufushi
		Madifushi
		Dhiyamigili
		Guraidhoo
		Hirilandhoo
		Thimarafushi
North Malé	8	Gaafaru
		Thulusdhoo
		Himmafushi
		Hulhumalé
		Malé
		Vilin'gili
		Hulhulé
		Tilafushi

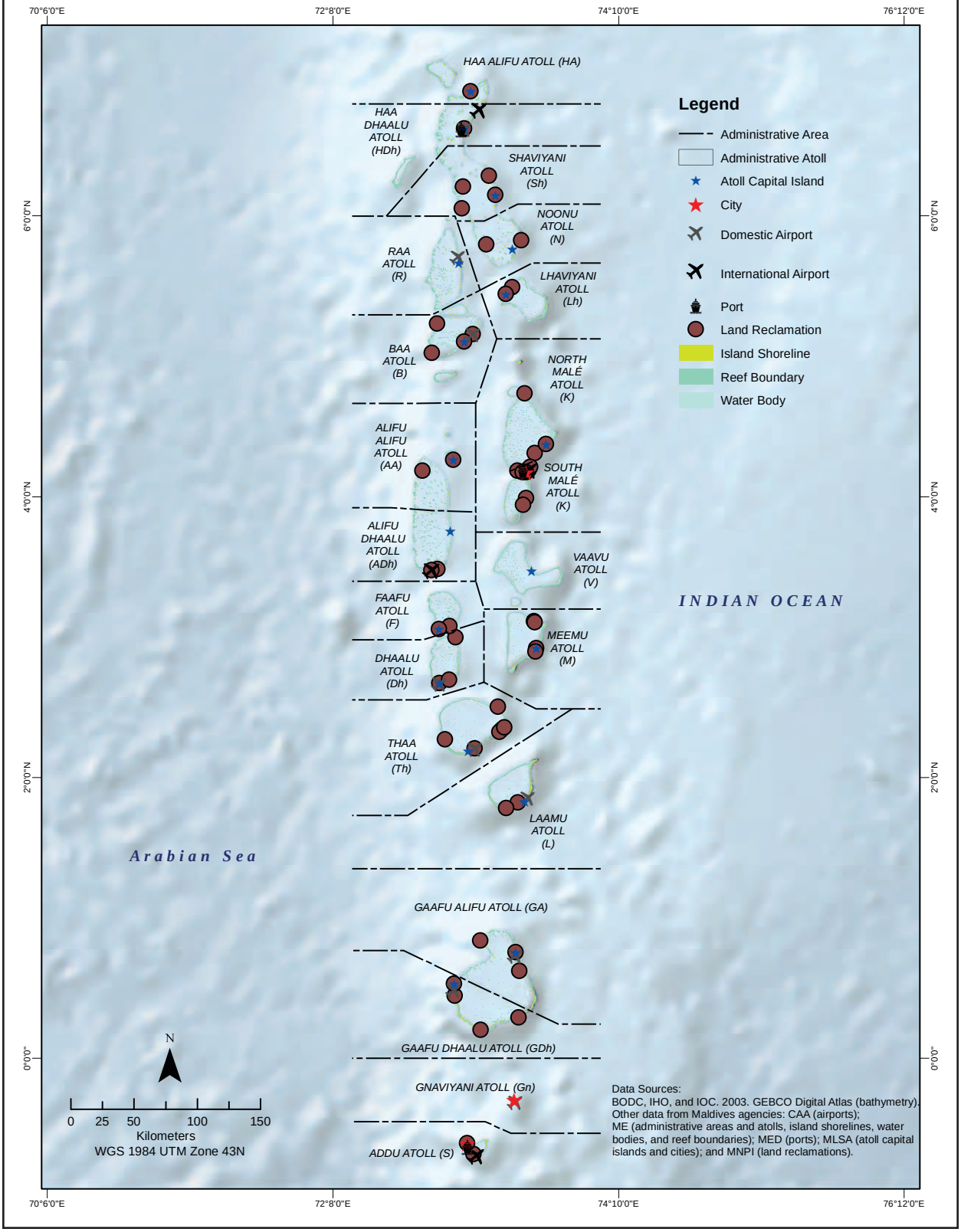
Source: Government of Maldives, Ministry of National Planning and Infrastructure, 2017.

Land reclamation. To accommodate more people and urban activities, the coasts of major islands have been reclaimed. The Government of Maldives prioritized the Hulhumalé Land Reclamation and Development Project to address the need for more space around Malé City. This project will expand the island by 12.8 square kilometers in a sustainable manner (ADB 2017) (photo by Shahee Ilyas).

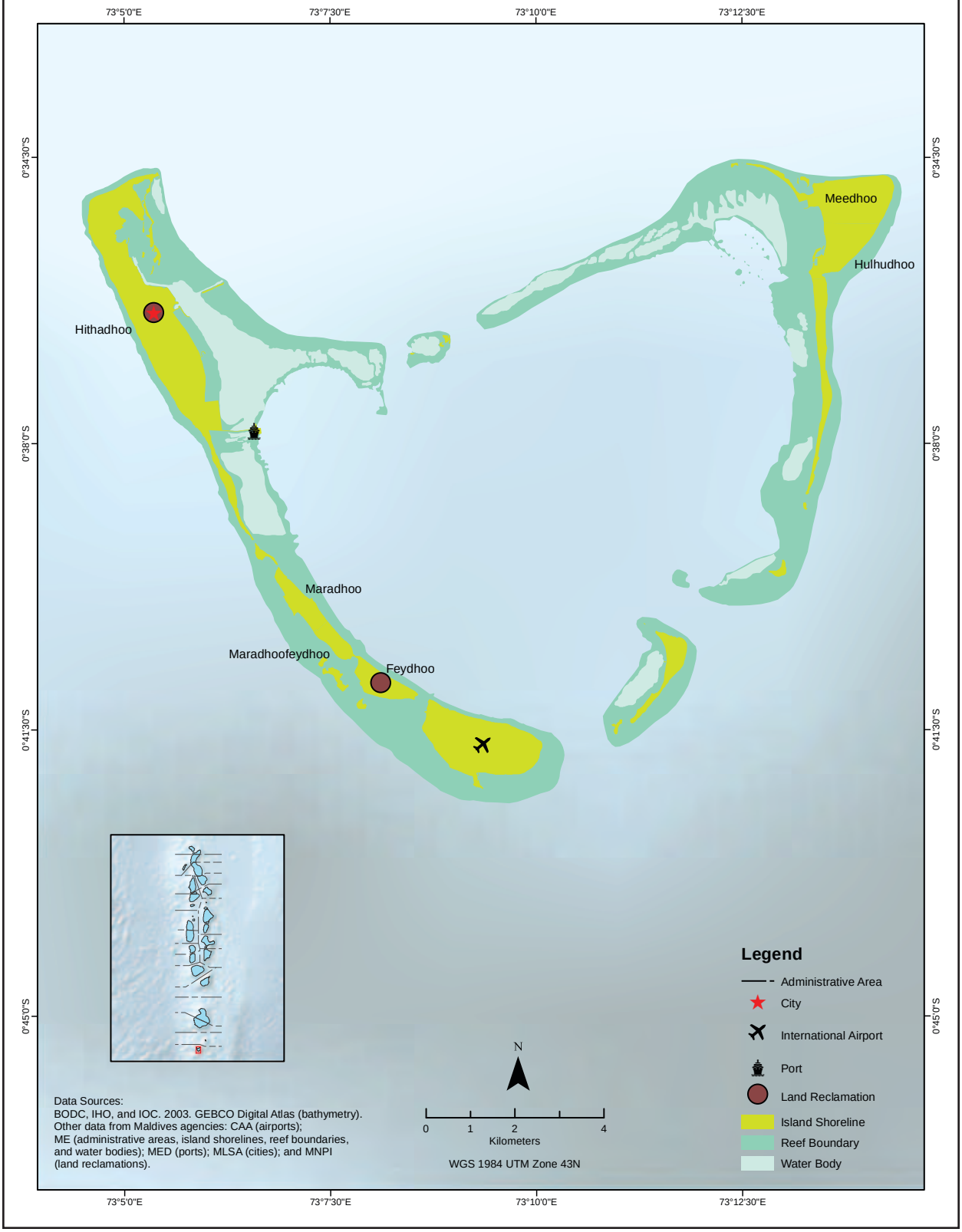
Map I.24: Thinadhoo, Basemap



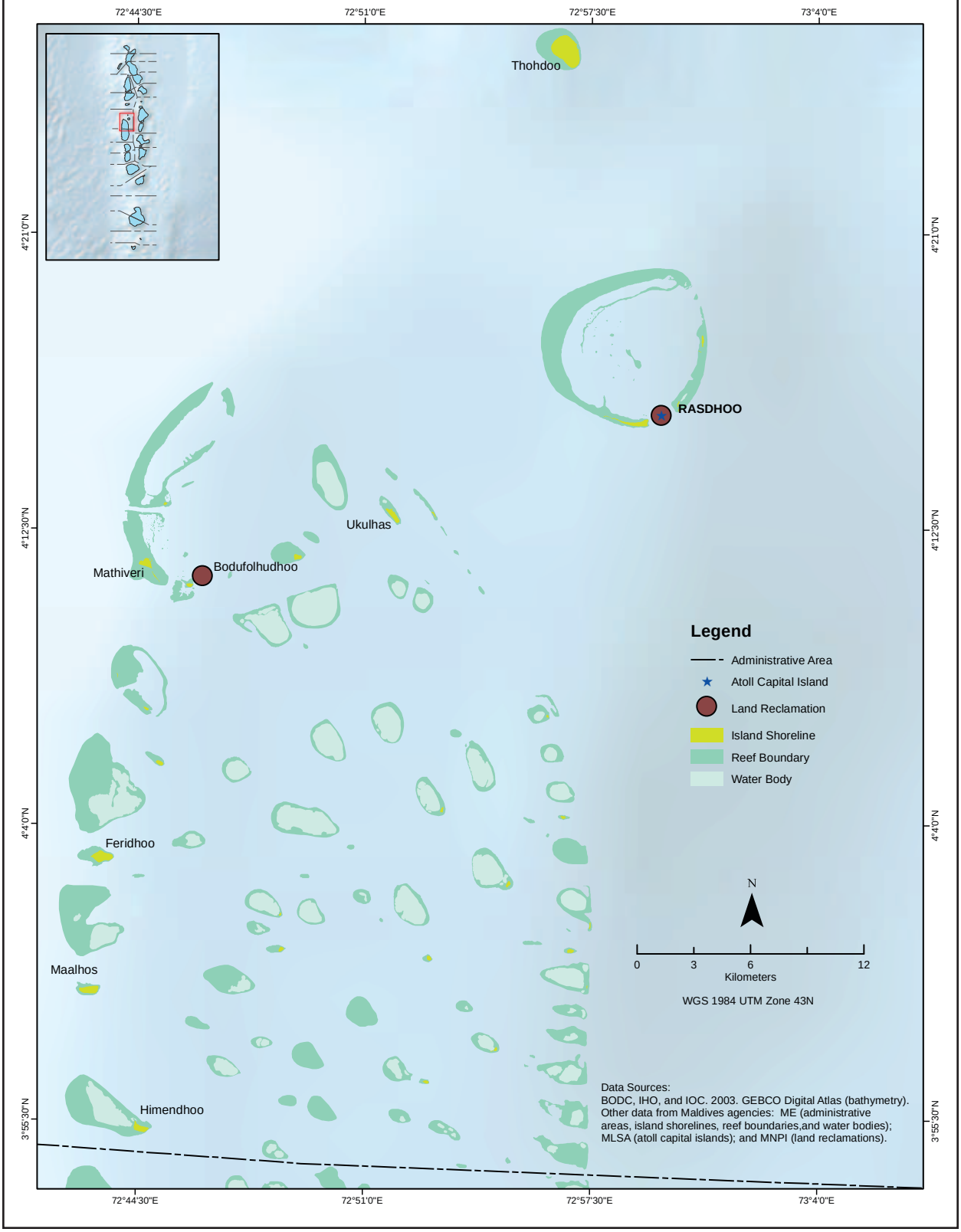
Map I.25: Maldives, Land Reclamation



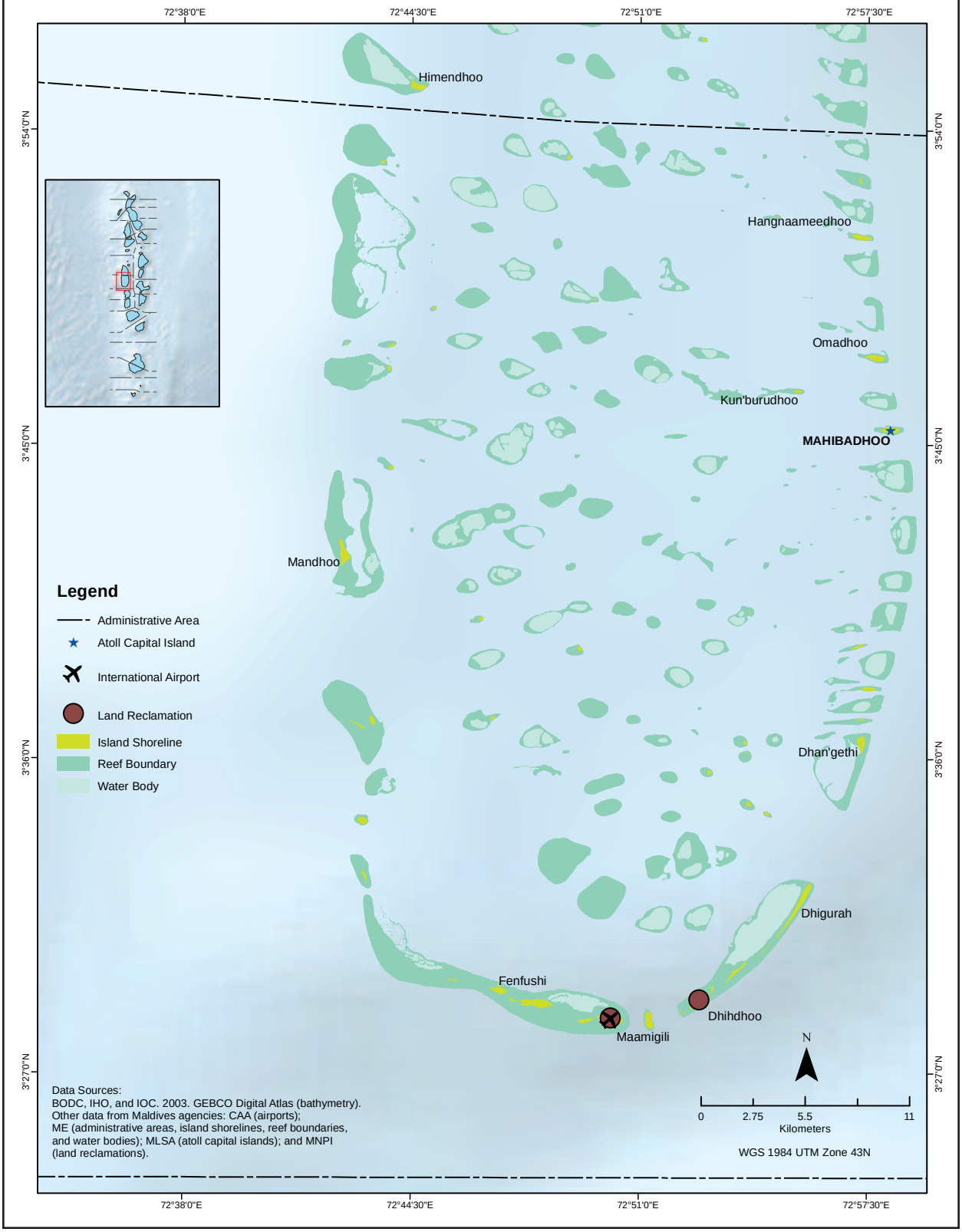
Map I.26: Addu City, Land Reclamation



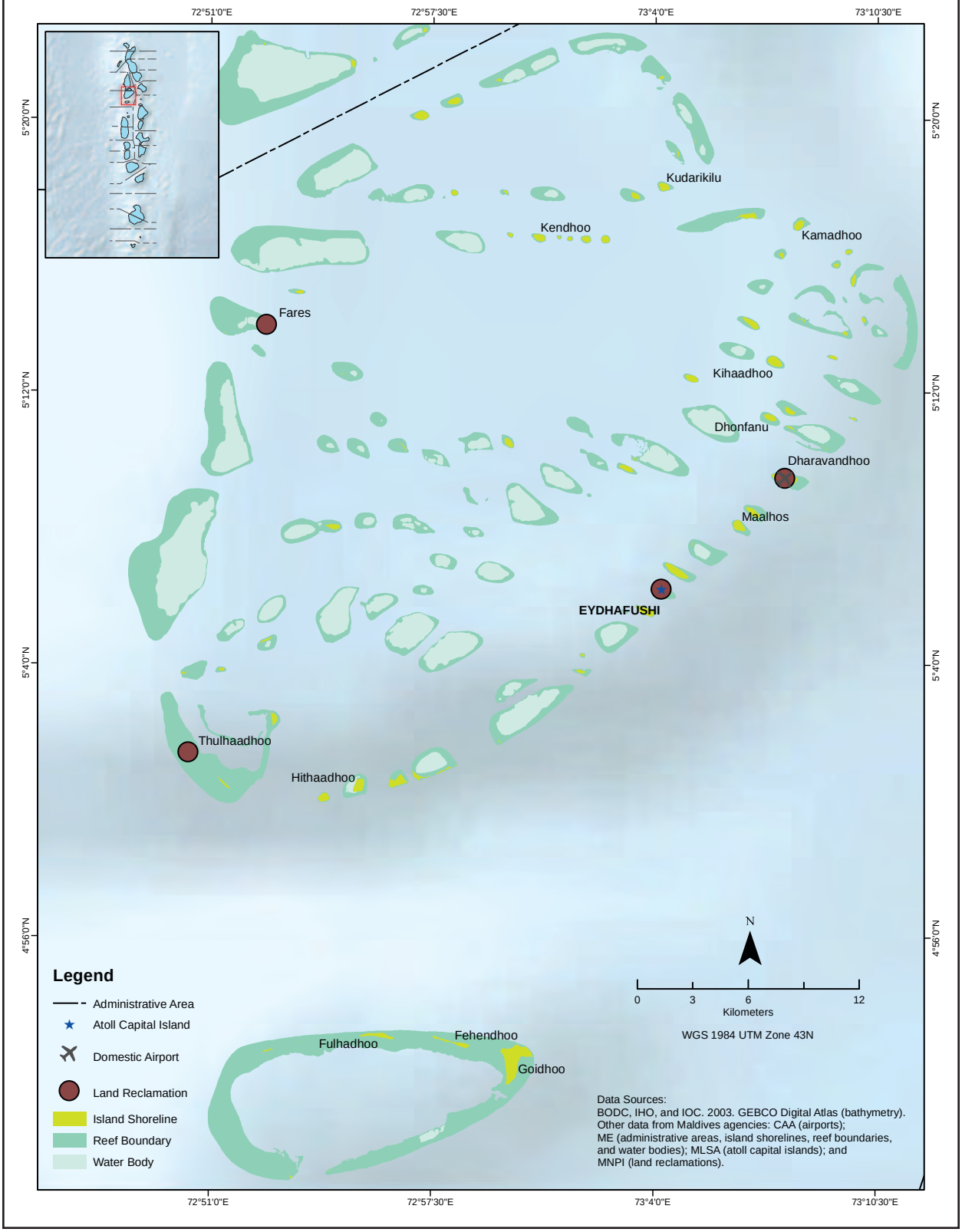
Map I.27: Alifu Alifu Atoll, Land Reclamation



