7.10 Madagascar

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Capital city	Antananarivo
Population (2005 est.)	18,600,000 (2.6% growth)
GDP per capita (USD 2005 est.)	$923
Life expectancy at birth (2005 est.)	58 4 years (male - 56.7, female - 60.1)
Land and water area	587,040 km^2 (land - 581 540, water - 5 500)
Length of coastline	4 828 km
Highest point of elevation	Maromokotro, 2 876 m
Coral reef area (2001 est.)	2 230 km^2
Mangrove area (2005 est.)	303,814 ha
Marine protected areas (2007 est.)	121.84 km^2 (0.10% of total territorial waters)
Capture fisheries prod. (2006 est.)	134,417 metric tones
Aquaculture fisheries prod. (2006 est.)	11,213 metric tones

Geographic Location: Located in the southern hemisphere between latitudes 10°S and 30°S, and longitudes 40°E and 50°E, the Tropic of Capricorn crosses the southern part of the "Great Island" Madagascar. Madagascar is separated from Africa by the Mozambique Channel and bounded by the Indian Ocean to the south, north and east.

Rivers to the Country's Coast: The Mananara and Mangoro rivers flow from the central highlands to the east coast, as does the Maningory, which flows from Lake Alaotra. Other rivers flowing east into the Indian Ocean include the Bemarivo, the Ivondro, and the Mananjary. These rivers tend to be short because the watershed is located close to the east coast. Owing to the steep elevations, they flow rapidly, often over spectacular waterfalls. The rivers flowing to the west coast and emptying into the Mozambique Channel tend to be longer and slower, because of the more gradual slope of the land. The major rivers on the west coast are the Sambirano, the Mahajamba, the Betsiboka (the port of Mahajanga is located at the mouth), the Mania, the North and South Mahavavy, the Mangoky, and the Onilahy. The Ikopa, which flows past Antananarivo, is a tributary of the Betsiboka. The Mangoky River has a basin area of some 50,000 km^2, the Ikopa River and the Betsiboka River have basin areas of 18,550 and 11,800 km^2 respectively. The principal

river in the south, the Mandrare, has a basin area of some 12,435 km^2, but it runs dry during certain months in this desert region.

Coastal Climate: The climate is generally tropical along the coast, temperate inland and arid in the south. There are two seasons in Madagascar – hot and rainy from November to April and cooler and dry from May to October. The island occasionally experiences cyclones.

Coastal Geomorphology: The coastal zone is mainly made up of sedimentary rock. The west coast has a wide continental shelf with maximum width around 90 km. It is characterized by the presence of estuaries and fringing coral reef attenuating wave energy. About 300,000 ha are occupied by mangroves and the total length of coral reef is around 1 000 km, whereas the east coast is very straight and has a narrow continental shelf with few estuaries. Coral reef is absent and waves break directly on the coastline.

Coastal Currents and Tides: Data from tide gauges show a semi-diurnal tide for west and east coast. The average tide range for the west coast is around 3.2 m while for the east coast is about 0.30 m. Only a few investigations are done concerning the coastal currents. However, the results of current measurements carried out on the north west coast show the influences of the tide and the wind on coastal current pattern.

Coastal Observations: During French domination up to 1960, some sea level measurements were made for some harbours: Nosy-Be, Antsiranana in the North and Toamasina in the East of Madagascar. The mean sea level was defined for each harbour as well as the major component of the tide. Therefore, a tide table is produced every year by the Service Hydrographique et Océanographique de la Marine (SHOM) in Brest for Nosy-Be, Antsiranana, Toamasina and some other harbours.

Operational and recorded data:

Nosy-Be Tide gauge: Observed and predicted data are available from the Centre National de Recherches Océanographiques. Analog data from charts are available from 1987 up to now. However, there are some gaps due to some technical problems. Raw hourly observed data is available in TOGA Sea Level Centre (TSLC) format from 1992 to 1996. Quality controlled data are available from 1992 to 1994 in TSLC format. Hourly predicted data are available from 1996 to 2000 in TSLC format. Predicted high and low tide are also available from 1996 to 2000.

