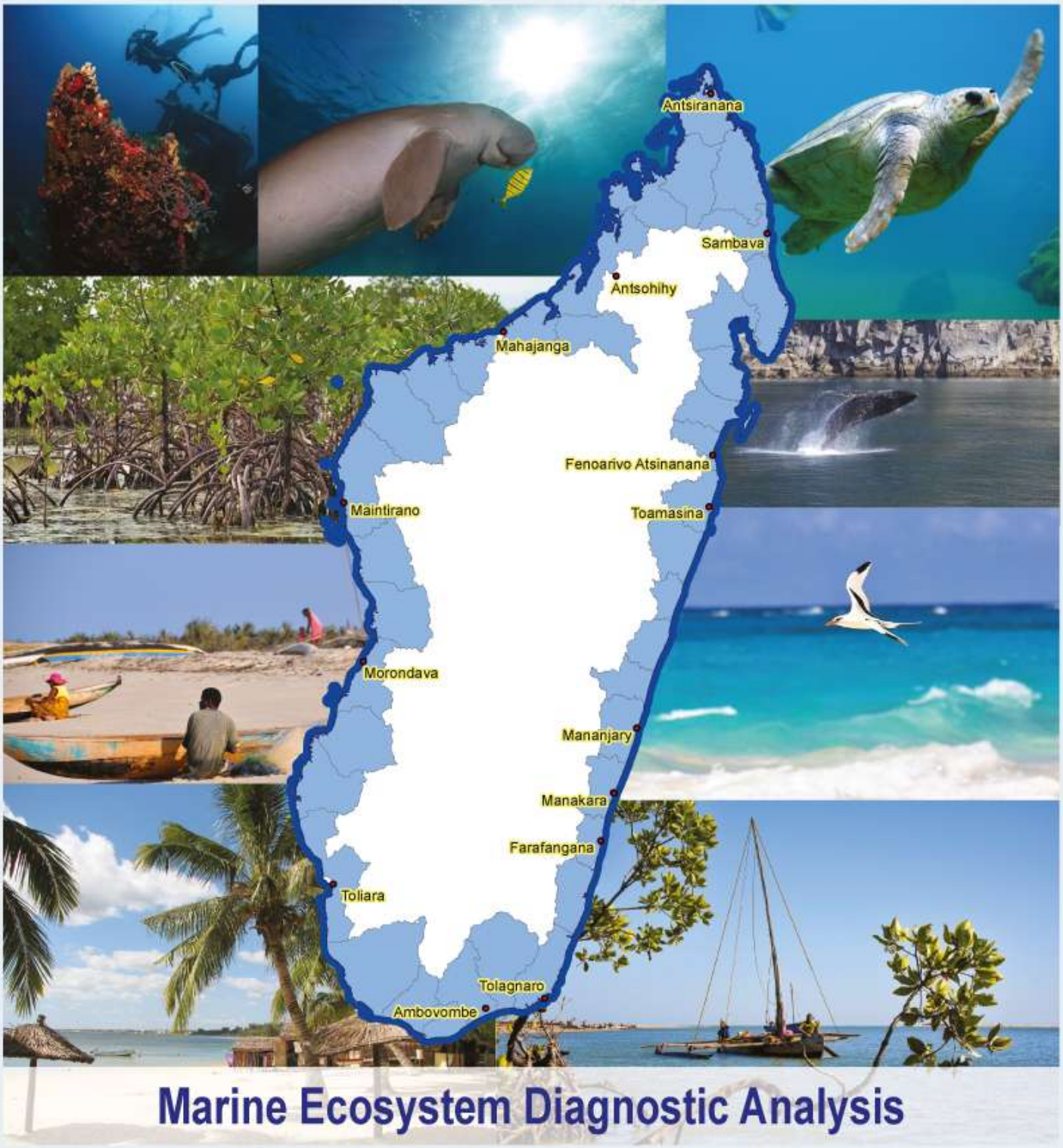


Marine Ecosystem Diagnostic Analysis

Madagascar - 2022

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Executive summary

MEDA aims to collect essential coastal and marine environment data and to identify areas that raise concerns which can in turn be analyzed during the cross-border diagnosis and the strategic plan programming for the western part of the Indian Ocean.

With a total surface of 591,896 km², Madagascar is the fourth largest island in the world. The total income per inhabitant is estimated at 471 USD (2019) and life expectancy is at 66,3 years old. There had been an average annual increase rate of 2.9% between the censuses of 1975 and 2018. Estuaries, mangroves, seagrass beds, coral reefs and offshore marine ecosystem that extend beyond the continental plateau are the main coastal ecosystem that sustains the whole livelihood. Mangrove forests cover up to 330,000 ha of the country, whereas coral reefs run along the island's 1,400 km coast. The eastern coast is steeper than the western coast. Two tropical climates prevail upon the country: warm and rainy season from November to April and a dry and cold season from May to October. Nevertheless, due to its altitude and its position face to major winds, important climatic differences can also be seen in the country.

The Malagasy eastern current (EMC), the South Equatorial current and the Mozambique Channel eddies influence the island. The mesoscale eddies flow southward into the Mozambique Channel and the East Malagasy Current flows southeastward through southern Madagascar. The south-equatorial current influences the northern regions of the island. Upwelling occurs in the south in winter and summer. The island has semi-diurnal tides with an amplitude of 3 m during the spring tides. The sea surface temperature (SST) averages slightly above 25°C. The maximum of 30°C is usually reached in February and the minimum of 23°C in July. The coral reefs of Madagascar are very valuable ecosystems, of great socio-economic and cultural importance. However in most populated areas, they are subject to both human-induced pressures such as overfishing, sedimentation, coral exploitation and pollution and natural degradation (cyclones, coral bleaching. For reefs already under severe stress, damage caused by bleaching is sometimes considered irreversible. Mangroves are another important ecosystem on the island but they are still not fully exploited. Nevertheless, the increasing need for firewood, charcoal and timber in the regions of Mahajanga and Toliara is a major threat to them ever since a great number of people has migrated to areas adjacent to mangrove forests because of drought. In addition, burning and agriculture has led to the destruction of the vegetation in river basins causing soil erosion to transport every year up to 40 to 50 million tons of sediment downstream. It is afterwards deposited in mangrove areas each year, resulting in a strong degradation of the ecosystem.