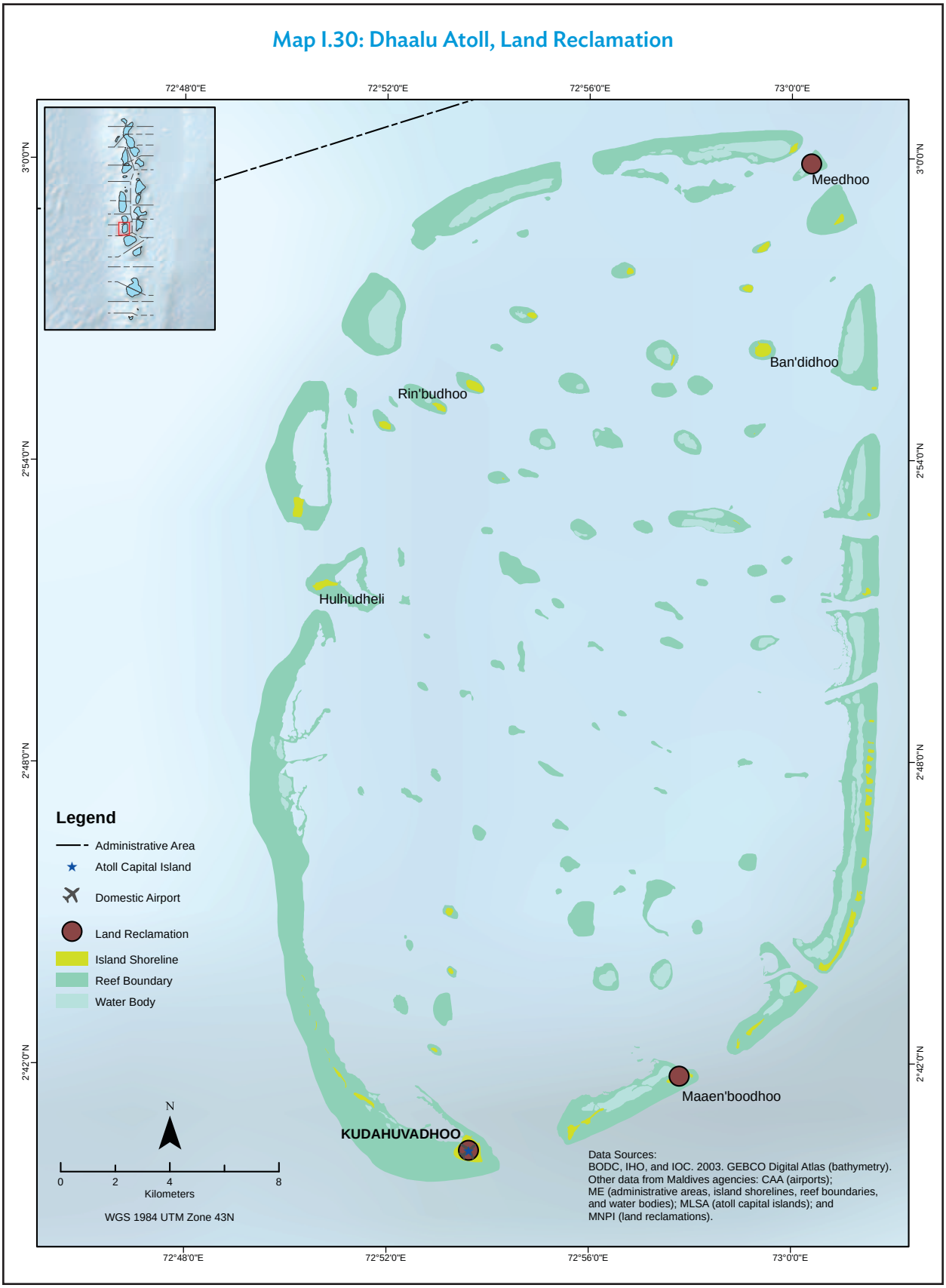
Map I.28: Alifu Dhaalu Atoll, Land Reclamation



Map I.29: Baa Atoll, Land Reclamation

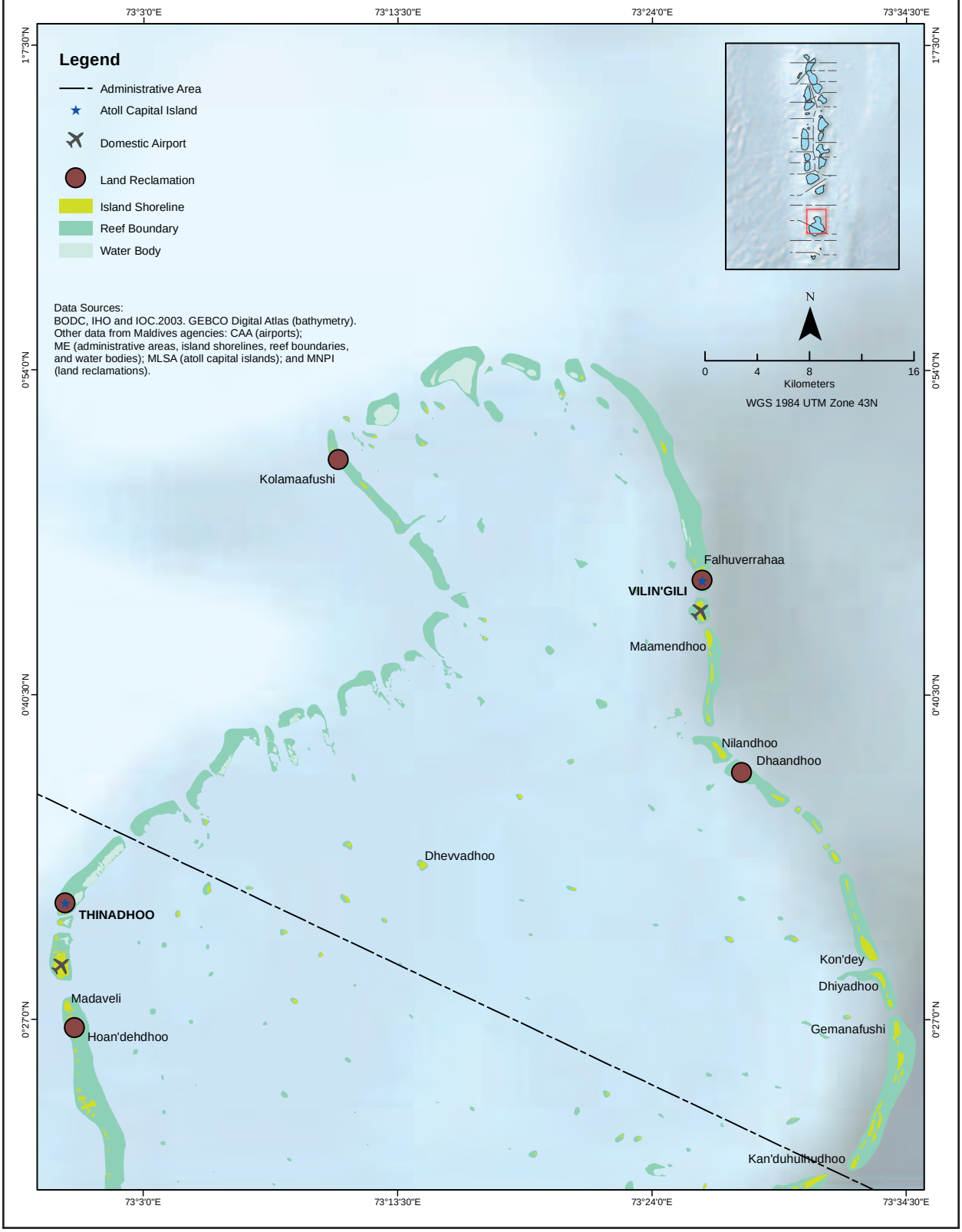


Map I.30: Dhaalu Atoll, Land Reclamation

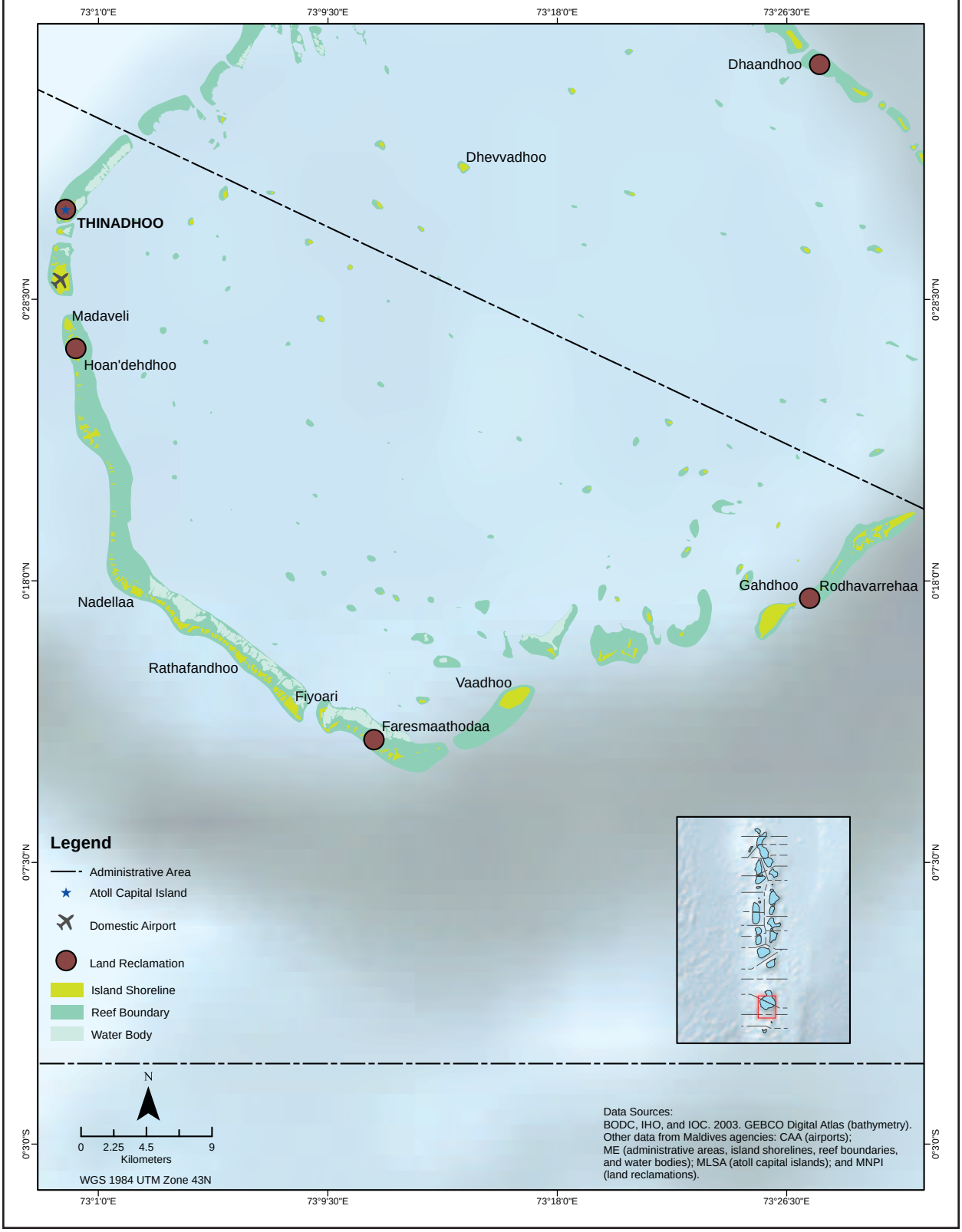


Map I.31: Faafu Atoll, Land Reclamation

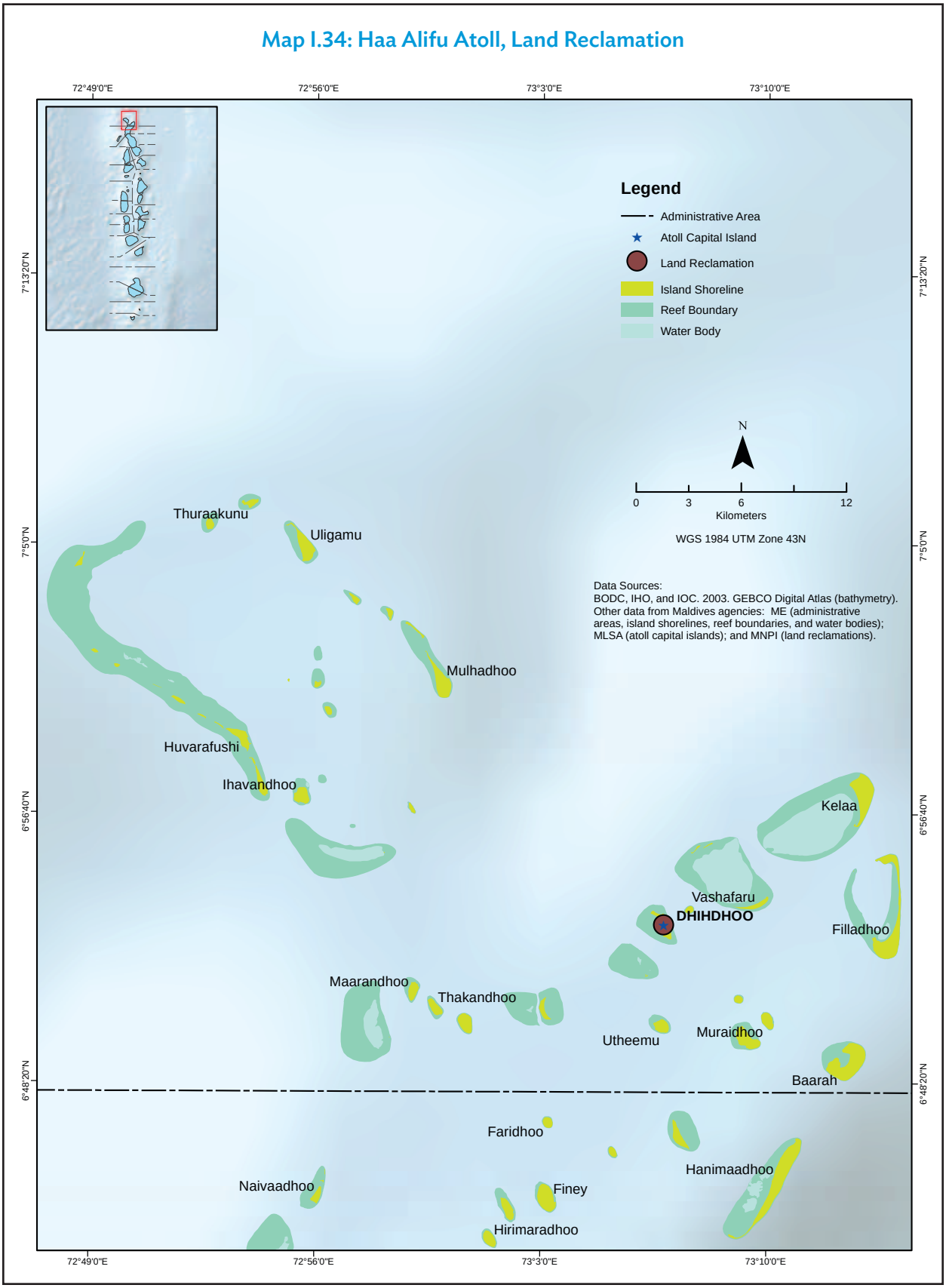
Map I.32: Gaafu Alifu Atoll, Land Reclamation