Taolagnaro Tide gauge: Only raw analog data on charts are available at the Centre National de Recherches Océanographiques up to 1989 with many gaps which are due to some technical problems.

Toliara Tide gauge: Raw analog data on charts are available at the Foibe Taosarintanin'i Madagasikara from 1991 to 1993. Digitized data are available at MD NODC for the years 1963 and 1964.

Coastal Economy: The coastal economy is mainly based on fishery activities, mineral and offshore oil resources exploitation. Recently, seafood processing industries are developing and since 2004 tourism (including eco-tourism) has become progressively more important. Malagasy Government encourages development of shrimp aquaculture and suitable habitats are increasingly used by the private business sector. Because of relatively low population densities and availability

Figure 1. Mangroves swamp of the Bombetoka bay in the northwest coast. Approximately 3 200 tones of lime are produced per year by 27 family of Belobaka village (image source: CIREEF Mahajanga).

of wood from other sources, direct harvesting of the mangrove trees has been relatively low with the exception of some areas, particularly Mahajanga and Toliara (Rasolofo 1993). However, demographic trends suggest this situation could change in the future (Spalding et al. 1997).

Fisheries: Despite the island's long coastline, fishing is a relatively under-developed industry in Madagascar. On the east coast, stormy seas and a lack of harbours mean that fishing is restricted mainly to coastal lagoons. There are approximately 52,000 artisanal fishers in Madagascar. The total catch in 2000 was estimated at 132,093 tones, of which 30,000 tones were caught in inland waters. Vessels from the European Union are licensed to catch up to 11,000 tones of tuna and prawns in Madagascan waters each year.

Mineral Resources: Madagascar has a number of natural resources, including graphite, chromite, coal, bauxite, salt, quartz, tar sands, semi-precious stones and mica. There are also fishing areas offshore, and potential for hydropower. In 2001, it was estimated that 5.07% of the land area was used for arable land, 1.03% had permanent crops.

Figure 2. Satellite dish for VSAT link installed at IHSM with ODINAFRICA support.

Due to slash and burn agriculture, only 26% of the land remains forested.

Agricultural Products: Agriculture, including forestry, accounts for more than one quarter of GDP and employs 80% of the population. Some of Madagascar's main agricultural products are coffee, vanilla, sugarcane, cloves, cocoa and rice. However, deforestation and erosion are serious concerns for farmers. Key industries are meat processing, seafood, soap, breweries, tanneries, sugar, textiles, glassware, cement, automobile assembly, paper, petroleum and tourism.

Other Marine Resources: Madagascar's long coastline, east and west facing coasts, large latitudinal range and 'upstream' location in relation to eastern and southern Africa provide suitable environments for most of the marine species and habitat-types of the region. The coastal waters host an impressive array of marine life, supporting populations of humpback whales, dolphins, marine turtles and over 56 species of sharks. However, many of Madagascar's endemic sea creatures are seriously endangered as a result of deforestation, habitat loss, overfishing and the introduction of exotic predators.

Addressing Key Coastal Issues: The principal marine and coastal environments of south-western Madagascar are mangroves, estuarine mud flats, beaches, coral reefs and seagrasses. Of the 3 540 km of reef systems surrounding the island of Madagascar, the majority are found on the west coast which has 90% of the island's coral reefs and 98% of its mangroves. In contrast, the east coast is dominated by steeply shelving beaches and rocky shores. The reef structures present in south-west Madagascar are emergent fringing reefs, true barrier reefs, patch reefs and submerged coral banks and shoals comprising 113 km of fringing reef, 557 km of reefs around islands and inlets, and patch reefs, 52 km of true barrier reefs (all in the Toliara region), and 1 711 km of submerged coral banks and shoals.