Madagascar has valuable living marine resources. Of the 123 species of sharks and rays found in Madagascar, 31 are classified by the IUCN as threatened, 1 is endangered (the ray Rostroraja alba), 17 are vulnerable (the whale shark and the endemic ray Dipturus crosnieri) and 10 are near being threatened. These three sawfish species are classified as "critically endangered" on the IUCN red list and in Appendix I of CITES. Today, sawfish are very rare. Potential causes run from shrimp trawling, to the use of gillnets in rivers and the installation of fish barriers in estuaries. About fifty species of sharks and rays in the deep neritic and oceanic waters of Madagascar are affected by industrial tuna fishing (longline and seine fishing), industrial fishing, industrial shrimp fishing, artisanal and traditional fishing. Due to their low reproductive rate, chondrichthyans are very vulnerable to overexploitation. Official statistics on local production and export of meat and fins show an annual mortality of sharks caused by various forms of fishing of 200,000 to 600,000 individuals.

In Madagascar, the coelacanth Latimeria chalumnae, is mainly reported in the southwestern part of the country, near Toliara (Anakao, Tsiandamba, Fiherenamasay) where seven coelacanths have been caught since 1995. Because of its small population due to a very slow reproduction and its high vulnerability to fisheries, the coelacanth is classified as "critically endangered" by the IUCN and in Appendix 1 of CITES. No legal protection is available for the time being in Madagascar, but the CITES control all export of specimens and the existing decrees date from the colonial period. Currently, 14 species of marine teleost fish found in Madagascar are listed on the IUCN red list. Tuna is fished by

industrial seine fishing and longline fishing. Official fishing statistics indicate catches of 10,000 to 11,000 tons per year.

Industrial fishing, industrial shrimp fishing, artisanal fishing and traditional fishing focus on non-reef marine fish. These mainly include Lutjanidae (Lutjanus bohar, Lutjanus sebae), Sparidae, Serranidae, Lethrinidae, Carangidae and Thonidae. On the other hand, small pelagic and demersal fish are not only the targets of the shrimp trawling that operate in all shrimp fishing areas, but they are also the prey of artisanal fisheries, mainly concentrated in the northwestern part of the island, as well as of traditional fisheries which are located along the west coast, in Antongil Bay and in the southeastern part of the island. Traditional fishermen mainly perform reef fish fishery. They mostly look for carnivorous fish (Serranidae, Lutjanidae, Lethrinidae, Carangidae), herbivorous fish (Siganidae, Scaridae, Acanthuridae), scavengers (Mullidae and others) and, to a lesser extent, planktivores such as Caesionidae. The annual catches of the traditional fishery are estimated at about 50,000 tons.

In addition to non-destructive fishing practices, sea turtles are affected by industrial offshore fishing (longline and seine), continental shelf fishing, industrial shrimp trawling, shark nets and traditional fishing using poisons. Industrial shrimp trawling is also an important cause of turtle bycatch, but so far, it has never been scientifically assessed in Madagascar. There are approximately 40 species of seabirds on Madagascar's coasts, and they include albatrosses, petrels, phaetons, frigatebirds, gannets and terns. The fact that people collect their eggs is the main threat to endangered seabirds ; it is though a common practice on a great number of the islands surrounding Madagascar that the fishermen can access.

Climate change is having an impact on Madagascar. Average annual rainfall is expected to decrease by 5% by 2100. However, a 5-10% increase in rainfall is expected from December to February whereas a maximum increase of 10% is expected in the regions of Atsimo Andrefana, Anosy and Androy. Projections of rainfall trends suggest that rainfall will increase in summer and decrease in winter. The magnitude and frequency of cyclones have also changed.

Although the total number of cyclones per year has remained the same, the percentage of intense cyclones has increased and they have become more frequent on the northeast and southwest coasts of the island. Sea level is rising at a pace ranging between 7.2 and 21.6 mm over all the coastal areas of the island, with strong impacts such as floods occuring on the low-lying coastal areas, decline of the coast, and changes of coastal ecosystems which particulary cause major concerns given the various advantages they provide.

Artisanal fishing in Madagascar, which includes subsistence, small-scale and recreational fishing, is largely concentrated on the west coast of the country, with total catches estimated at 107,300 tons per year in 2008, compared to 13,800 tons per year in 1950. Artisanal fisheries account for about 72% of total fish production, mainly focused on export products such as crustaceans, sea cucumbers and cephalopods. In 2003, the small-scale fishery as a whole contributed nearly 26 percent of the total tonnage of fish export production and nearly 9 percent of the total value of exports, with an estimated value of $142 millions.

Tourism and the hotel sector contribute about 3.7 percent of GDP and is the country's second largest source of foreign currency, contributing between $116 and $303 millions to the economy. The sector also directly employs nearly 27,300 people. However, agriculture remains the main sector contributing 27% of GDP, 70% of employment and 20% of total exports.

Generally speaking, the governance of the coastal and marine environment is weak. Integrated Coastal Zone Management (ICZM) is supposed to guide the development of Madagascar's coastal and marine areas ; up to now, it has been largely ineffective.

In conclusion, MEDA has enabled to identify the following problem areas:

Decline of fisheries and changes in ecosystem structure and function: There is a significant decline in small pelagic fisheries, demersal fisheries, elasmobranchs (sharks and rays), marine turtles, cetaceans and tuna;

Habitat modification: The degradation of coral reefs, mangroves and seagrass beds, which are essential habitats testify of this situation. In addition, other habitats such as soft-sediment seabeds, sandy beaches, seamounts and coastal wetlands are affected by both human and natural factors ;

Decline in water quality: Water quality is degrading, particularly due to changes in river flows, sedimentation, pollution, agrochemical residues (pesticides and fertilizers) and eutrophication.

Climate change: This is shown by the rising sea levels, increased magnitude and frequency of cyclones and extreme events such as droughts and floods.

Lack of effective governance of the coastal and marine environment: There is evidence of lack of ability to monitor, supervise and control. Coastal development planning is weak and there is a failure to implement the relevant legislation.