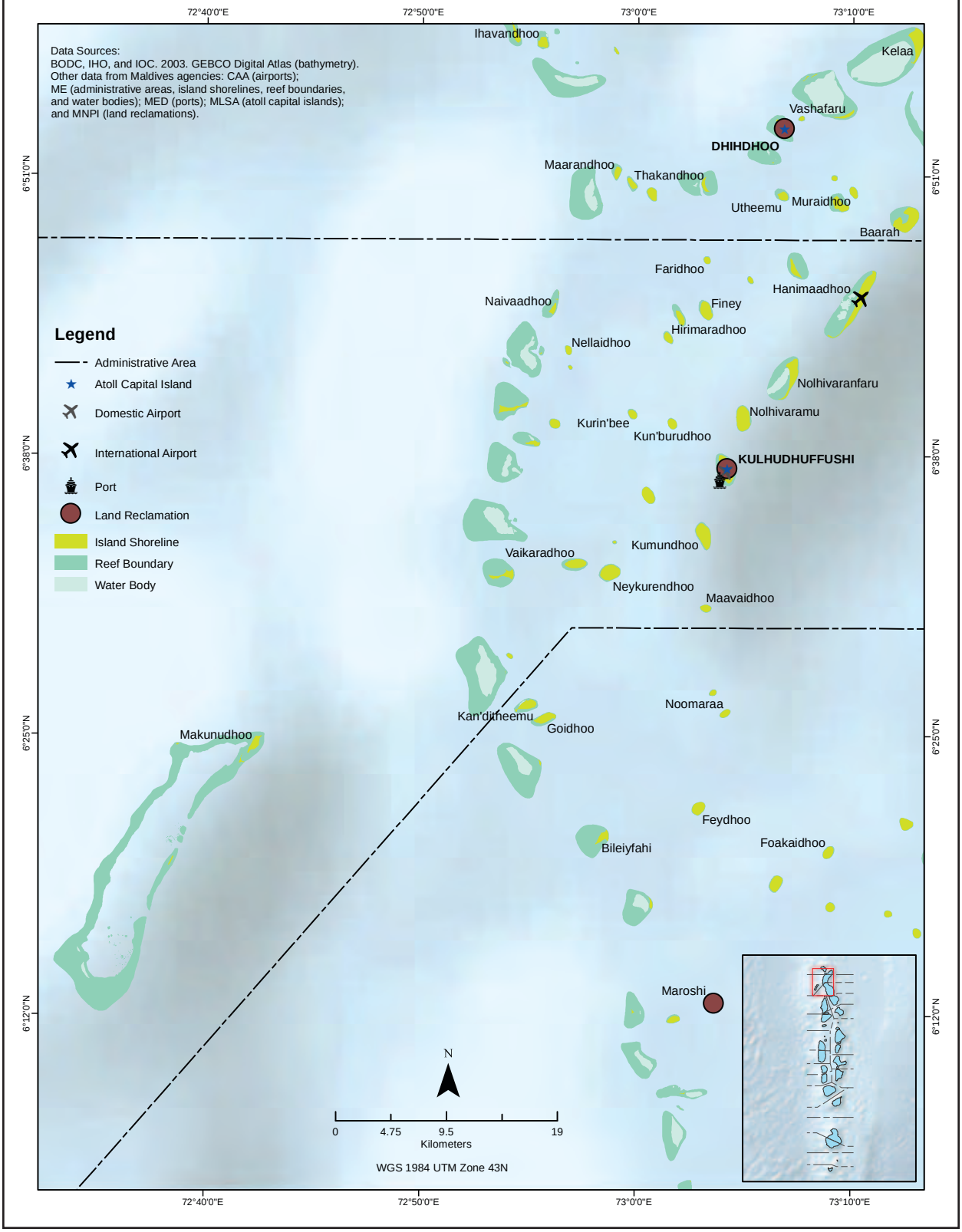
Map I.33: Gaafu Dhaalu Atoll, Land Reclamation



Map I.34: Haa Alifu Atoll, Land Reclamation



Map I.35: Haa Dhaalu Atoll, Land Reclamation



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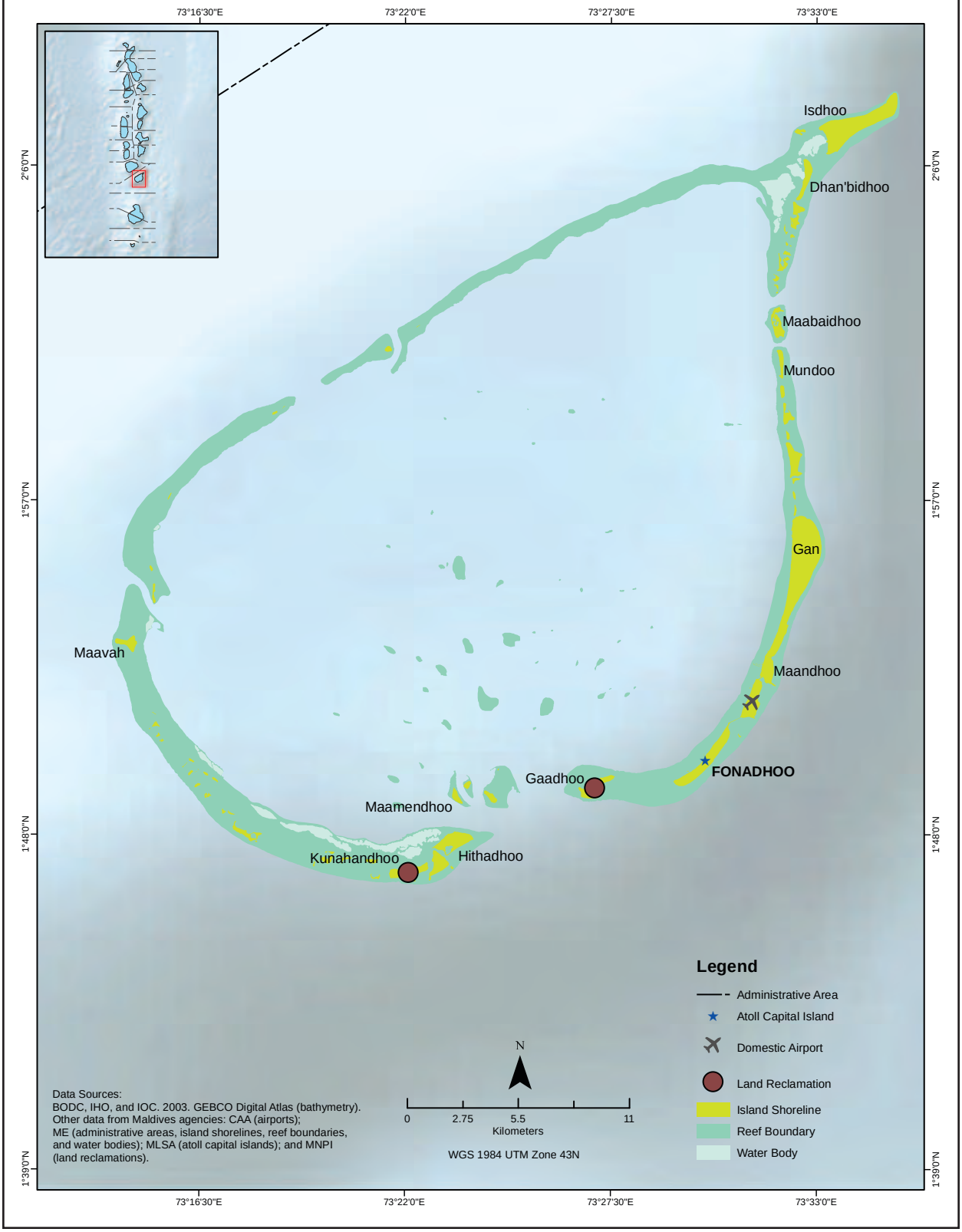
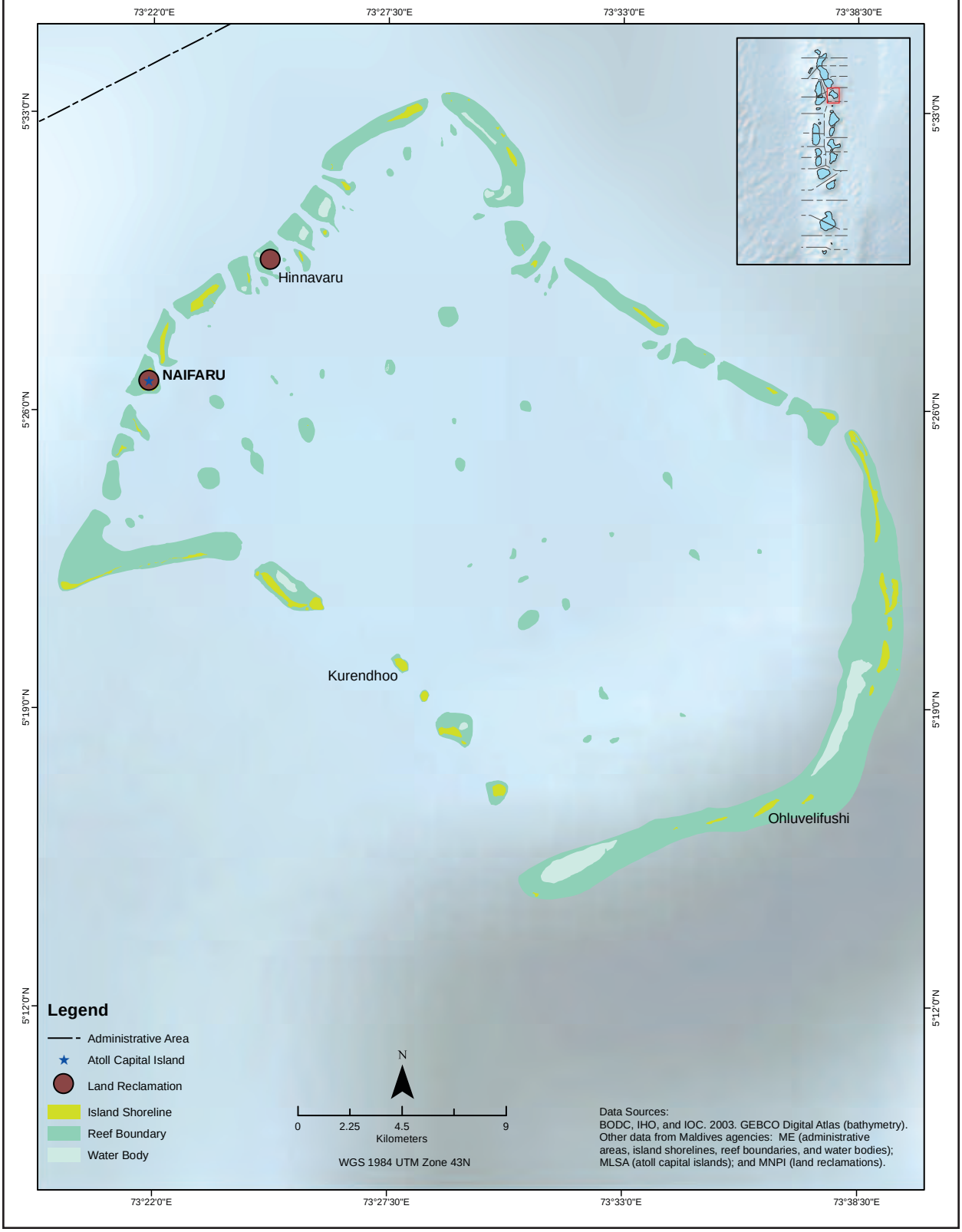
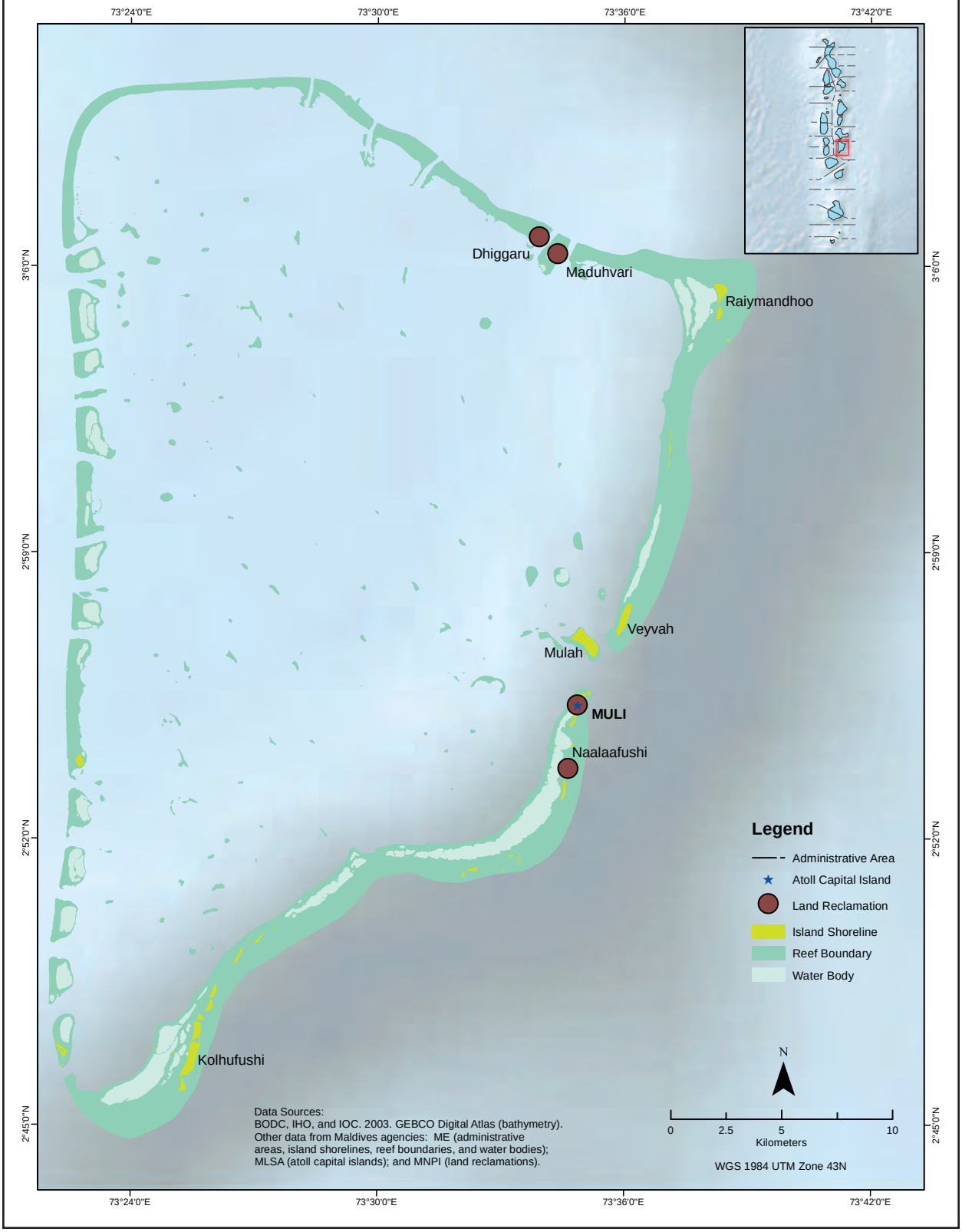


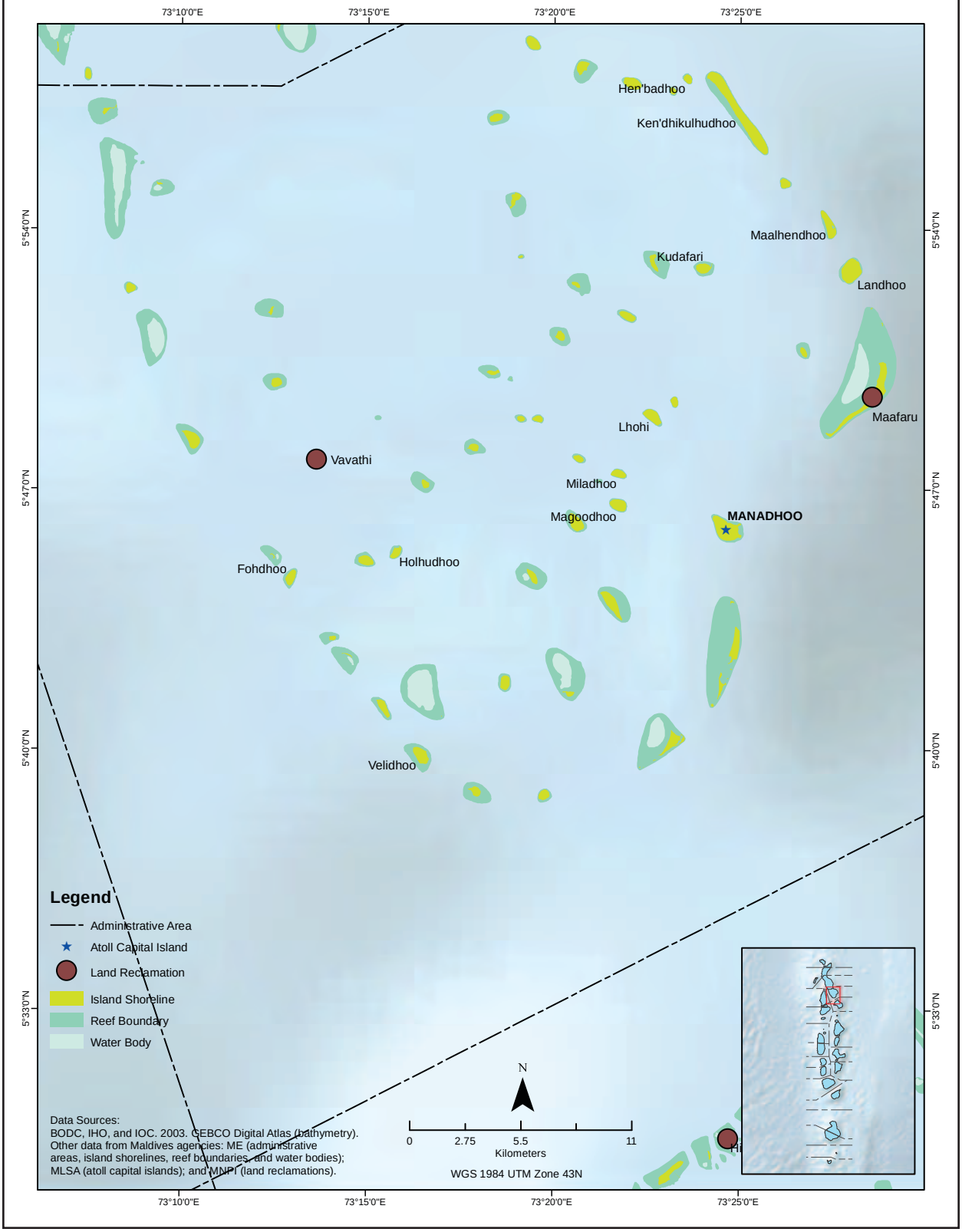
Map I.37: Lhaviyani Atoll, Land Reclamation