On Madagascar, mangroves are found primarily along the western coast. They occur in a wide range of environmental and climatic conditions, fostered by a low coastal platform, high tidal range, and a constant freshwater supply from numerous rivers that also bring a high silt load which is deposited along the coast (CEC 1992, Rasolofo 1993). The largest mangrove stands are found at Mahajamba Bay,

Bombetoka, south Mahavavy and Salala, and Maintirano (Spalding et al. 1997). Mangroves occupy a stretch of coastline of approximately 1 000 km in length where they are often associated with coral reefs, which protect the mangroves from ocean swells. The southern part of Madagascar has fewer mangroves because, in addition to having a longer dry season and lower rainfall, it is subject to intensive ocean swells and lacks the necessary alluvial sediments deposited by major river systems. This latter point is especially true of the eastern side of the island.

Mangroves are threatened by development of urban areas, over-fishing, and erosion caused by tree-cutting in the highlands. Some mangrove areas have been converted to rice farming and salt production.

Coastal erosion, which is amplified along the west, north-west and east of Madagascar (region of Mahajanga, Maintirano, Morondava and Manakara) takes place following the coastal hydrodynamic modifications. The best known for this phenomenon is located in the northwest coast of Madagascar. The Betsiboka Estuary on the northwest coast of Madagascar is the mouth of Madagascar's largest river and one of the world's fast-changing coastlines. Nearly a century of extensive logging of Madagascar's rainforests and coastal mangroves has resulted in nearly complete clearing of the land and exceptionally high rates of erosion. After every heavy rain, the bright red soils are washed from the hillsides into the streams and rivers to the coast. Astronauts describe their view of Madagascar as "bleeding into the ocean." One impact of the extensive 20th century erosion is the filling and clogging of coastal waterways with sediment - a process that is well illustrated in the Betsiboka estuary. In fact, ocean-going ships were once able to travel up the Betsiboka estuary, but must now berth at the coast.

A bad situation is made worse when tropical storms bring severe rainfall, greatly accelerating the rates of erosion. As an illustration, observations made from the International Space Station documented widespread flooding and a massive red sediment plume flowing into the Betsiboka estuary and the ocean in the wake of Tropical Cyclone Gafilo, which hit northern Madagascar on March 7th and 8th, 2004.

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC:

The Madagascar National Oceanographic Data and Information Centre (MD NODC) is hosted by IHSM (Institue Halieutique et des Sciences Marines) and under supervision of the High National Ministry of Education. The centre is supported by UNESCO/IOC through the Ocean Data and Information Network for Africa (ODINAFRICA) since 1998.

The main objectives of the Centre are to:

- Provide marine scientists, students and operators in the country and the region the necessary scientific information related to the marine and coastal environment
- Promote the use of marine data and information both in the country and regionally
- Promote and facilitate communication between the scientists, both intra - and inter - regionally
- Disseminate information on marine scientific research activities in the country

Figure 3. Betsiboka river runs out to the sea - Brick-red lateritic soils, the result of tropical weathering, are responsible for the strong color of the sediments. The sediment lost is an irreplaceable natural asset (Image source: NASA, Image reference ISSOO8-19233, taken on March 25, 2004).