Several recommendations were suggested. These include the need to: establish systems for data and information sharing and tracking, conduct research on measures to adapt and soften the impacts of climate change, develop a list indicating the existing species to facilitate coastal monitoring and to develop regional oceanographic models. Other recommendations include the need to develop refined coastal zone maps, conduct vulnerability assessments of key ecosystems (mangroves, seagrass beds, coral reefs, etc.), develop a framework for monitoring coastal human population dynamics, and build the capacity of national institutions for effective governance of the coastal and marine environment as well as natural resources use.

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- Projet QIT Madagascar Minerals
- Projet SAPPHIRE
- SMOI Crewing and Technical
- Société Maritime de l'Océan Indien
- Turtle Survey Alliance
- Wildlife Conservation Society

Acronyms

ADEMA	:	Aéroport de Madagascar
AGETIPA	:	Agence d'Exécution des Travaux Publics et d'Aménagement
AMP	:	Aires Marines Protégées
AP	:	Aires protégées
APMF	:	Agence Portuaire Maritime et Fluviale
APPAM	:	Association Professionnelle du Secteur Pétrolier Amont de Madagascar
ARTEC	:	Autorité de Régulation des Technologies de communication
ASCLME	:	Agulhas and Somali Current Large Marine Ecosystems
BEPC	:	Brevet d'Etudes du Premier Cycle de l'enseignement secondaire
BNGRC	:	Bureau National de Gestion des Risques et de Catastrophes
BV	:	Bassin Versant
C3EDM	:	Centre d'Economie et d'Ethique pour l'Environnement et le Développement
CCEE	:	Centre Culturel Educatif à l'Environnement
CE	:	Consultation Externe
CEG	:	Collège d'Enseignement Général
CEM	:	Courant Est de Madagascar
CEPE	:	Certificat d'Etudes Primaires Elémentaires
CHRD	:	Centres Hospitaliers de référence District
CHRR	:	Centre Hospitalier de Référence Régional
CHU	:	Centre Hospitalier Universitaire
CI	:	Conservation International
CIME	:	Comité Interministériel de l'Environnement
CISCO	:	Circonscription scolaire
CITES	:	Convention sur le commerce international des espèces de faune et de flore
CLPC	:	Commission des Limites du Plateau Continental
CNAT	:	Conseil National de l'Aménagement du Territoire
CNC-PSM	:	Comité National de Coordination de la Planification Spatiale Maritime
CNGISC	:	Comité National de Gestion Intégrée des Zones Côtières
CN-GIZC	:	Comité National pour la Gestion Intégrée des Zones Côtières
CNLEGIS	:	Centre National d'Information et de Documentation Législative et Juridique
CNRO	:	Centre National de Recherches Océanographiques
CNUCED	:	Conférence des Nations Unies sur le Commerce et le Développement
CNUDM	:	Convention des Nations Unies sur le Droit de la Mer
CO_2	:	Gaz Carbonique
COE	:	Comité d'Orientation et d'Evaluation
COI	:	Commission de l'Océan Indien
COS	:	Comité d'Orientation et de Suivi
CPGU	:	Cellule de Prévention et Gestion des Urgences
CR	:	Commune Rurale
CRCO	:	Centre Régional de Coordination des Opérations
CRFIM	:	Centre Régional de Fusion d'Informations Maritimes
CSB 1	:	Centre de Santé de Base Niveau 1
CSB 2	:	Centre de Santé de Base Niveau 2
CTD	:	Collectivités Territoriales Décentralisées
CTOI	:	Commission des Thons de l'Océan Indien

DAPRNE	:	Direction des Aires Protégées, des Ressources Naturelles Renouvelables et des Ecosystèmes
DD	:	Développement Durable
DDT	:	DichloroDiphénylTrichloroéthane
DGP	:	Direction Générale de la Pèche
DIREDD	:	Directions Interrégionales de l'Environnement et du Développement Durable
DPE	:	Direction de la Planification de l'Education
DRAEP	:	Directions Régionales de l'Agriculture, de l'Elevage et de la Pêche
DREDD	:	Directions Régionales de l'Environnement et du Développement Durable
DREN	:	Direction Régionale de l'Education Nationale
DSIC	:	Direction des Systèmes d'Information et de la Communication
EDD	:	Education pour le Développement Durable
EITI	:	Extractive Industries Transparency Initiative
EN	:	En danger
ENEM	:	Ecole Nationale d'Enseignement Maritime
EPIC	:	Etablissement Public à caractère Industriel et Commercial
EPP	:	Ecole Primaire Publique
FAO	:	Food and Agriculture Organization
FAPBM	:	Fondation pour les Aires Protégées et la Biodiversité de Madagascar
FCE	:	Fianarantsoa Côte Est
FTM	:	Foiben-Taosarintanin'i Madagasikara
GIZ	:	The Deutsche Gesellschaft für Internationale Zusammenarbeit
GIZC	:	Gestion Intégrée des Zones Côtières
GIZCM	:	Gestion Intégrée des Zones Côtières et marines à Madagascar
GRC	:	Gestion des Risques de Catastrophes
IAA	:	Insécurité Alimentaire Aiguë
IAEA	:	Agence internationale de l'énergie atomique
ICAM	:	Intoxications par consommation d'aliments marins
IHSM	:	Institut Halieutique et des Sciences Marines
INSTAT	:	Institut National de la Statistique
IORA	:	Indian Ocean Rim Association
IPC	:	Indice de Prix à la Consommation
IPCC	:	Intergovernmental Panel on Climate Change
IRA	:	Infections Respiratoires Aiguës
IRD	:	Institut National de Recherche pour le Développement
IST	:	Infections Sexuellement Transmissibles
IST/VIH-SIDA	:	Infection sexuellement transmissible / Virus de l'Immunodéficience Humaine Syndrome Immuno Déficience Acquise
STCW	:	Standards of Training, Certification and Watchkeeping for Seafarers
lEM	:	lnitiative Emergence Madagascar
LME	:	Large Marine Ecosystems
LMMA	:	Locally Managed Marine Area
LOAT	:	Loi portant Orientation de l'Aménagement du Territoire
MAEP	:	Ministère de l'Agriculture de l'Elevage et de la Pêche
MAHTP	:	Ministère de l'Aménagement du territoire, de l'Habitat et des Travaux Publics
MAS	:	Malnutrition Aiguë Sévère
MATHTP	:	Ministère de l'Aménagement du Territoire, de l'Habitat et des Travaux Publics