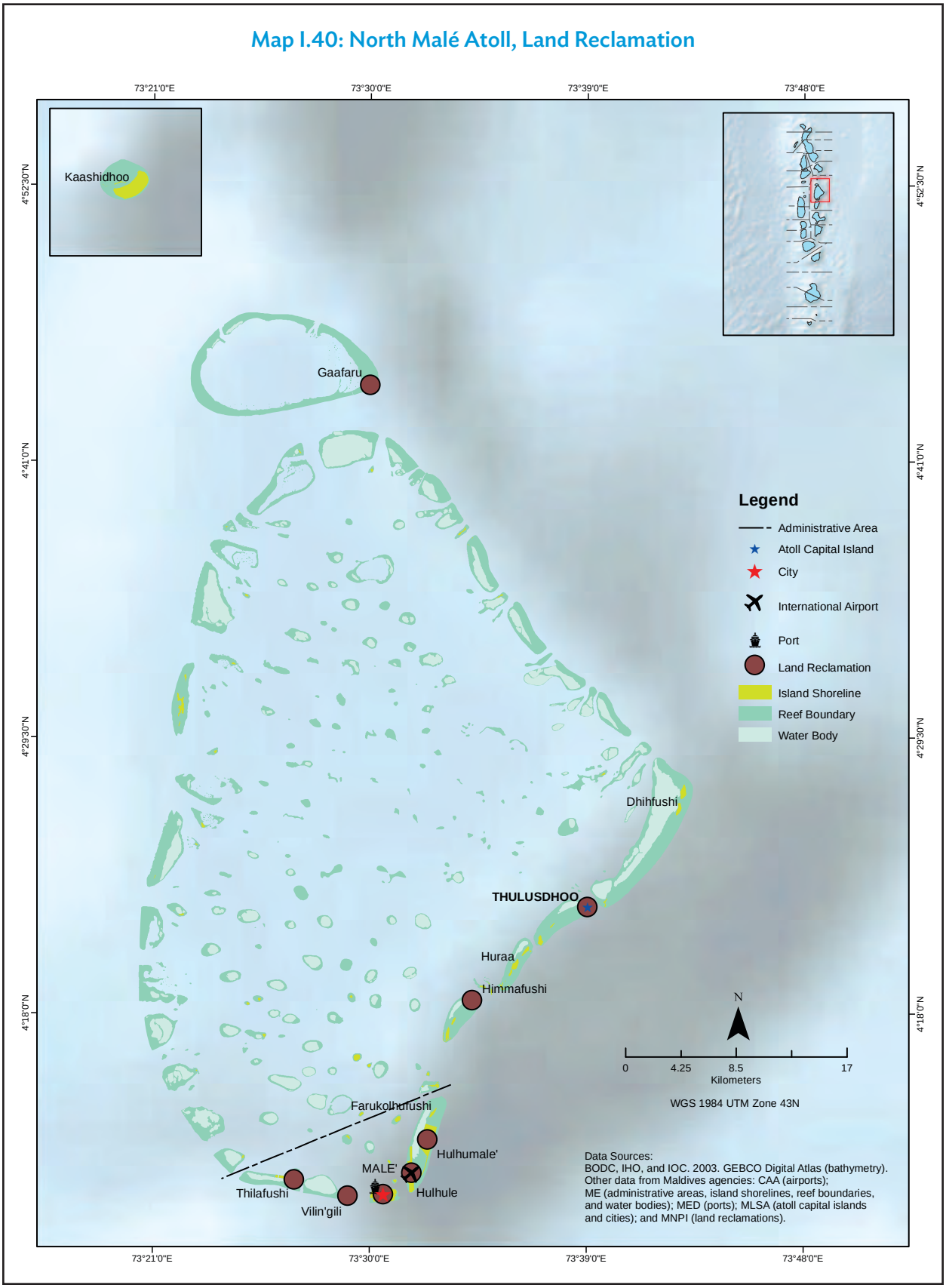
Map I.38: Meemu Atoll, Land Reclamation



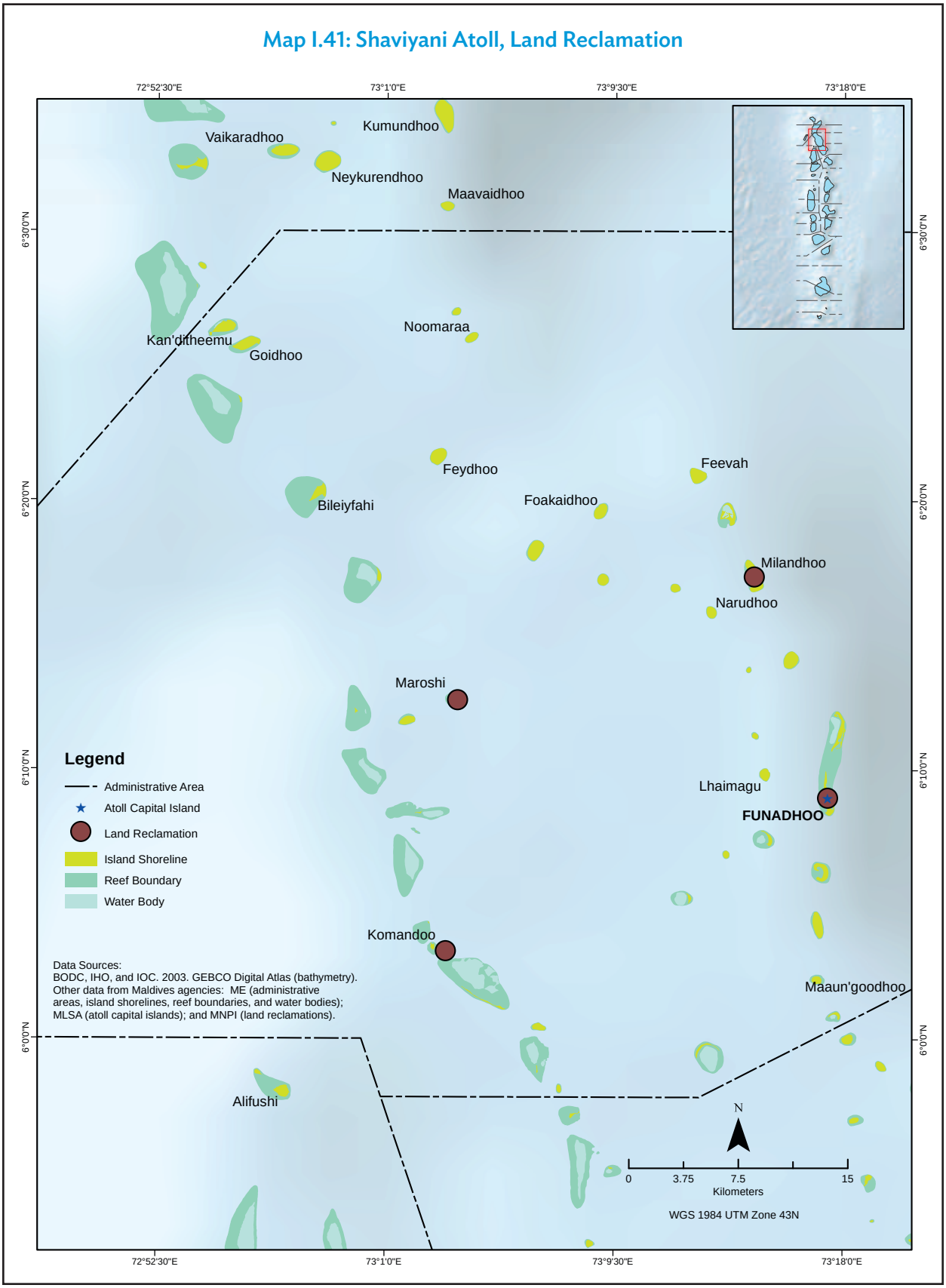
Map I.39: Noonu Atoll, Land Reclamation



Map I.40: North Malé Atoll, Land Reclamation

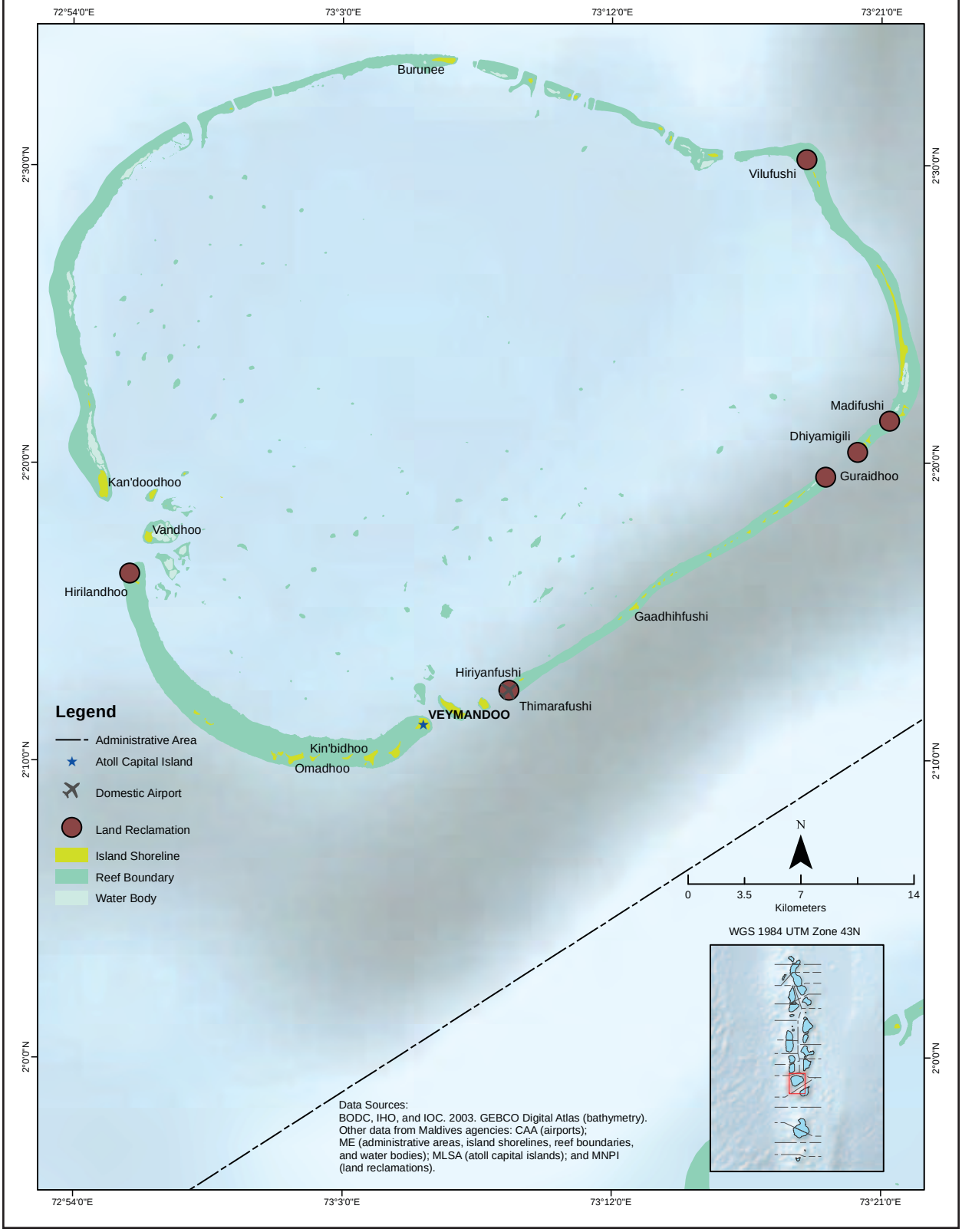


Map I.41: Shaviyani Atoll, Land Reclamation



Map I.42: South Malé Atoll, Land Reclamation

Map I.43: Thaa Atoll, Land Reclamation



Land Management

Land space is a necessary resource for development. Maldives has only less than 250 square kilometers (km^2) of land. With its limited available land, allocation of space for specific land use is a challenge. Currently, the country has more vegetated land cover (shrubs, herbs, forest, and palm trees) than built-up areas (high density urban areas, road, airport, and low density urban areas). Huge land is allocated for beaches (20.9 km^2) and island resorts (16.8 km^2). A small portion (6.7 km^2) is for agriculture. Other spaces are classified as inland water and wetlands (Table I.2).

Table I.2: Land Use and Land Cover, Maldives

Land Use and Land Cover	Area (km^2)	Percentage
Land Use		
High density urban areas	1.79	0.76
Roads	4.66	1.98
Airports	5.80	2.46
Harbors	7.32	3.11
Island resorts	16.78	7.12
Low density urban areas	29.62	12.56
Agricultural areas	6.65	2.82
Land Cover		
Inland waters	2.97	1.26
Wetlands	3.39	1.44
Barren, sparsely vegetated areas	8.88	3.77
Beaches and sand	20.85	8.84
Shrubs and/or herbaceous vegetation areas	36.07	15.30
Forests	40.86	17.33
Palm trees	50.10	21.25
Total	**235.74**	**100.00**

km^2 = square kilometer.

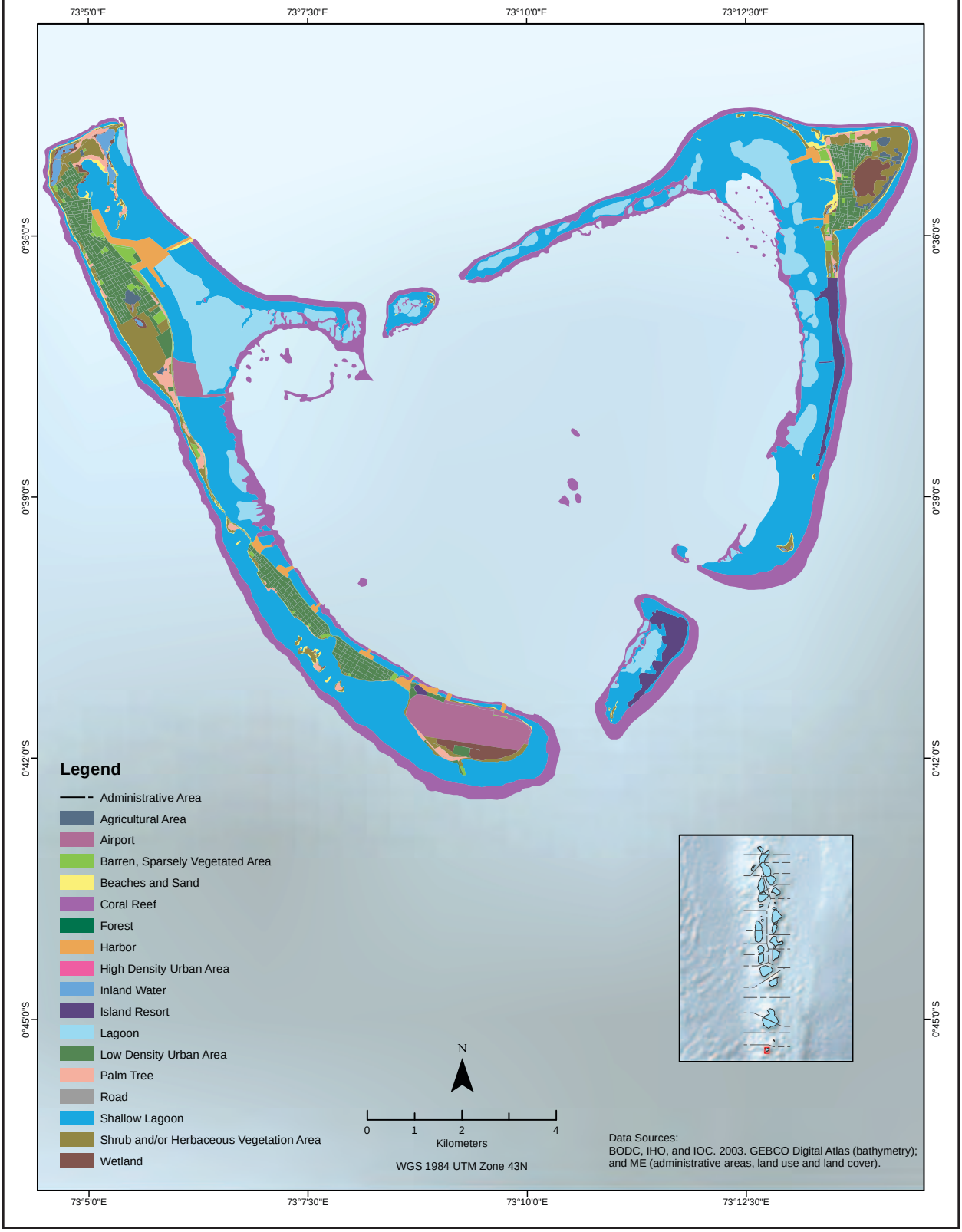
Note: Total may not add up due to rounding.

Source: Government of Maldives, Ministry of Environment, 2016.

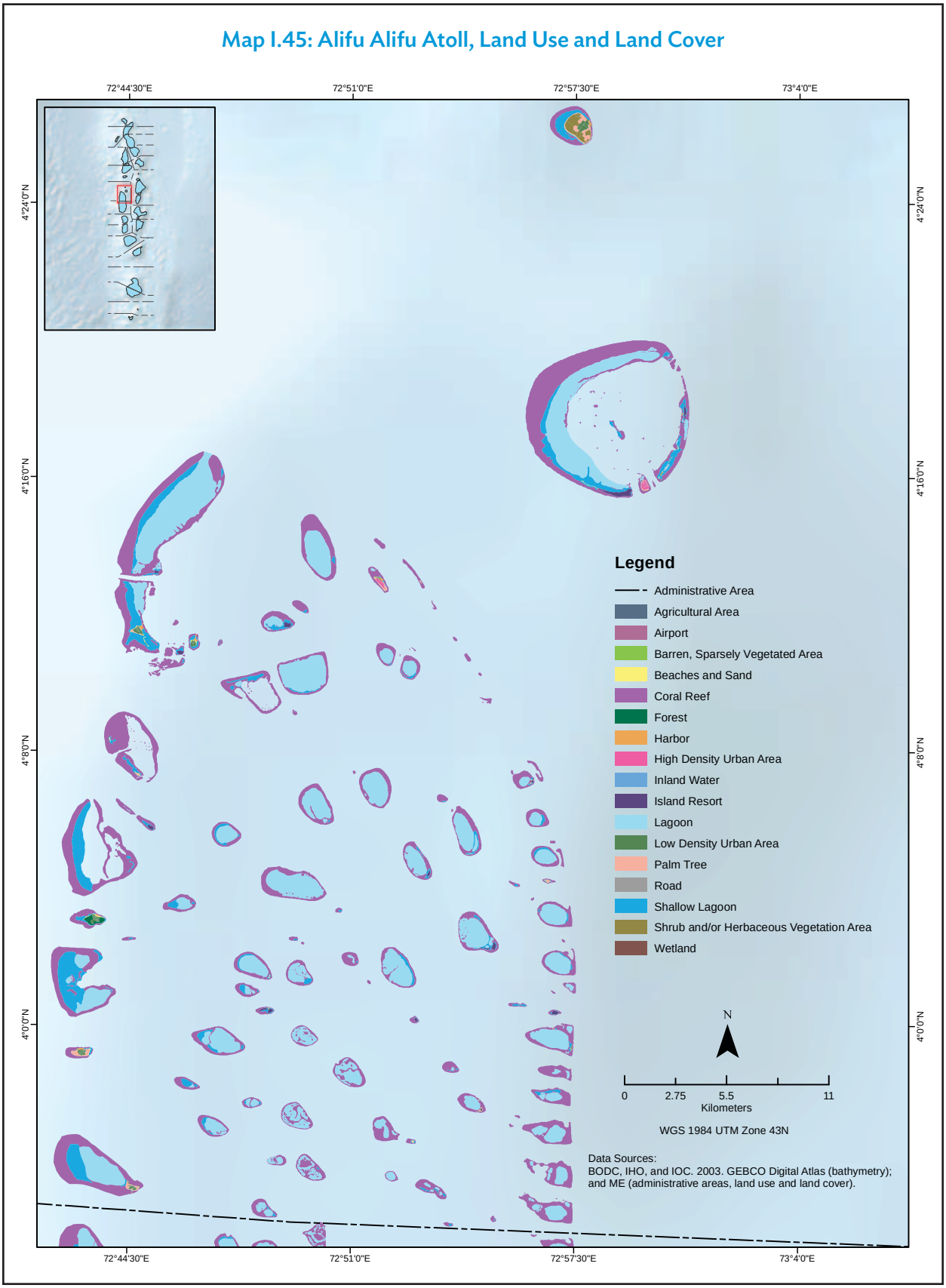
Land cover. Maldives' national tree, the palm tree, covers a fifth of the country's land area. Together with palm trees, forests and shrublands cover more than half of the country's land (photo by Shifaaz Shamoon).