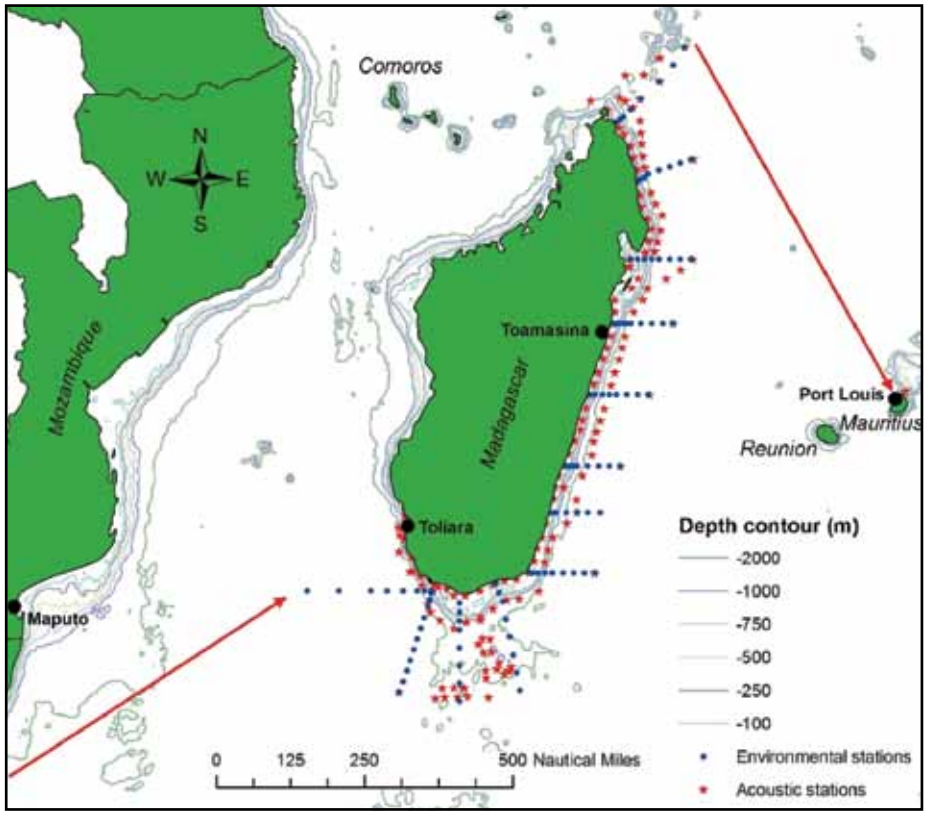

Figure 4. Results of a Madagascar ecosystem assessment survey of the shelf and deep water regions carried out in 2008. Acoustic assessment of the pelagic fish assemblages are shown in red and environmental sampling including nutrient analyses, and to collect data on zoo- and phytoplankton are shown in blue (image source: ASCLME. 2008. - to be made available at: www.asclme.org).

The centre receives students from various sectors for training in marine data and information management regularly. MD NODC also provides lectures on marine data and information management and Operational Oceanography to local graduate students.

National marine data and information collection has been done, and is available at the centre to be used by those working in marine and coastal management. The collection covers meteorological, oceanographic, freshwater, and related terrestrial environmental data. Oceanographic data collection combines data both from national and international databases delimited by an area of interest from: latitude: 10°S, 37°S and longitude 37°E, 57°E. International data is mainly from the World Ocean Database 2005 produced by the US-NODC, IFREMER/SISMER-France and SHOM (Service Hydrographique et Oceanographique de la Marine). SHOM deals with sea level data management. Data are flagged and quality controlled by using Ocean Data View (mp) software for data from the World Ocean Database 2005. Parameters include measurements of temperature, salinity, oxygen, phosphate, nitrate, silicate, chlorophyll, alkalinity and pH.

Complete Marine Ecosystem Survey in the south and east coast of Madagascar was carried out in the last semester of 2008 by R/V Dr Fridtjof Nansen. The main objective is to establish a baseline for the ecosystem off southern and eastern Madagascar. MD NODC has actively participated in this campaign and data from the survey is available at the centre.

Products and services available at the NODC include:

- Metadata of marine related datasets, which provides information on types, quantity, geographic coverage, sensors used, institutions/individuals holding the data, and conditions for access
- Library catalogue recorded with the INMAGIC software
- Directory of marine and freshwater scientists within the country
- Provision of datasets and meta data from ocean observing programs such as ARGO floats (provided by SISMER-France) and sea level data (SHOM)
- Provision of bibliographic search and delivery services to the scientific community in the institute

The beneficiaries of these products and services are mainly:

- Students
- Marine scientists and researchers
- Development bodies
- Professional bodies
- Maritime administration
- Maritime operators

Marine Related Programmes And Organizations

The following are organizations that work in collaboration with the MD NODC:

- The Institut Halieutique et des Sciences Marines (IH.SM) (www.nodc-madagascar.org/ihsm)
- The Ministry of High Education and Scientific Research
- The Ministry of Environment
- The Fishery Department
- The National Centre for Oceanographic Research (CNRO)
- The National Service of Meteorology
- The national committee of Tsunami Warning System

Figure 5. Students using the Madagascar Oceanographic Data Centre facilities.