MATSF	:	Ministère de l'Aménagement du Territoire et des Services Fonciers
MDN	:	Ministre de la Défense Nationale
MEAH	:	Ministère de l'Eau, de l'Assainissement et de l'Hygiène
MECIE	:	Mise En Compatibilité des Investissements avec l'Environnement
MEDA	:	Marine Ecosystem Diagnostic Analysis
MEDD	:	Ministère de l'Environnement et du Développement Durable
MEN	:	Ministère de l'Education Nationale
MESRS	:	Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
MFG	:	Madagascar Fauna and Flora Group
MICS	:	Multiple Indicator Cluster Surveys
MID	:	Ministère de l'Intérieur et de la Décentralisation
MMRS	:	Ministère des Mines et des Ressources Stratégiques
MNP	:	Madagascar National Park
MOR	:	Mid-Oceanic Ridges
MPEB	:	Ministère de la Pèche et de l'Economie Bleue
MRAG	:	Marine Resources Assessment Group
MSANP	:	Ministère de la Santé Publique
MSP	:	Ministère de la Santé Publique
MTM	:	Ministère des Transports et de la Météorologie
MTTM	:	Ministère des Transports, du Tourisme et de la Météorologie
NFDS	:	National Features & Documentary Series
NM	:	Milles Nautiques
OATF	:	Observatoire de l'Aménagement du Territoire et du Foncier
OCDE	:	Organisation de Coopération et de Développement Economiques
ODD	:	Objectifs du Développement Durable
OEPA	:	Observatoire Economique de la Pêche et de l'aquaculture
OIT	:	Organisation Internationale du Travail
OMI	:	Organisation Maritime International
OMNIS	:	Office des Mines Nationales et des Industries Stratégiques
OMS	:	Organisation Mondiale de la Santé
ONE	:	Office National pour l'Environnement
ONG	:	Organisation Non Gouvernementale
ONU	:	Organisation des Nations Unies
ORSTOM	:	Office de la Recherche Scientifique et Technique Outre-Mer
OSCIE	:	Organisation de la Société Civile sur les Industries Extractives
PALM	:	Projet d'Aménagement intégré et durable du Littoral côtier de Morondava
PANA	:	Programme d'Action National d'Adaptation au changement climatique
PANGIZC	:	Plan d'Action National de Gestion Intégrée des Zones Côtières
PANLCC	:	Plan d'Action National de Lutte contre le Changement Climatique
PCG	:	Ports à Concession Globale
PEM	:	Plan Emergence Madagascar
PERR-FH	:	Projet Eco-Régional REDD+ - Forêts Humides de Madagascar
PFL	:	Produits Forestiers Ligneux
PFNL	:	Produits Forestiers Non Ligneux
PGA	:	Ports à Gestion Autonome
PGE	:	Politique Générale de l'Etat

PIB	:	Produit intérieur brut
PIC	:	Pôle Intégré de Croissance
PIR	:	Ports d'Intérêt Régional
PLOF	:	Plan Local d'Occupation Foncière
PNA	:	Plan National d'Adaptation au changement climatique
PNAT	:	Politique Nationale de l'Aménagement du Territoire
PNEDD	:	Politique Nationale de l'Environnement pour le Développement Durable
PNF	:	Politique Nationale Foncière
PNLCC	:	Politique Nationale de Lutte contre le Changement Climatique
PNUE	:	Programme des Nations Unies pour l'Environnement
PSAEP	:	Programme Sectoriel Agriculture Elevage et Pêche
PSE	:	Plan Sectoriel de l'Education
PSM	:	Planification Spatiale Maritime
PUDi/PUDé	:	Plan d'Urbanisme Directeur/de Détail
QMM	:	Qit Madagascar Minerals
RAEM	:	Réseau d'Action des Entrepreneurs Multiculturel
RAEM	:	Rapport sur l'Avenir de l'Environnement de Madagascar
RC	:	Routes Communales
RCOC	:	Centre Régional de Coordination des Opérations
REPC	:	Réseau des Educateurs et Professionnels de la Conservation
RGPH	:	Recensement Général de la Population et de l'Habitation
RIMES	:	Regional Integrated Multi-Hazard Early warning System
RIP	:	Routes d'Intérêt Provincial
RN	:	Routes Nationales
RNP	:	Routes Nationales Primaires
RNS	:	Routes Nationales Secondaires
RNT	:	Routes Nationales Temporaires
RRC	:	Réduction des Risques de Catastrophes
SAC	:	Schéma communal d'aménagement du territoire
SAGE	:	Service d'Appui à la Gestion de l'Environnement
SAIC	:	Schéma intercommunal d'aménagement du territoire
SAPM	:	Système des Aires Protégées de Madagascar
SAPPHIRE	:	Strategic Action Programme Policy Harmonisation and Institutional REforms
SCT	:	SMOI Crewing and Technical
SE&AM	:	Suivi-Eau & Assainissement à Madagascar
SEC	:	Courant Sud Equatorial
SEIR	:	Southeast Indian Ridge
SIDA	:	Syndrome d'Immunodéficience Acquise
SMOI	:	Société Maritime de l'Océan Indien
SNAT	:	Schéma National de l'Aménagement du Territoire
SNDAM	:	Stratégie Nationale pour le Développement de l'Aquaculture à Madagascar
SOOI	:	Sud-Ouest Océan Indien
SPAT	:	Société du Port à Gestion Autonome de Toamasina
SRAT	:	Schéma Régional de l'Aménagement du Territoire
SSE	:	Service de la Statistique de l'Education
SSEnv	:	Service de Santé et Environnement