Buildings stand next to one another along the narrow roads of Malé City in Maldives. Less than 1% of Maldives has high density urban land use classification (photo by Shahee Ilyas).

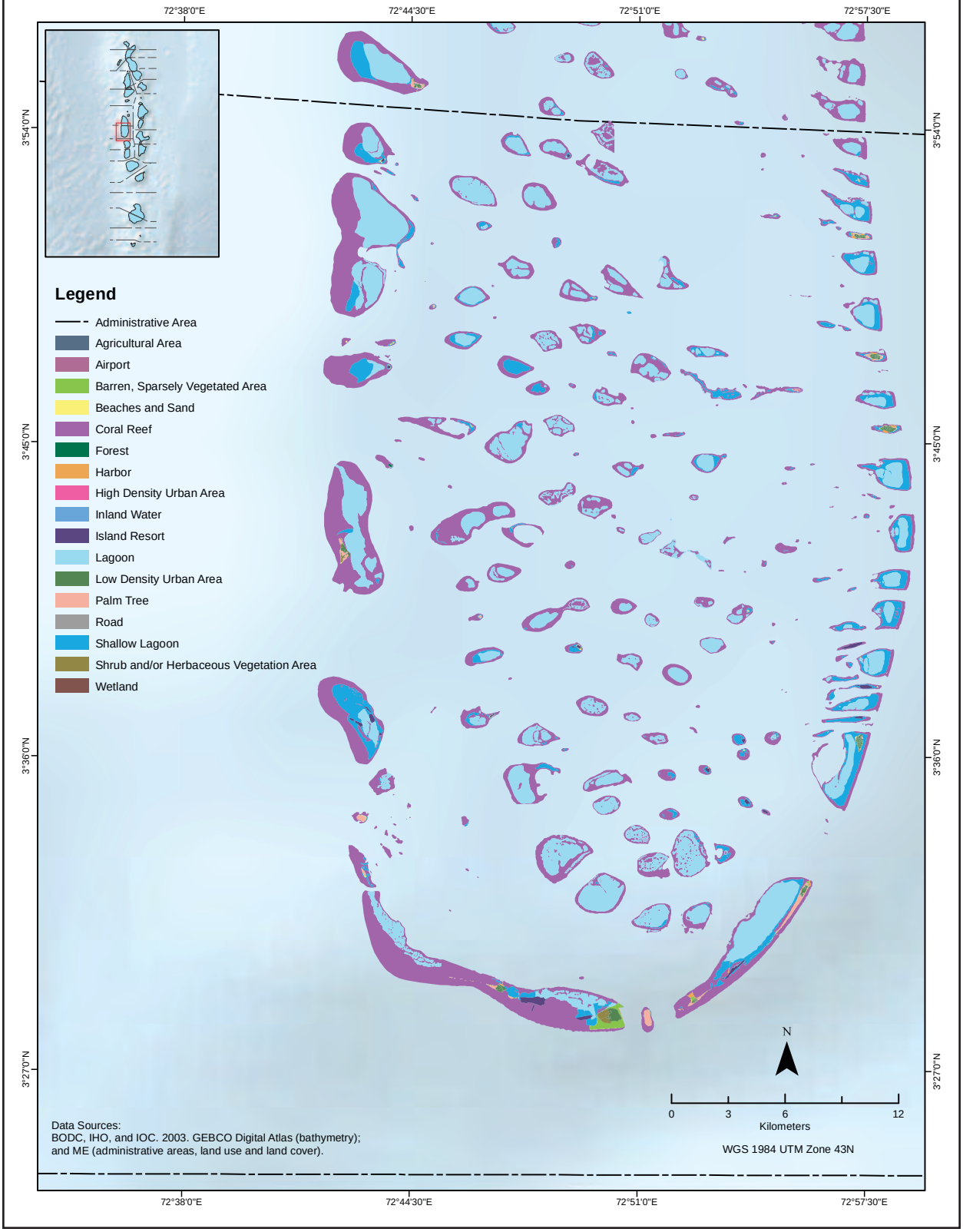
Map I.44: Addu City, Land Use and Land Cover



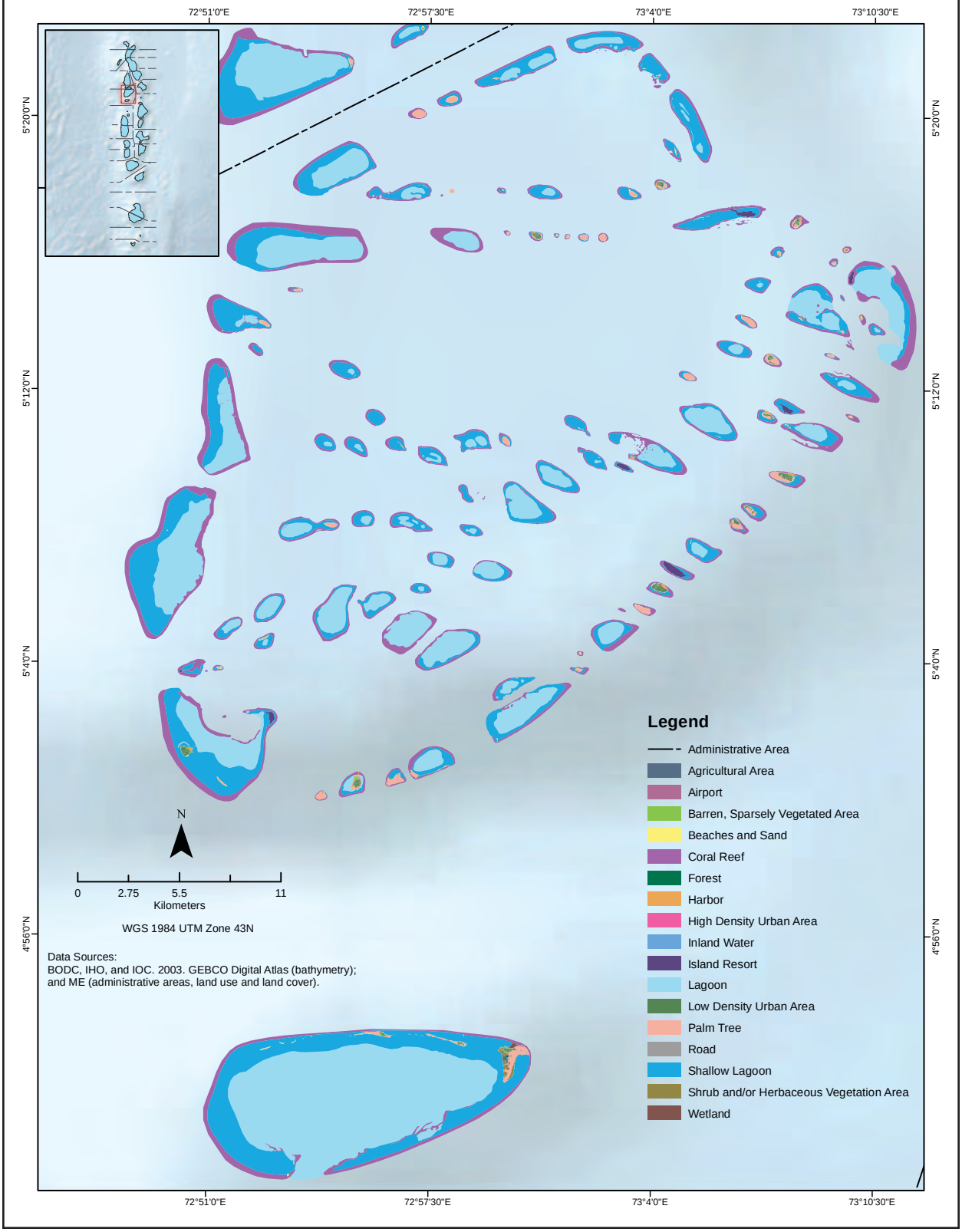
Map I.45: Alifu Alifu Atoll, Land Use and Land Cover



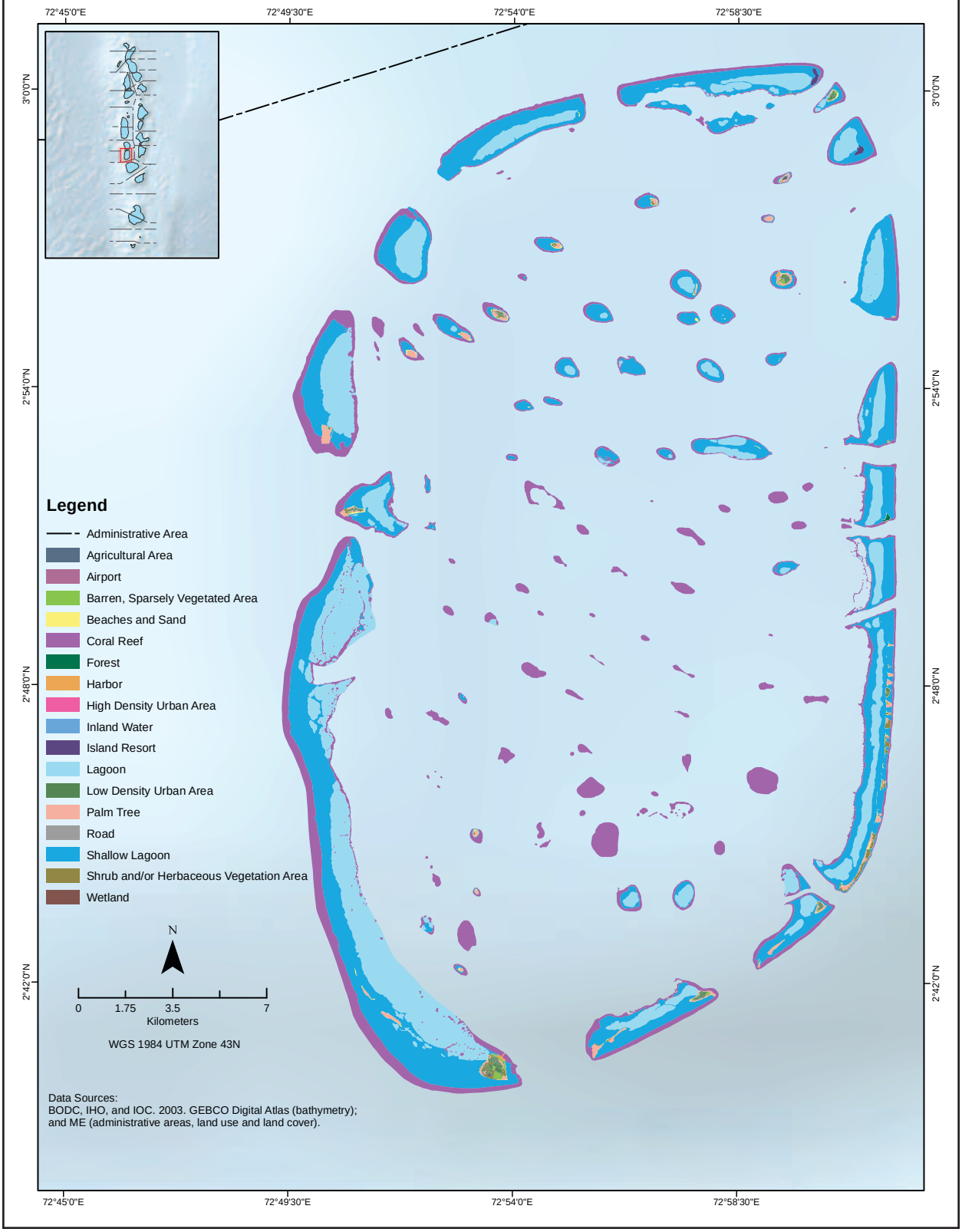
Map I.46: Alifu Dhaalu Atoll, Land Use and Land Cover



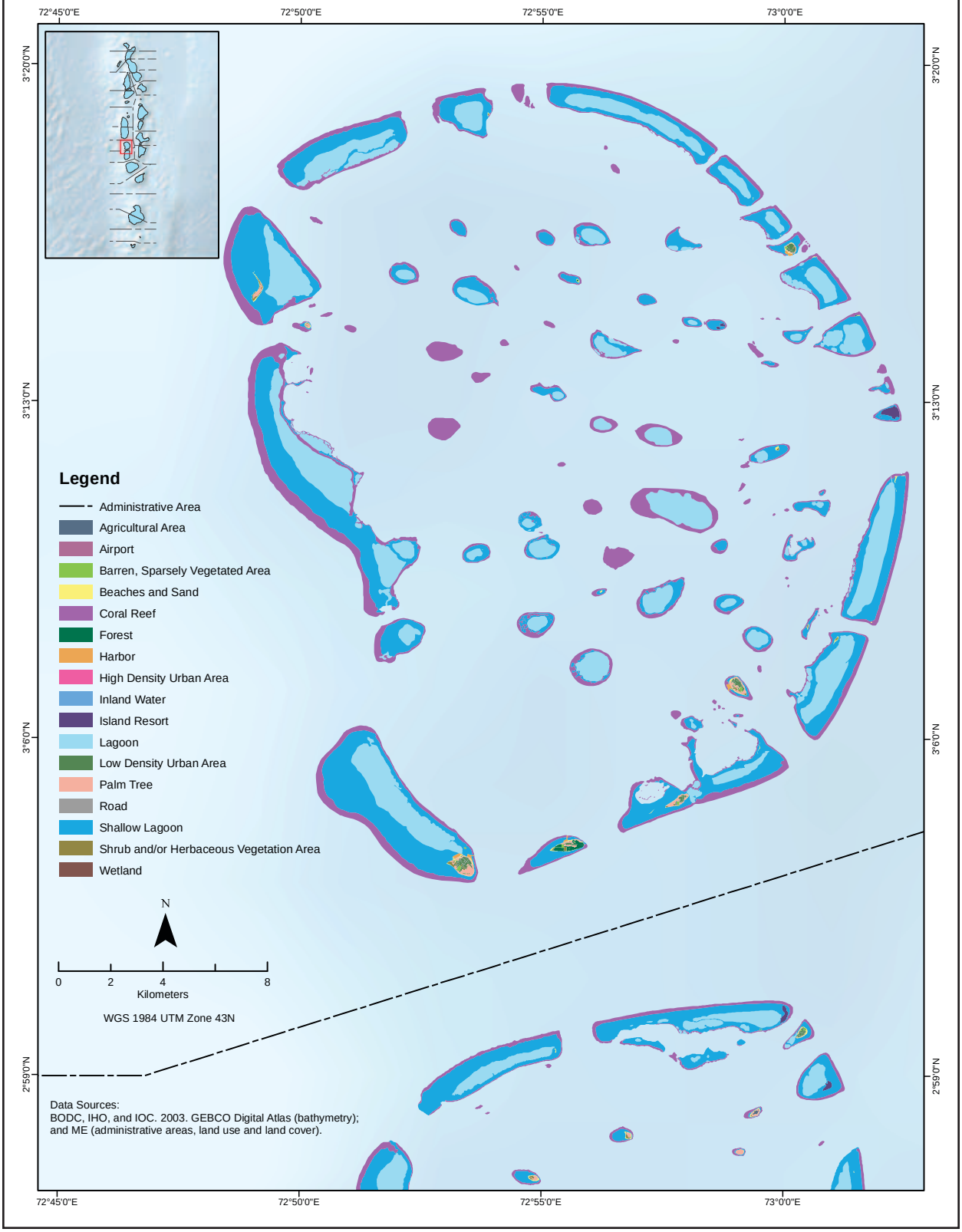
Map I.47: Baa Atoll, Land Use and Land Cover