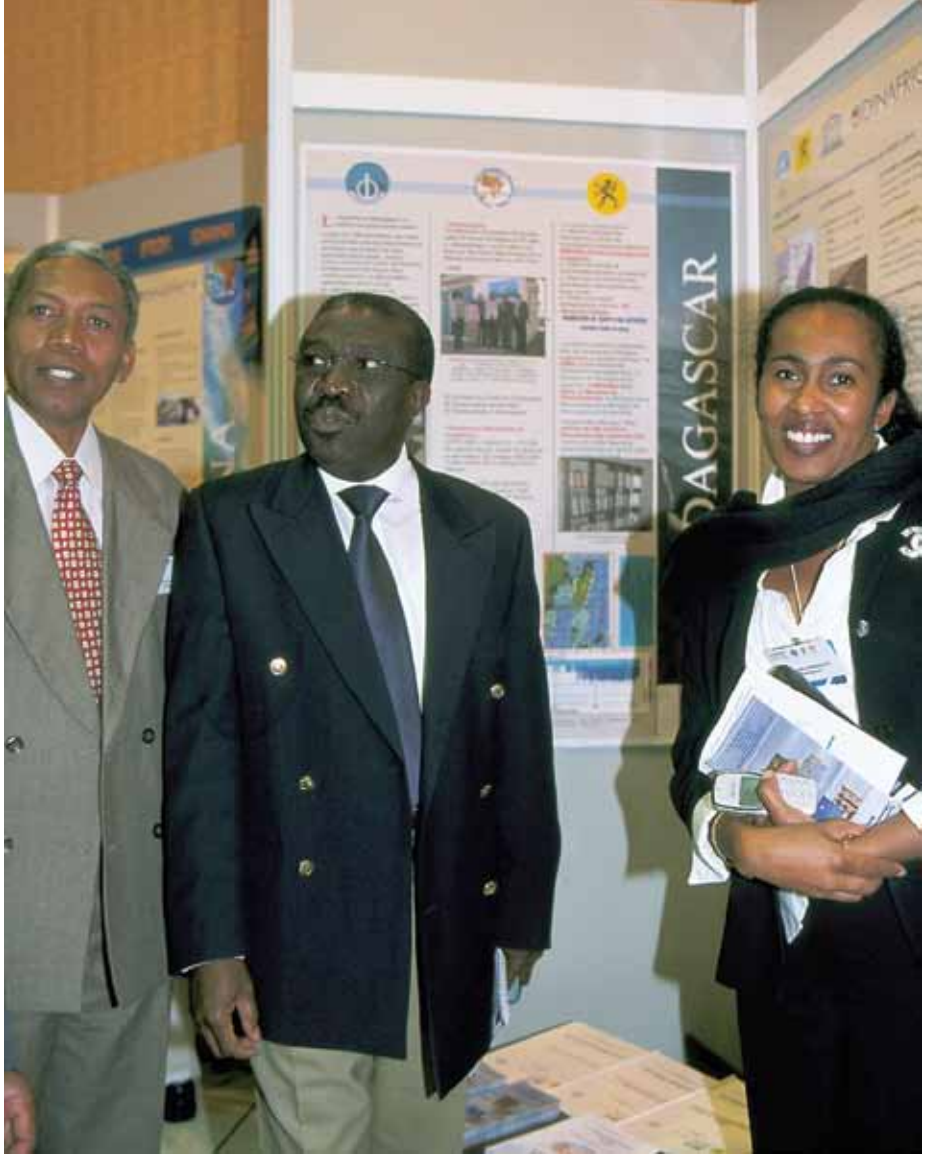

Figure 6. Dr Mara, ODINAFRICA Coordinator Madagscar with representatives of the Angola and Madagscar embasssies in Brussels during a seminar in 2003.

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