SST	:	Sea Surface température
SWIO	:	South West Indian Ocean
SWIOFISH	:	South West Indian Ocean Fisheries
SWIR	:	Southwest Indian Ridge
TBER	:	Table de Bord Environnemental Régional
TCE	:	Tananarive Côte Est
TDA	:	Transboundary Diagnostic Analysis
TGRH	:	Transfert de Gestion des Ressources Halieutiques
TGRN	:	Transfert de Gestion des Ressources Naturelles
TSA	:	Turtle Survey Alliance
TSM	:	Température de Surface de la Mer
UICN	:	Union Internationale pour la Conservation de la Nature
UNCLOS	:	United Nations Convention on the Law of the Sea
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
UNICEF	:	United Nations of International Children's Emergency Fund
USAID	:	United States Agency for International Development
VIH	:	Virus d'Immunodéficience Humaine
VOI	:	Vondron'Olona Ifotony
VU	:	Vulnérable
WCS	:	Wildlife Conservation Society
WIO	:	Western Indian Ocean
WMO	:	Organisation Météorologique Mondiale
WWF	:	World Wildlife Fund
ZAP	:	Zone d'Administration Pédagogique
ZEE	:	Zone économique exclusive



Chapter 1. Description of the country

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Madagascar, the fourth largest island in the world with a total area of approximately 592,340 km², is located in the southwestern Indian Ocean. The Mozambique Channel separates the island from East Africa. In a general NNE-SSW orientation, Madagascar extends over a length of 1,600 km, from Cap d'Ambre to Cap Ste Marie, between latitudes 11˚57 'S and 25˚39' S and is 570 km wide. The lenght of the island's coastline is about 5,697 km.

The island ranks second in the world in terms of biodiversity. 60% of the marine biological wealth of the southwestern region of the Indian Ocean is found in Madagascar. Its coastline covers more than 51% of the territory and it is home to nearly 65% of the total population. It includes some of the richest and most diversified natural environments of the country. Coral reefs, mangroves, coastal marshes or even coastal forests are of major economic and ecological interest for the future of the population living on the coasts and of the country itself. For example, coral reefs and mangroves, which generally shelter shrimps, represent respectively a potential income of about 100 million and 200 millions euros per year. This income includes the environmental services that these resources provide. There is also the fact that reefs attenuate the strength of the waves, thus reducing their impact on the coastline and at the end, they cut down coastal erosion.

The ecosystems complement each other, demonstrating a kind of solidarity that is useful to the ecology but which is also essential to the very survival of the local population (For instance, fishing compensates for the low agricultural harvest that happens quite frequently due to irregular rainfall, preventing therefore a much more serious food crisis). It is therefore of the utmost importance for Madagascar and for the people living on the coasts to maintain and preserve the diversity, the health condition and this close relationship or bond between the resources and the productivity of the Malagasy coastline.

The contrasting characteristics of the relief on the two parts of the island have direct impact on the drainage systems ; the largest rivers are found on the west coast, while the eastern slope is characterized by short rivers with very steep profiles and numerous very large waterfalls. Madagascar is also subject to the influence of two major meteorological action centers that control the general conditions ruling over the atmospheric circulation in the southwestern Indian Ocean: the zone of low intertropical pressure in the north and the oceanic high pressure cell, almost permanently centered south of the Mascareignes. Madagascar's climate is also linked to geographical factors, mainly latitude and relief.

Since August 2021, Madagascar has officially been divided into 23 Regions, 14 of which are located on the coast whereas 45 districts are on the seafront. As for its maritime areas, the issue between Madagascar and France over the Indian Ocean's scattered islands has still not been settled despite the 1979 United Nations resolution that affirms Madagascar's sovereignty over these islands and which recommends that France returns them to Madagascar or at least begins negotiations towards their reintegration.

More than three quarters of the country's 25.6 million population [RGPH 3] live in rural areas. A large part of the island of Madagascar has very low density, up to an average density of about 42 people per square kilometer. About 38% of the population lives in seafront districts.

With its gross domestic product of about $471 per capita, its life expectancy of 67 years old, and a population growth rate of 3%, Madagascar is considered one of the least developed and poorest countries in the world (the country ranks 161st out of 189 countries in the 2019 Human Development Index ranking, UN Report 2019). Local population primarily relies on small-scale agriculture for its living. Less than 2 million ha of the country's 3 million ha cultivated land is permanently planted whereas only 484,000 ha of agricultural land is irrigated. About 300,000 km² of the total surface of land is devoted to grazing, while the remaining land is used as forests, shrublands, and urban areas.