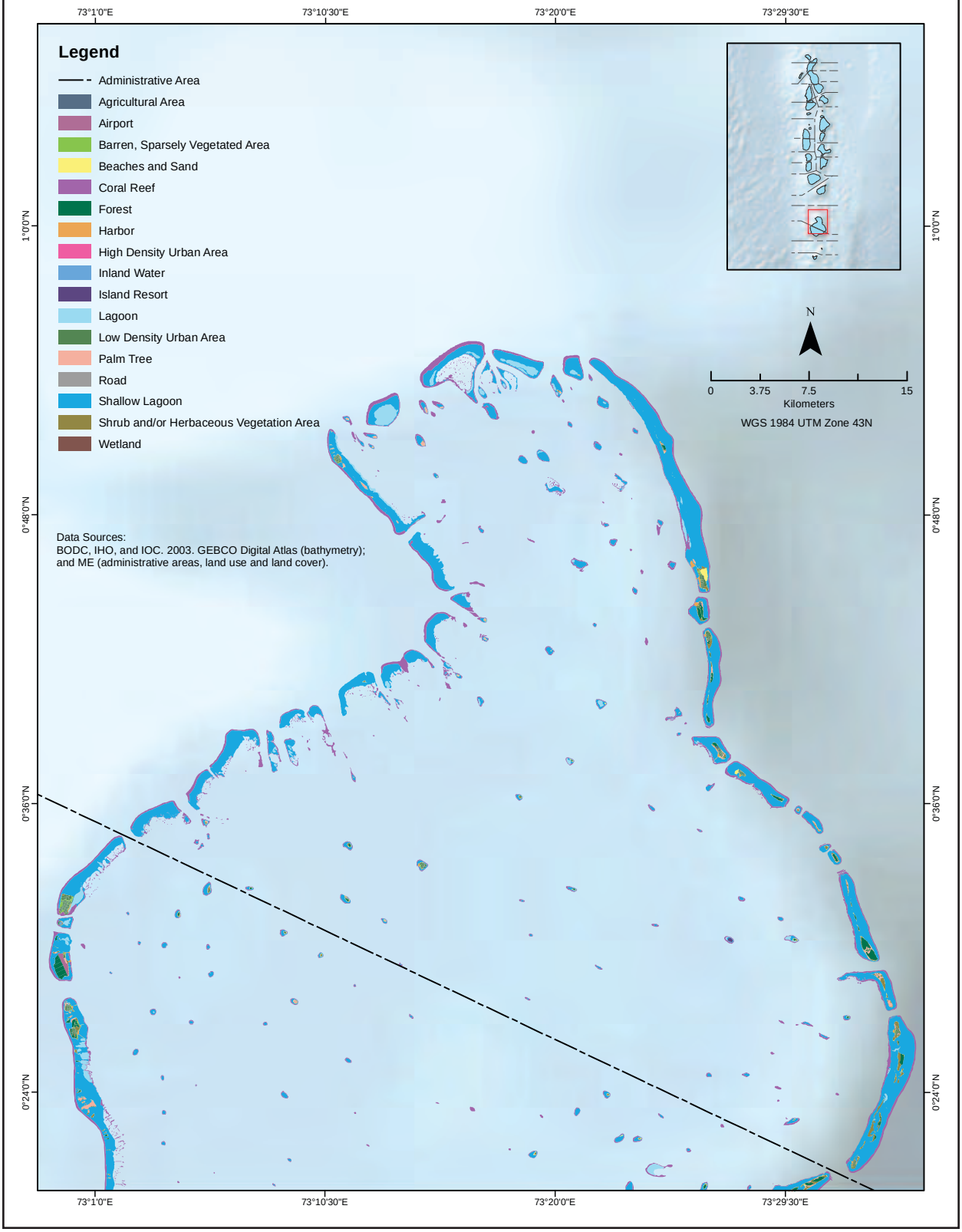
Map I.48: Dhaalu Atoll, Land Use and Land Cover



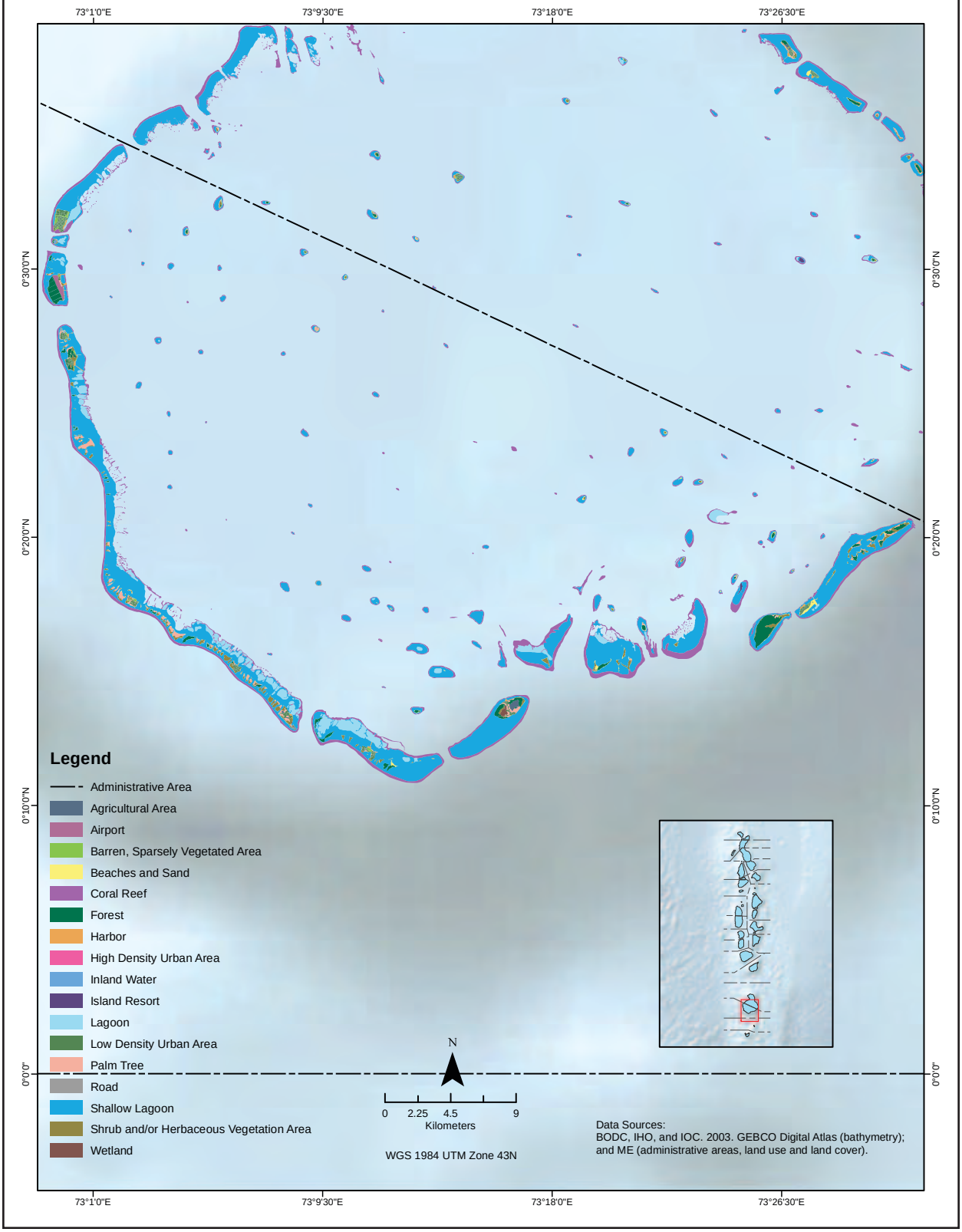
Map I.49: Faafu Atoll, Land Use and Land Cover



Map I.50: Gaafu Alifu Atoll, Land Use and Land Cover

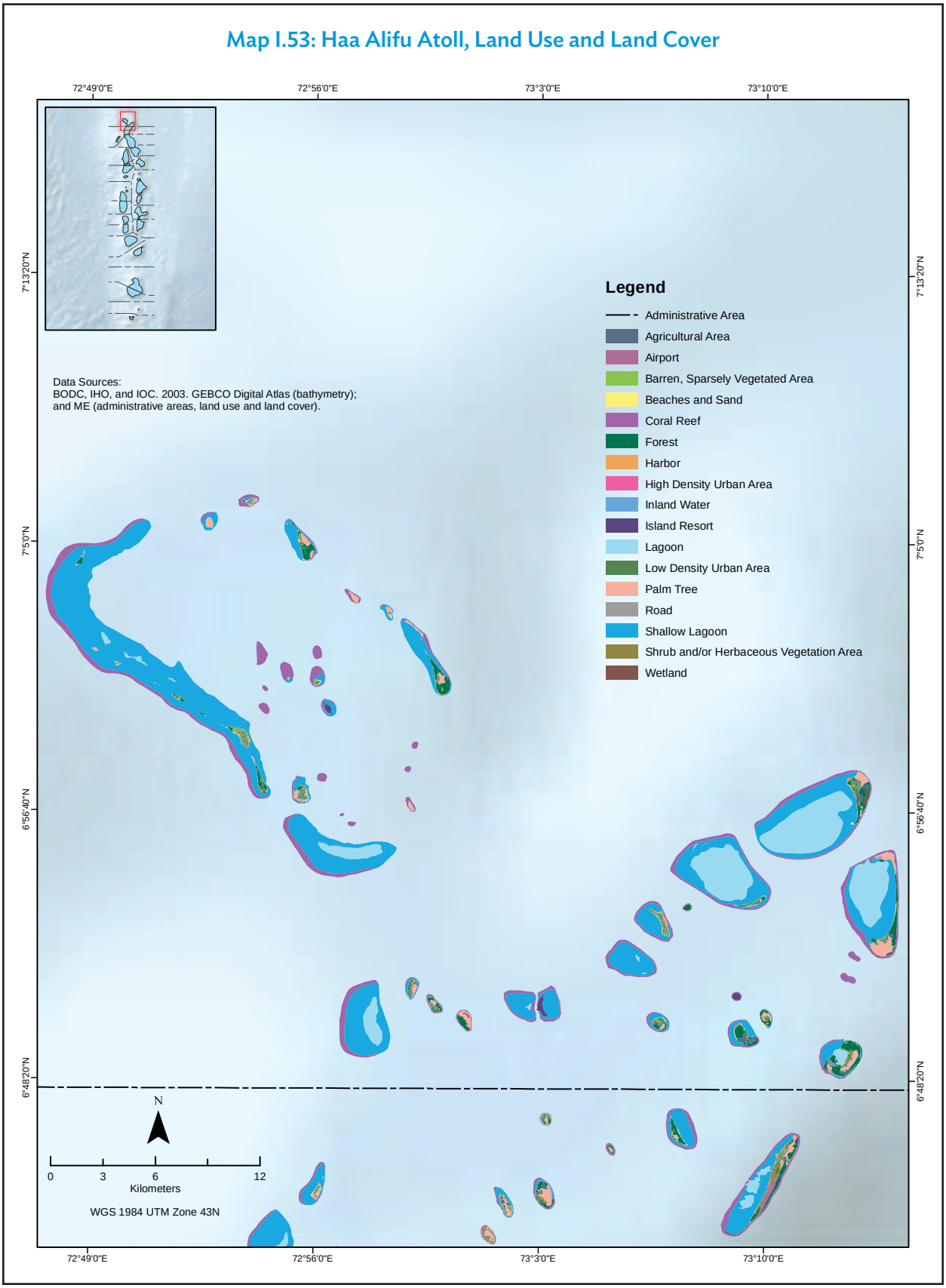


Map I.51: Gaafu Dhaalu Atoll, Land Use and Land Cover

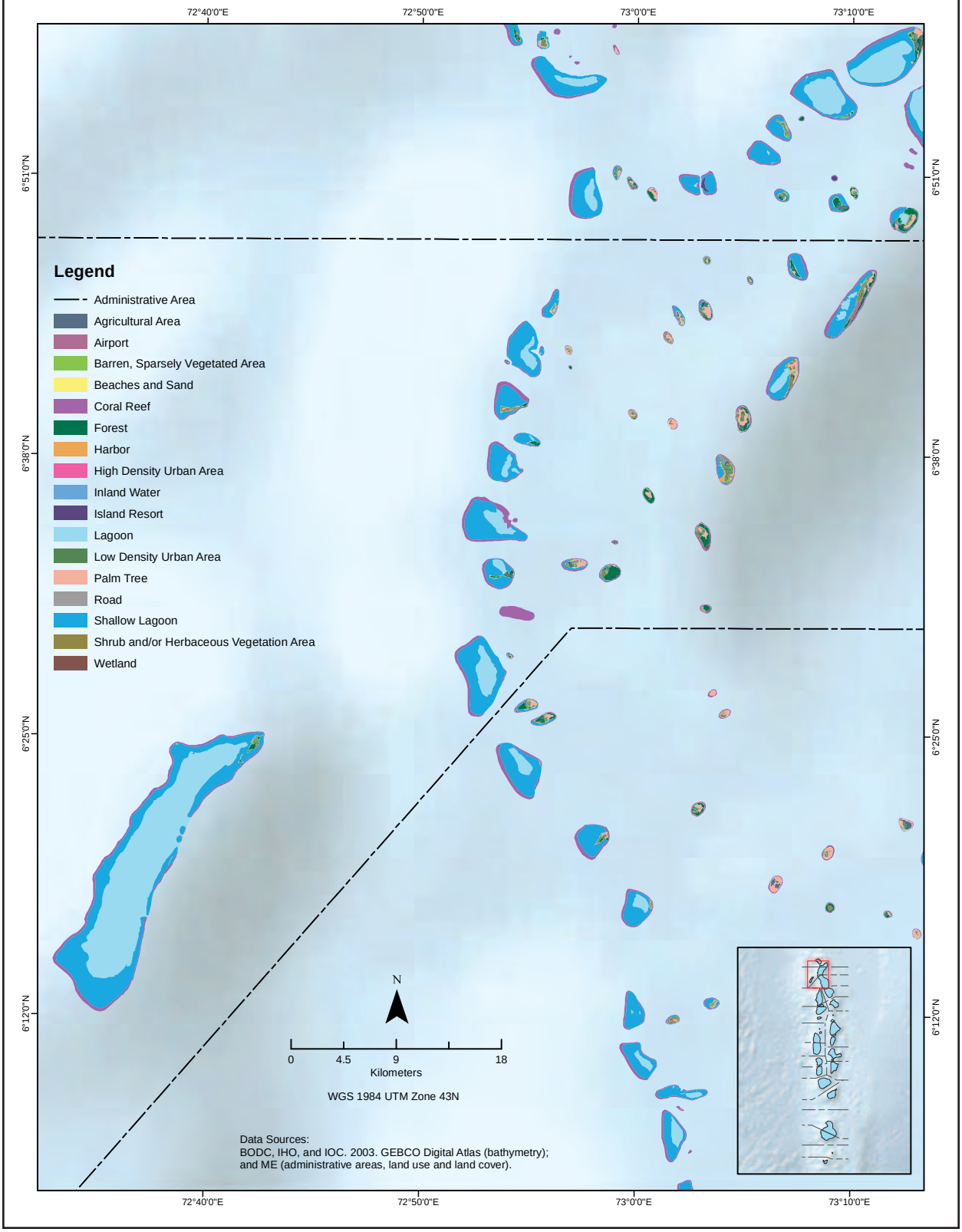


Map I.52: Gnaviyani Atoll, Land Use and Land Cover

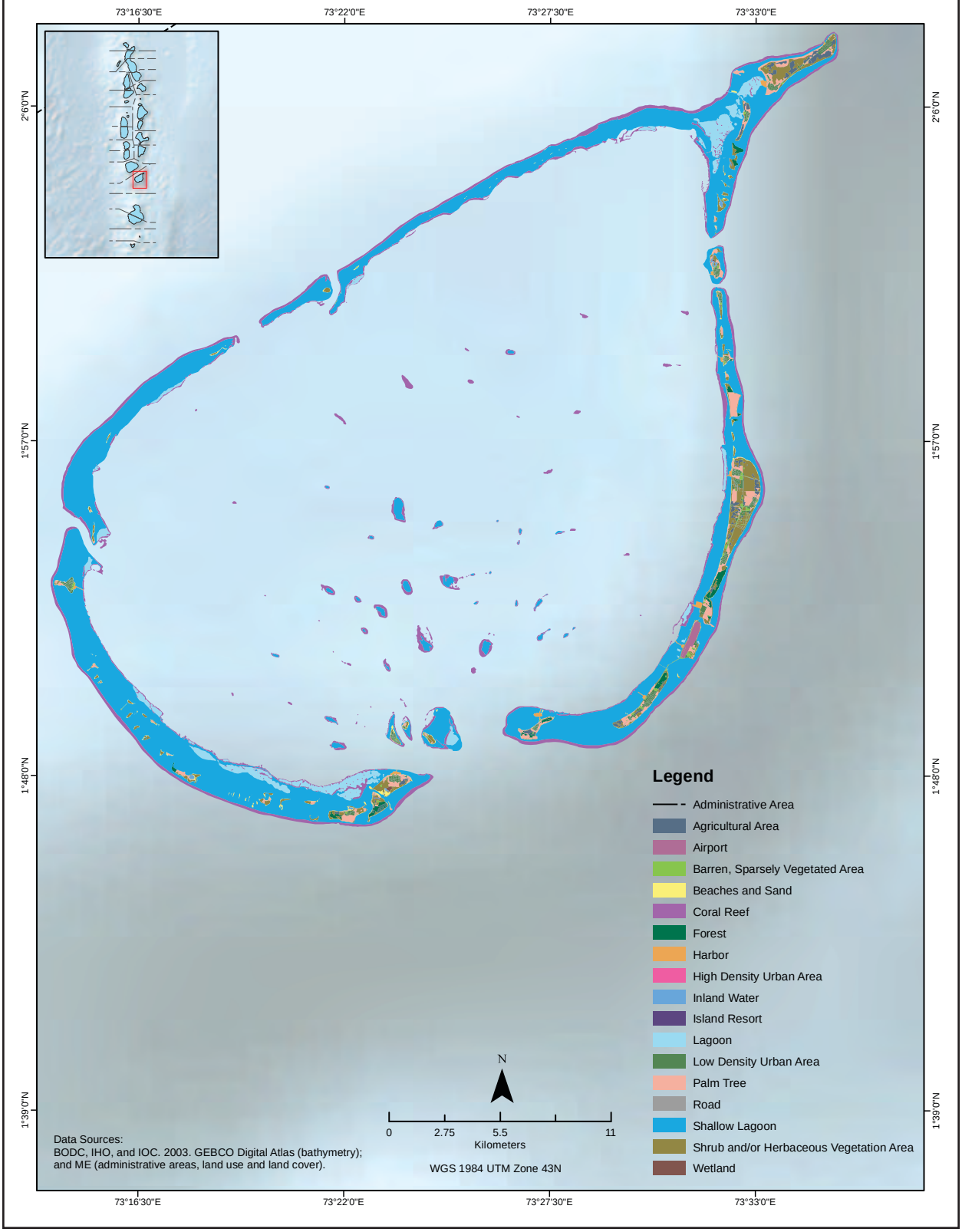
Map I.53: Haa Alifu Atoll, Land Use and Land Cover



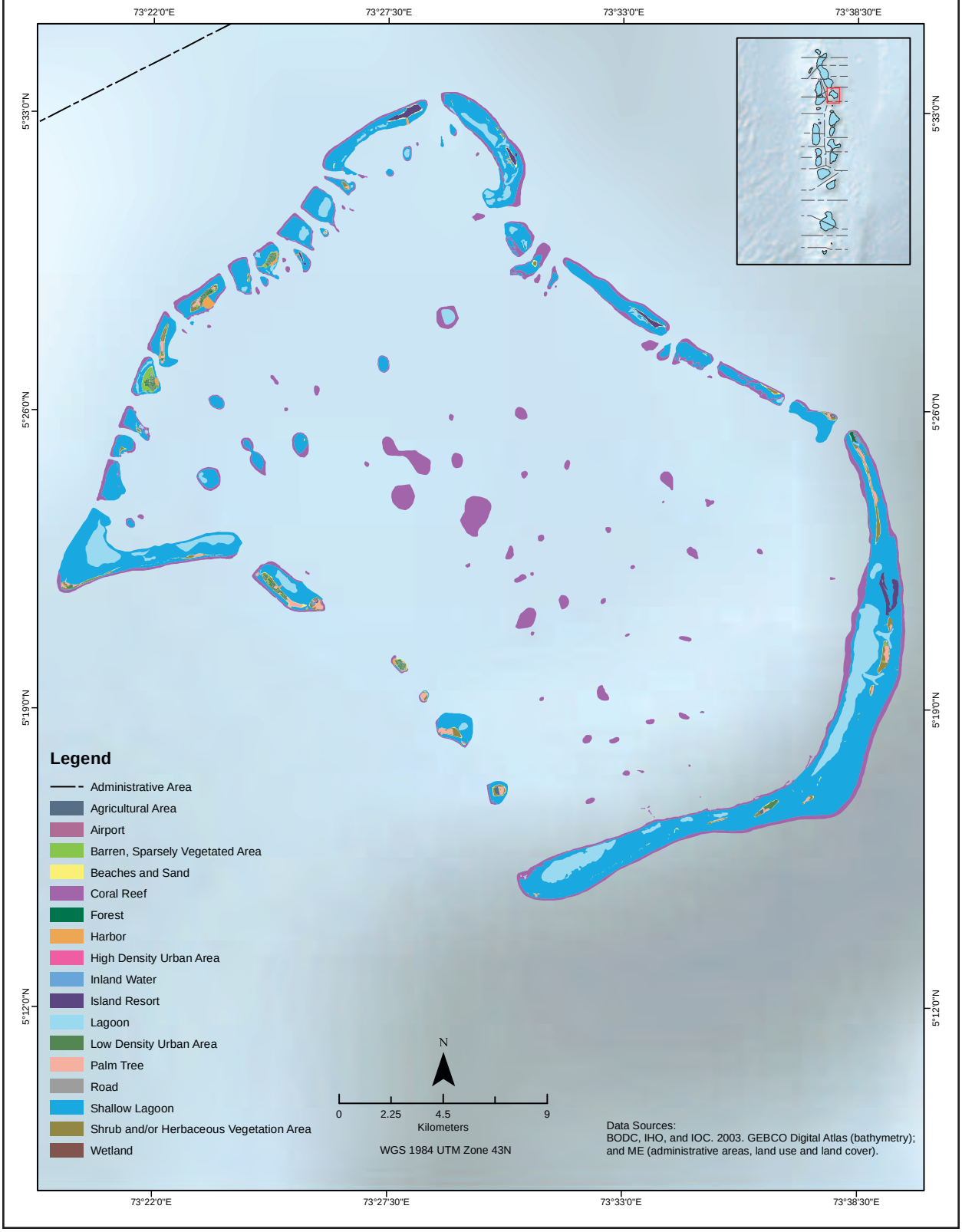
Map I.54: Haa Dhaalu Atoll, Land Use and Land Cover



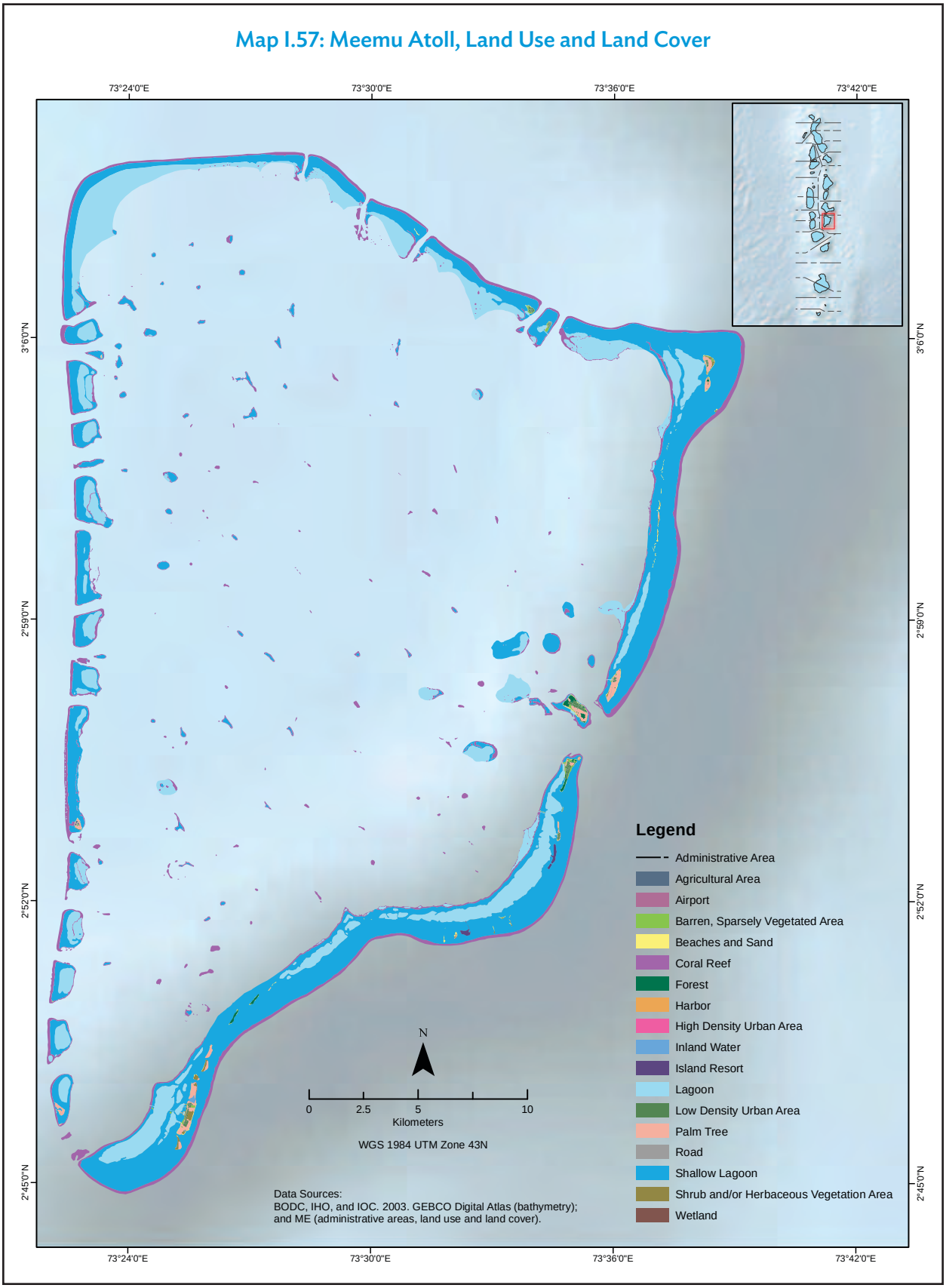
Map I.55: Laamu Atoll, Land Use and Land Cover



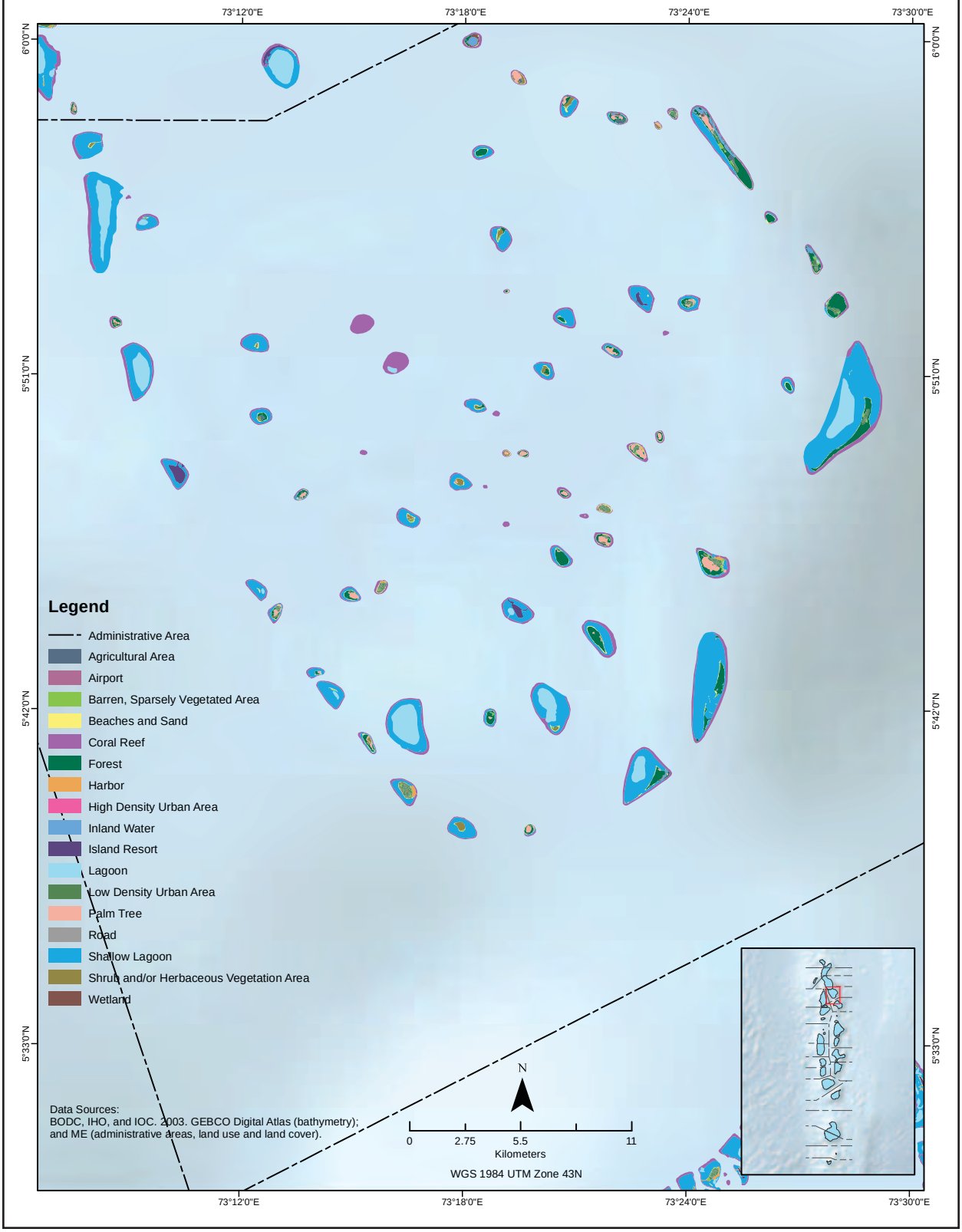
Map I.56: Lhaviyani Atoll, Land Use and Land Cover



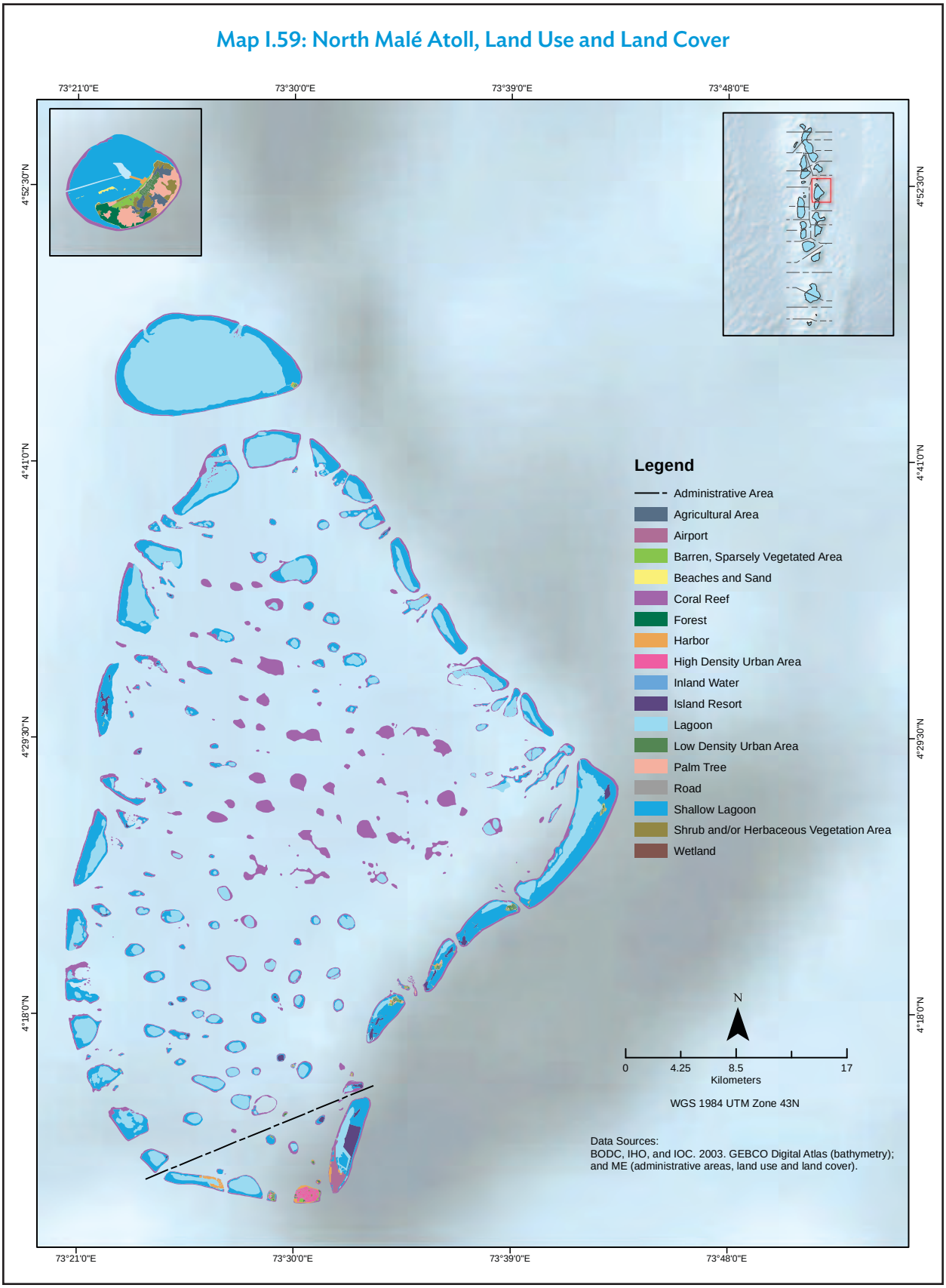
Map I.57: Meemu Atoll, Land Use and Land Cover



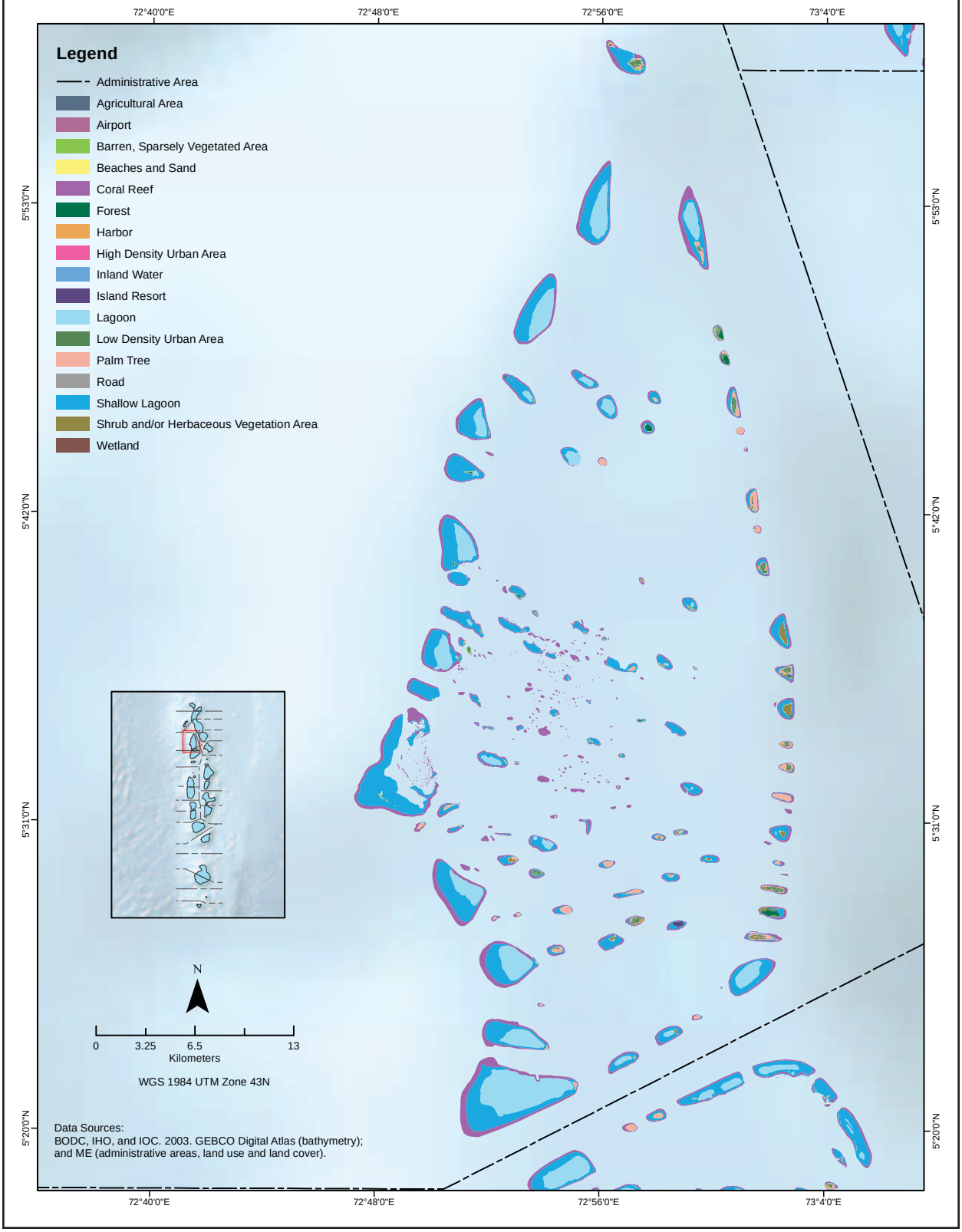
Map I.58: Noonu Atoll, Land Use and Land Cover