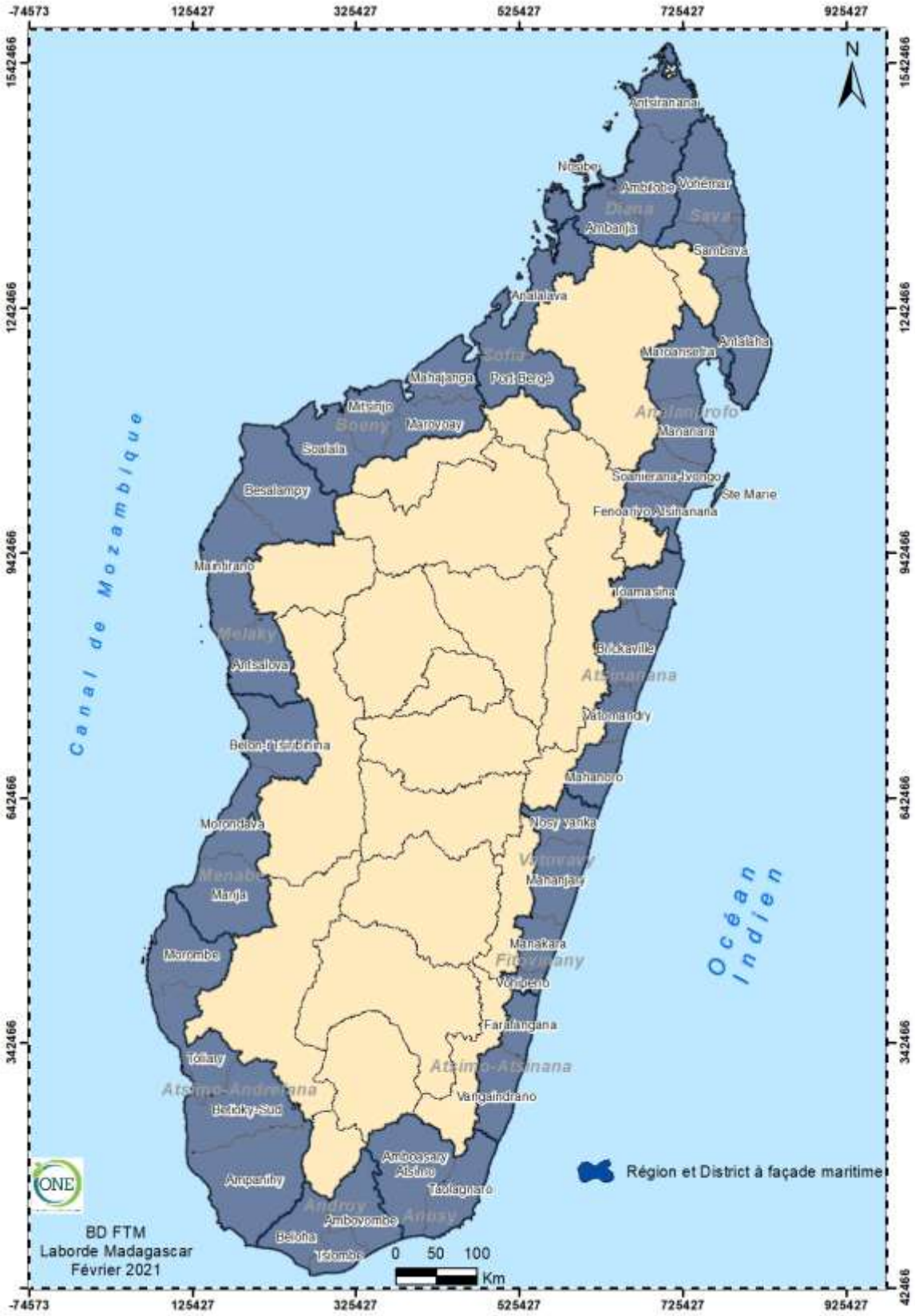
People on the coasts depend on ports for communications, and supplies, and on exports of agricultural products, handicrafts, and fishing for their living. Tourism is an important source of income, and the island largely benefits from its unique flora and fauna as ecotourism attractions.

Many impacts are seen on the coast, particulary on sensitive environments such as reef, seagrass and mangrove areas despite the fact that the density of the population is much lower than the national average. The negative consequences of uncontrolled and / or unregulated activities such as fishing, logging, tourism or even industrial activities, on areas located near the large coastal cities keep on increasing. Land-based pollution, due to the erosion of deforested watersheds, affects almost all coastal areas of the country: thus, silting of coastal plains and rice fields, salinization of soils, degradation of reefs, seagrass and mangrove areas have become common occurences. Moreover, conflicts often rise in these production areas, as is the case between traditional fishing, and industrial as well as artisanal shrimp fishing.

Map 1: Location map



Map 2: Seafront Districts





Chapter 2. Biophysical Environment

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2.1. Coastal and marine ecosystems

The different marine ecosystems are interdependent. They are connected by a complex network of direct and indirect interactions namely nutrient exchange and energy flow, as well as various mechanisms such as migration, symbiosis, and competition. Talking about connectivity, some of its aspects include demographic connectivity and genetic connectivity or genetic bridging. The diversity of the environments stands out in the coastal zone. It corresponds to a diversity of floristic and faunistic species which mainly depends on the physical conditions of the ecosystems.

The coastal regions represent about 68% of the national territory. With 5,697 km of coastline stretching between 12°S and 25°S, 117,000 km² of continental shelf, 113,131 km² of territorial waters and 1,140,000 km² of EEZ (third after the Seychelles and Reunion Island), Madagascar offers an important prospect for biodiversity conservation at the regional level, which responds to the changes occuring in species distribution, due to ocean warming as well as other responses to climate change.

2.1.1. Coastal areas

The coastal and marine areas are delimited on the land side by the whole coastal districts and communes, the 14 coastal regions, and all the areas defined by watersheds and steep slopes; on the sea side, the entire continental shelf within the limits of Madagascar's EEZ, in accordance with its ratification of the United Nations Convention on the Law of the Sea (UNCLOS); and by the part of the atmosphere that lies above the marine and terrestrial areas of Madagascar.

2.1.1.1. Rocky coasts

The rocky coasts which are located within 150 km are represented by the plateaus of Makira and Masoala, the limestone escarpments of Cape Sainte Marie and the cliff of Barn-Hill (South of Toliara). They are moderately high (between 50 and 150 m) located at Cap Masoala (East coast), between Mahajanga and the northern tip of the island except at the mouths and in front of the bay of Ambaro as well as between Cap Sainte Marie and South-East of Taolagnaro.

The rocky coasts at Evatraha, a southeastern village in the Anôsy Region, are composed of ridges with metamorphic basement that surround the peninsula and extend northward as far as Sainte-Luce. On the western shore of the Evatraha Peninsula, these ridges extend below sea level to a depth of 10 to 12 m, and then give way to the sandy environment of Fort Dauphin Bay. At this depth, the substrate is covered with stones of various sizes, from small to rocky, and of all shapes. These stones have accumulated at the foot of the basement ridges. Between these ridges, stones and rocky outcrops, lies a sandy environment.

As you approach the shore from the sea, longitudinal and transverse faults can be seen in the basement ridges. Scattered tabular corals grow overhanging along these faults, while tabular and encrusting corals as well as mats of turf algae can be seen on top of the ridges.

2.1.1.2. Sandy coasts

Beaches and dunes are another type of ecosystem that can be found on the Malagasy coast. From an ecological point of view, they play major role in the prevention of erosion. Sea turtles for instance lay their eggs on some beaches.

These areas represent an important potential for the increase of beach tourism.

They extend over the Western and Eastern coasts:

- In the western part of the country, they run along the whole coast except at the mouths of rivers.
- In the eastern part, they are located between Taolagnaro and Fenoarivo Atsinanana (Fénérive-Est).

2.1.2. The coastline

Coastal formations are forest formations specific to muddy shores and estuaries located in tropical and sometimes subtropical regions.