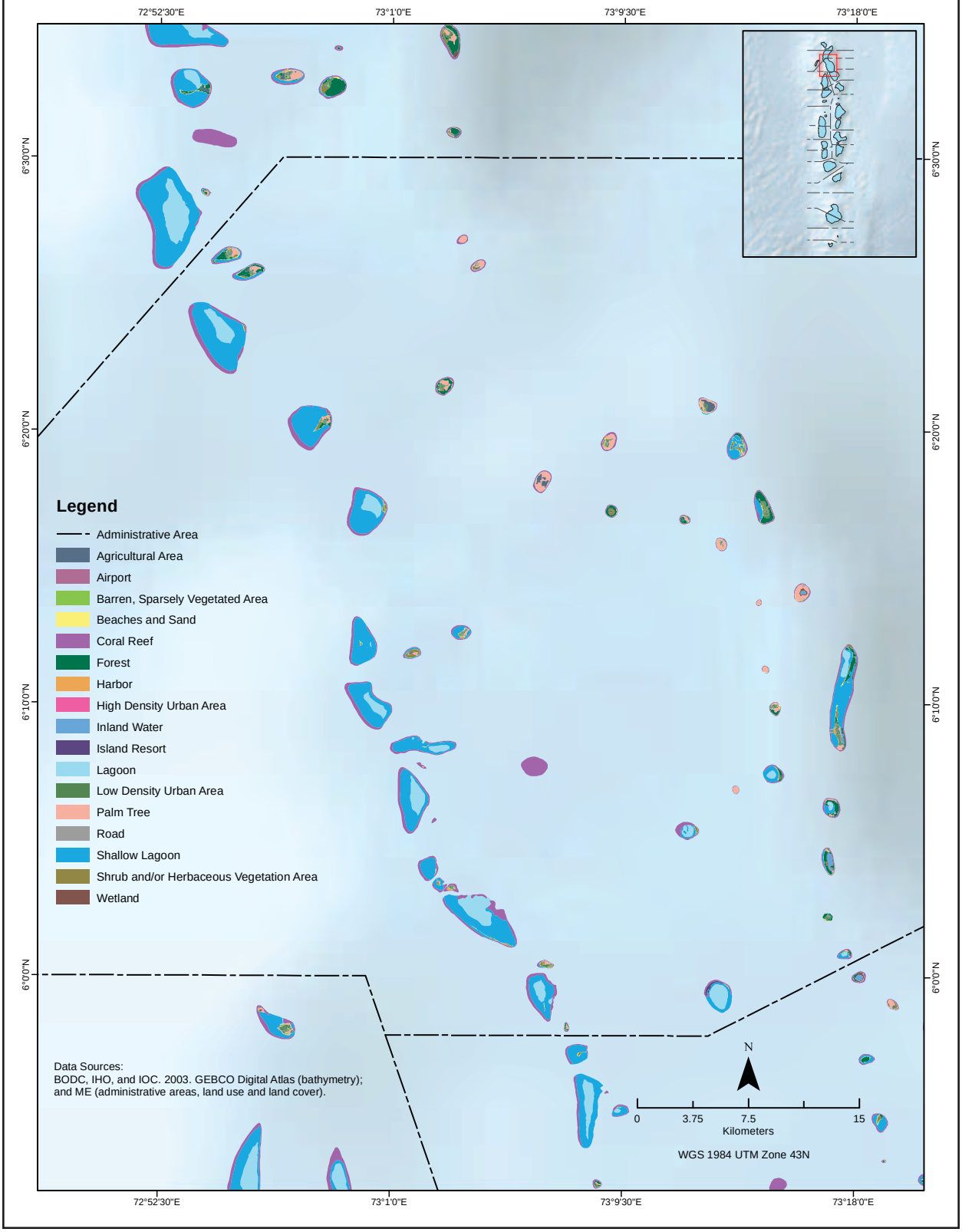
Map I.59: North Malé Atoll, Land Use and Land Cover



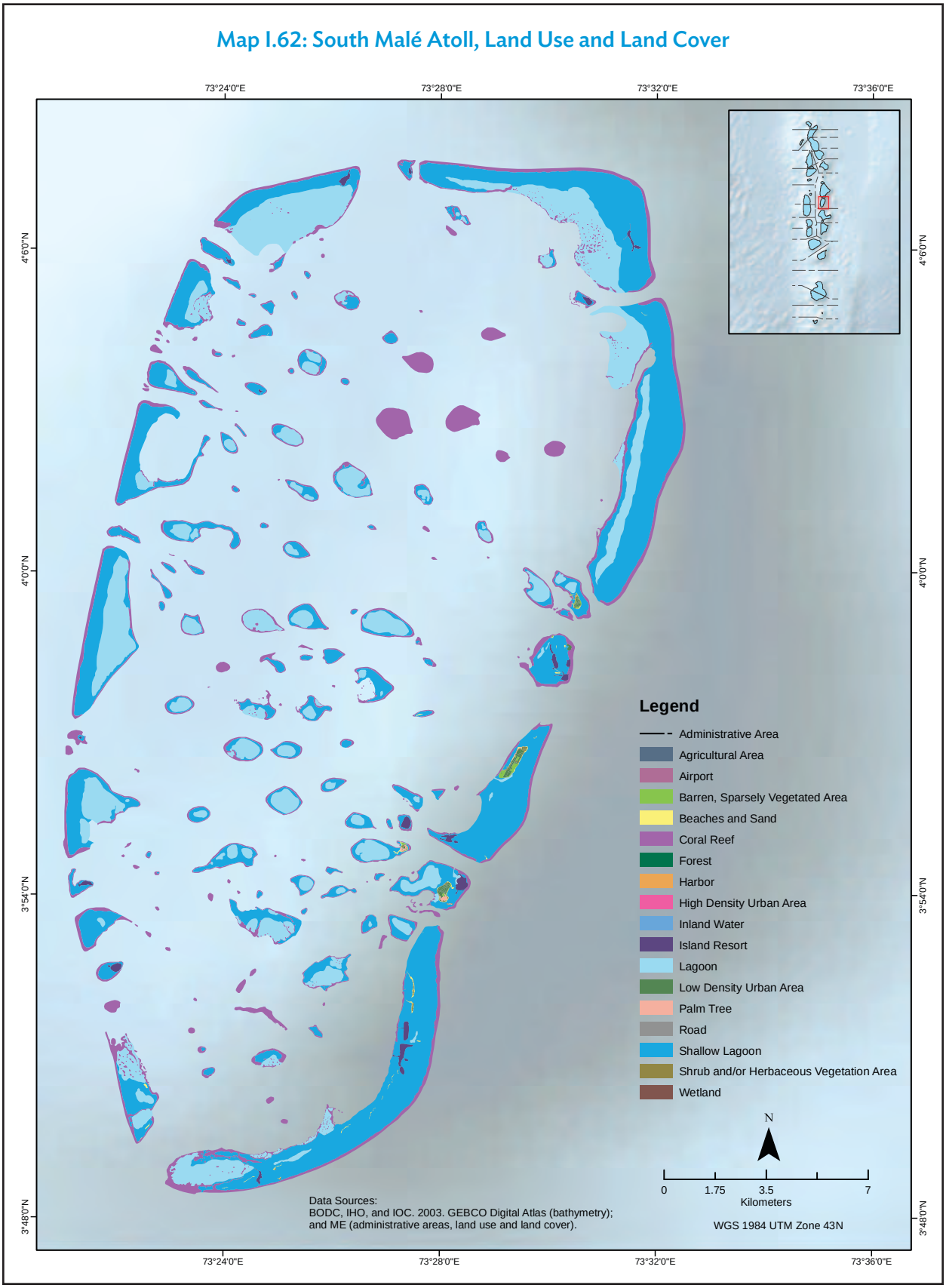
Map I.60: Raa Atoll, Land Use and Land Cover



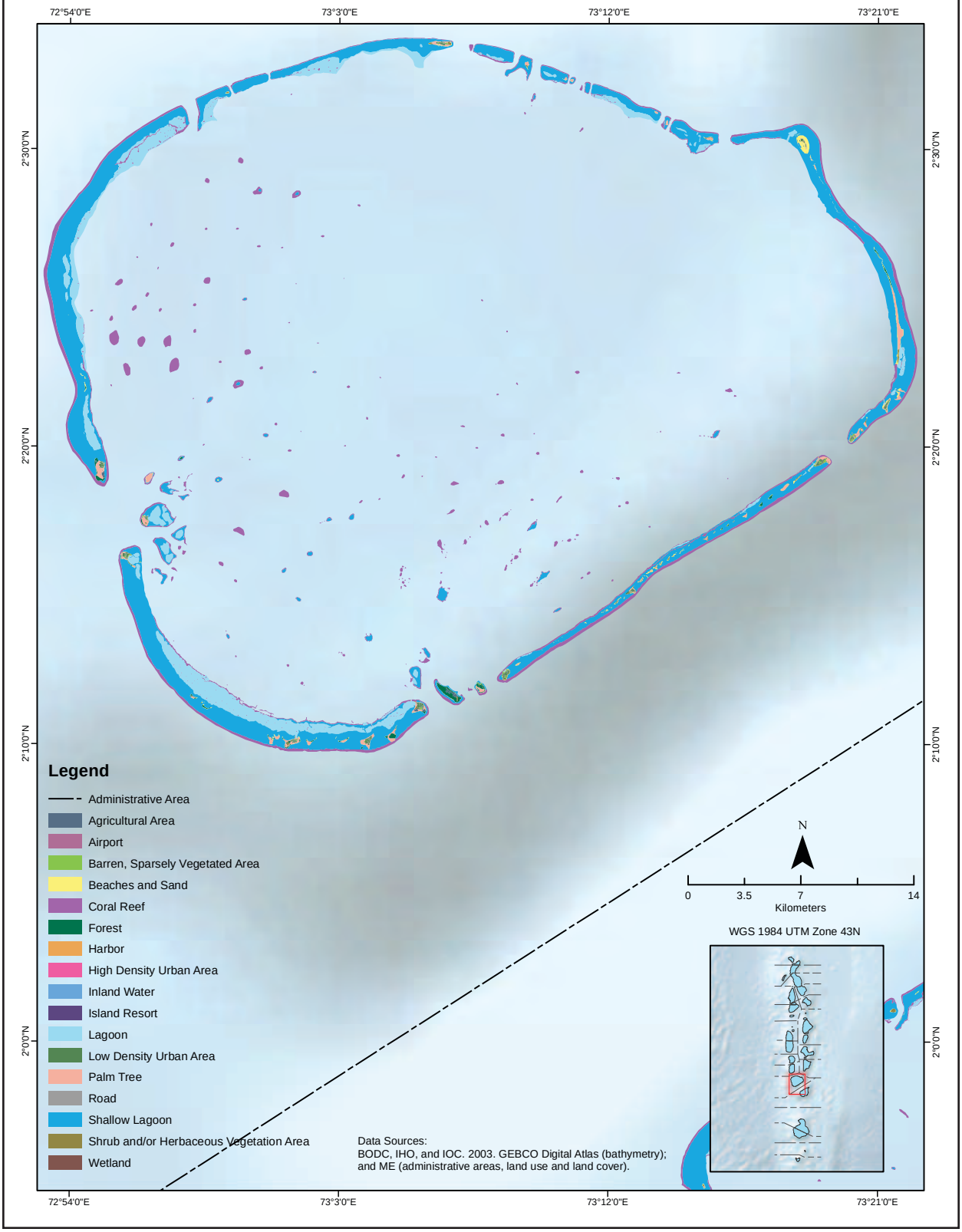
Map I.61: Shaviyani Atoll, Land Use and Land Cover



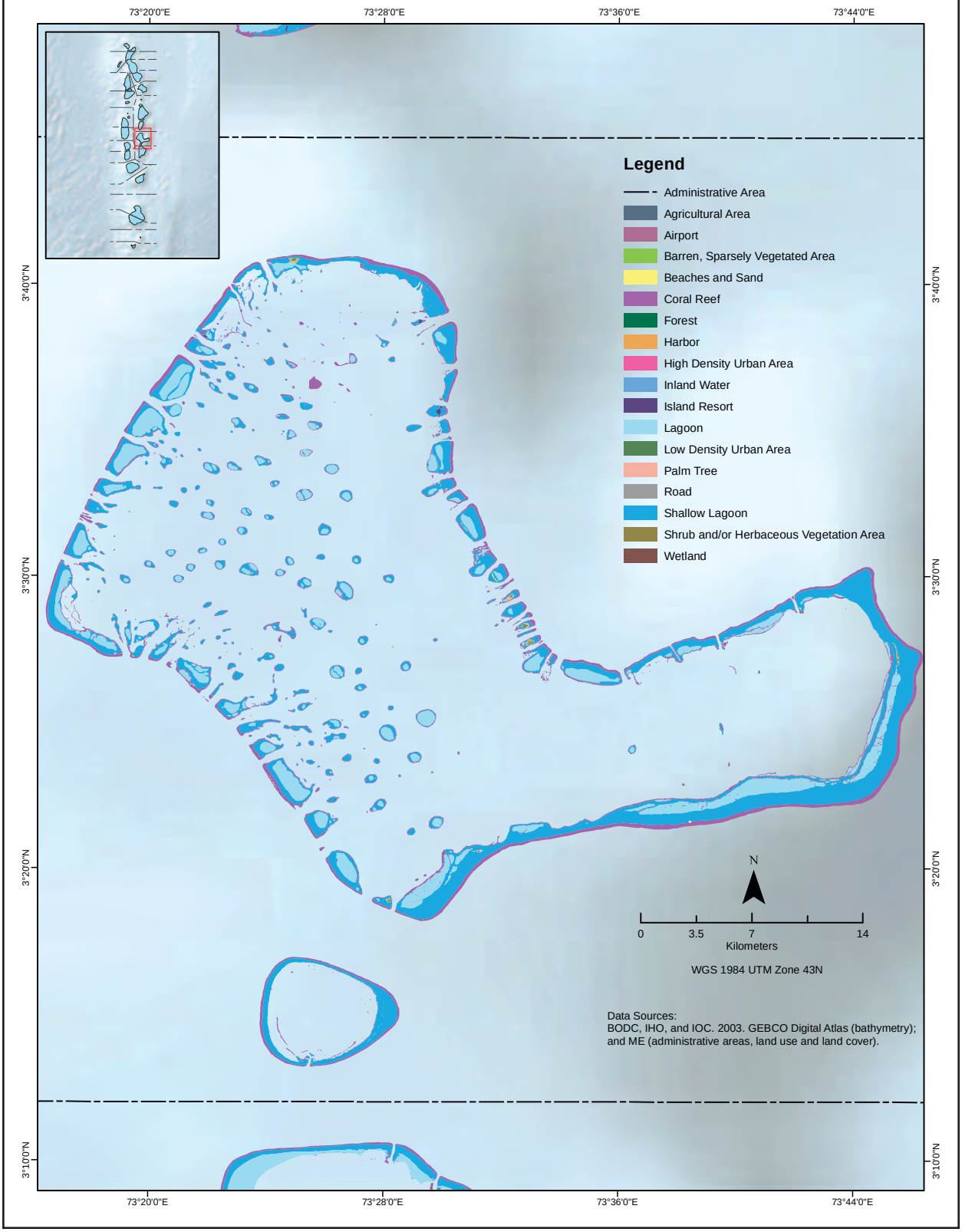
Map I.62: South Malé Atoll, Land Use and Land Cover



Map I.63: Thaa Atoll, Land Use and Land Cover



Map I.64: Vaavu Atoll, Land Use and Land Cover



Map Data Sources

Government Ministries, Departments, and Agencies in Maldives
- Civil Aviation Authority
  - Airports
- Land and Survey Authority
  - Atoll capital islands
  - Cities
- Ministry of Economic Development
  - Ports
- Ministry of Environment
  - Administrative area
  - Administrative atoll
  - Island shorelines
  - Land use and land cover
  - Reef boundaries
  - Water bodies
- Ministry of National Planning and Infrastructure
  - Land reclamation

References

Asian Development Bank. 2017. *Climate Risk Screening for Mainstreaming Climate Change Adaptation into Development Activities and Policies in the Maldives.* Consultants' report. Manila (TA 8572-REG).

Ahmed, M., and S. Suphachalasai. 2014. *Assessing the Costs of Climate Change and Adaptation in South Asia.* Manila: Asian Development Bank, UK Aid.

British Oceanographic Data Centre (BODC), International Hydrographic Organisation (IHO) and the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization. 2003. *General Bathymetric Chart of the Oceans (GEBCO) Digital Atlas.* UK: British Oceanographic Data Centre.

Khan, T., D. Quadir, T. Murty, A. Kabir, F. Aktar, and M. Sarker. 2002. Relative Sea Level Changes in Maldives and Vulnerability of Land Due to Abnormal Coastal Inundation. *Marine Geodesy* 25 (1–2). pp. 133–143.

Waheed, M., and H. Shakoor. 2015. The Impact of the Indian Ocean Tsunami on Maldives. In C. Bassard, D. W. Giles, and A. M. Howitt, eds. *Natural Disaster Management in the Asia-Pacific: Policy and Governance.* pp. 49–68. New York: Springer.

Maps were prepared by the Country Consultant Team and the Manila Observatory on behalf of the Asian Development Bank.

Multihazard Risk Atlas of Maldives

Geography—Volume I

This atlas provides spatial information about Maldives and thematic maps necessary for assessing future development investments in terms of climate risks and geophysical hazards. It is also intended to support the formulation of cobeneficial options for climate change adaptation and disaster risk reduction and management. The five-volume atlas is a major output of the project "Establishing a National Geospatial Database for Mainstreaming Climate Change Adaptation into Development Activities and Policies in Maldives" under the Asian Development Bank's regional knowledge and support (capacity development) technical assistance Action on Climate Change in South Asia (2013–2018).

The *Multihazard Risk Atlas of Maldives* is composed of *Geography—Volume I, Climate and Geophysical Hazards —Volume II, Economy and Demographics—Volume III, Biodiversity—Volume IV, and Summary—Volume V.*

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