The coastal forest is a dense evergreen forest formation (20 to 25m), often interspersed with herbaceous beaches in swampy areas. The littoral forest is characterized by *Intsia bijuga* (Fabaceae) and Sarcolenaceae. The most common species found in this type of forest are (RAJAONARIVELO, 2005): *Barringtonia racemosa* (Lecythidaceae), *Acacia mangeum* (Fabaceae), *Dracaena* sp (Liliaceae), *Dypsis sp* (Palmae), *Coffea sp* (Rubiaceae), *Paederia sp* (Rubiaceae), *Terminalia catappa* (Combretaceae), *Diospyros sp* (Ebenaceae), *Cinnamosma sp* (Cannelaceae). There are also other species of trees of Asian or pantropical affinity namely *Hymenaea verricusa*, *Intsia bijuga* (Fabaceae), *Calophyllum inophyllum* (Calophyllaceae), *Terminalia catappa* (Combretaceae), *Casuarina equisetifolia* (Casuarinaceae) and *Barringtonia asiatica* (Lecythidaceae). There are endemic species like *Uapaca littoralis* (Phyllanthaceae), *Labramia bojeri*, *Mimusops coriacea* (Sapotaceae), *Pandanus spp*. (Pandanaceae), *Asteropeia sp* (Asteropeiaceae) and some Sarcolaenaceae: *Leptolaena sp*, *Sarcolaena sp* and *Cycas thouarsii* (Cycadaceae), *Dypsis lutescens* (Arecaceae) as well as *Brexia madagascariensis* (Celastraceae).

The coastal forest is limited to the east coast, up to an altitude of 50 or even 100m. Originally, it was an almost continuous forest standing from Iharana (Vohémar) to Taolagnaro along a narrow strip of 1 to 5 km wide. However, it is currently fragmented (Association Vahatra, 2018).

The coastal thicket is a shrubby to bushy formation on the substrate. It is most often sandy and exposed to winds laden with sea spray. The most exposed part is herbaceous dominated with pan- or paleotropical species such as *Ipomoea pes-caprae* (Convolvulaceae), *Canavalia rosea* (Fabaceae), *Scaevolia taccada* (Goodeniaceae), *Sporobolus virginicus* (Poaceae) and *Tribulus cistoides* (Zygophyllaceae). When on its own, it takes on a shrubby thicket appearance with, Salicaceae: *Flacourtia ramontchi*, *Homalium*, *Casearia* and Rhamnaceae: *Zizyphus*, *Berchemi*, *Colubrina* (Association Vahatra, 2018).

2.1.3. Coral islets and banks

According to Cooke et al. (2004), Madagascar counts about 270 islands and islets, 70% of which are located in the extreme north and northwest of Madagascar, while 15% are scattered along the east and southeast coasts and 15% are recorded in the west coast. Almost all those in the north and west have coral formations. Some of them are surrounded by real lagoons.

The most famous islands and islets are: Nosy Be, Nosy Komba, Archipelago of Mitsio, Nosy Lava, Radama Island, Cape Saint Sebastien and Grande Mitsio, Sainte Marie Island as tourists often visit them.

Located not far from the coast, these islands and islets are particularly productive for marine life and are considered as ecosystems in their own right. The local population often give them sacred value, which protects them from any kind of habitation.

For the fauna, some of them are areas of particular importance for reef fish, such as:

- Nosy Hao: large flat reef, an external and exposed reef escarpment ;
- Mitsio Islands: the best reefs for fish are located off the northern tip of Mitsio Island and near Nosy Ankarea ;
- Nosy Tanikely: the habitat includes large sandy areas dotted with coral formations of various sizes ;
- Nosy Kivonjy: island in the shape of a beehive rising abruptly from the sea to 110 m in altitude. There is a good mixture of bottom types including steep walls, rock garden and isolated coral banks.

As for the vegetation, the floristic composition of the islands and islets varies according to their nature (Land Resources & al., 2005).

2.1.3.1. Nosy Tanikely

Several vegetation formations still exist in Nosy Tanikely, which include:

- Back beach vegetation:

A formation with *Leucaena leucocephala* in the coconut field presents the structure of low vegetation with three strata: a 6m high upper stratum with individuals of 20 cm in diameter, a 3m high middle stratum and a 1,5 m high lower stratum. The whole forms a density of 64 individuals/100m². The regeneration has a density of 9 individuals/100m².

- Formation with *Leucaena leucocephala* on slope:

It is a high monospecific formation with three strata: a 10 m high upper stratum with individuals of 20 cm of diameter; a denser middle stratum that stands 6 m high; a lower stratum not exceeding 2 m high, with individuals of 1 m diameter. The regeneration is very weak with one (1) individual/100 m². This formation is almost entirely covered with lianas.

- Formation with *Poupartia* sp on slope

It is very high, with individuals that can reach up to 15 to 20 m high and 50 cm diameter that form the upper stratum. The middle stratum is dominated by 8 m high *Manguifera indica*. The regeneration has a density of 56 individuals/100m², while this density is 64/100 m² for the adult stand.

- Formation with *Ficus* sp. on slope

It is higher, because the upper stratum can exceed 20m high. The adult individuals have a density of 48 individuals/100m², while the regeneration is only 12 individuals/100 m².

- Formation with *Terminalia* sp. on the seaside

It is 8m high with a density of 64 individuals/100 m² with very little regeneration.

- Formation on rocky slope

Inventories carried out on this station revealed the presence of a very low vegetation, hardly 4m high, composed mainly of Flacourtia *ramontchii*, *Cordia subcordata*, *Tamarindus indica*, *Ficus grevei*, *Diporidium greveanum*, *Grewia* sp. These different shrubs contribute to preserve the rocks against marine erosions.

2.1.3.2. Karst islets of Tsingy

The largest of these islets is Nosy Hara, but there are also Nosy Lakandava, Nosy Andrantsara, Nosy Anjombavola, Nosy Lakandalovo, Nosy Belomotra, Nosy Ambatomanitra and Nosy Mely. Due to lack of floristic inventory, very little information is available on the existing flora and vegetation. However, among the typical sclerophyllous plants are *Aloe* sp. (Aloaceae), *Adenia sp.* (Passifloraceae), *Euphorbia* sp. (Euphorbiaceae), *Pachypodium* sp. (Apocynaceae) and the Aphyllons *Cynandium sp*. The presence of the palm *Bismarckia nobilis* and Baobabs *Adansonia sp* has also been noted.

Small stands of mangroves are found in Nosy Hara at the edge of the beaches facing west. In the Vahilava area, five species of mangroves have been identified: *Avicennia marina*, *Sonneratia alba*, *Ceriops candolleana*, *Carapa obovata* and *Rhizophora mucronata*.

2.1.3.3. Protected Area of Lokobe

It is located in an area of Quaternary eruptive rocks that are in the form of untouched stratum volcanoes. It is made up of low hills (highest point 430 m) which abruptly open out into the sea in the southern and western parts of the reserve.

The vegetation is an unspoilt witness of the primitive forest. This reserve of about 600 ha, presents a perfectly protected natural forest zone which is of great biological interest: there are numerous plant species (pallisander, pandanus, palm, orchids and ferns).

An average 30 m high canopy stands out inside the forest that covers the entire surface of the reserve. This tree stratum is dominated by *Canarium madagascariense* (Burseraceae). Its largest trees reach 35 m high for a more than 1 m diameter. There are also other families such as Lauraceae, Annonaceae, Apocynaceae and Ebenaceae or Fabaceae, Euphorbiaceae, *Vonitra nossibensis* (Arecaceae).

The shrub layer is quite important. There are mainly palms such as *Dypsis gracilis* (with a very thin and slender trunk), *Vonitra nossibensis* and *Neodypsis loucoubensis* (species specific to this region), as well as Annonaceae, Fabaceae, Araliaceae, Cyperaceae and Selaginellaceae. Epiphytic plants such as *Platycerium bifurcatum* ferns and *Asplenium nidus*, Orchidaceae, *Rhipsalis madagascariensis* (Aspleniaceae), *Drynaria wildenowii* (Cactaceae) and *Bulbophyllum* sp. and *Angraecum* sp. (Orchidaceae) are numerous in this area.

2.1.4. Coral reefs

2.1.4.1. Different types of existing reefs in Madagascar

Les The different types of reefs that can be seen in Madagascar are:

- The barrier reefs which are composed of coral structures parallel to the coast and at a certain distance from it;
- The fringing reefs which are located immediately on the edge of the continent;
- And patch reefs, wich are located in the lagoon.

Fringing reefs are well developed in the northwest, on the coast, and on the islands (the four Radama Islands, Nosy Be, Mitsio, etc.). On the other hand, there are no atolls in Malagasy waters.

The coral reefs of the coasts of Madagascar are mainly formed by Madreporaria corals, but other organisms such as the calcareous algae of g. *Lithothamnium* (Lithothamniae), Foraminifera, Hydrocorallia *Millepora* sp., Alcyonaria *Tubipora musica*, Polychaetes Serpulidae, and Bryozoa are also recorded. These are all associated with macroalgae, sponges, tunicates and other macro invertebrates such as giant clames, sea stars, and sea urchins.

Reef extent and biodiversity:

Madagascar's 1,130 km fringing reefs lie adjacent to the mainland, along with 557 km of reef beds, 502 km of barrier reefs (formed by a structure of corals parallel to and at some distance from the coast), and 171 km of submerged reefs, for a total of 3,450 km (Cook, 2003 ; Harding et Radriamanantsoa, 2008).

Tropical coral reefs have the richest biodiversity and some of the highest economic value per area of any type of marine ecosystem. In 2002, Veron and Turak recorded 380 species of corals, 463 species of reef fish and 525 species of mollusks, which is high (Obura et al., 2011). Madagascar shelters about 60% of the marine invertebrate macrofauna of the Western Indian Ocean.

2.1.4.2. Reef distribution

From the North to the South of Madagascar, coral reefs covered 1,400 km (Rabesandratana H. UNEP 1986). The total area of coral reefs is 2,000 km². In the region of Toliara, coral reefs run along the coast for 300 km between the Mangoky delta and the village of Ambohibola, Androka.

There are three types of coral reefs **in the North-Western** part of the country (Nosy-Be region):

- Real coastal coral reefs, in the geomorphological sense of the term, which develop on a continental (or insular) base and which can be qualified as fringing reefs;
- Submerged coral banks, generally between six and thirty meters deep, isolated on sedimentary bottoms and fairly close to the coast,

- Patch reefs, isolated reefs generaly localized in the lagoon.

These coral reefs of Nosy Be cover about 176 ha of the area, to which are added those of the other islets of Nosy Sakatia. Studies carried out on the reefs of Nosy Be show that their state of health range from average to excellent in some parts but punctual and weak degradation are also visible in some parts. Their biodiversity is at the same time, important but very different from one reef to another. (Source: Monograph of the Nosy Be Prefecture, 2016). In 2014, the rate of living coral colonies varied from 20.5 to 95% around Nosy Be. But after the rise in sea temperature in 2016 (El Niño event), this living corals rate oscillates between 12 and 40%. (Source: National Center for Oceanographic Researchs (CNRO), 2017).

The drowned barrier of the northwest of Madagascar, which runs over 500 km between Cap St. Andre and Cap St. Sebastian, and is separated from the coast by about thirty meters depths must also be taken into consideration (Gough, 2009).

According to Pichon (1971) and the studies carried out in 2005 by the EDSA group, Détente consultants, GLW Conseil and SPENCLEY, A., the coral reefs in the Nosy Be region show several species of marine phanerogam meadows. Their distributions and quantities vary on how deep they are located. The reefs in the northwest of Madagascar are relatively isolated.

For corals, 323 species of Scleractinian belonging to 62 genera and 17 families are recorded (McKenna et al., 2005).

As for Molluscs, 525 species are listed, divided into 382 gastropods, 139 bivalves, 1 scaphopod, 2 cephalopods and 1 chiton. These species belong to 92 families and 193 genera.

Reef fish count 463 species belonging to 191 genera and 65 families, of which six (6) are of biological importance: Chaetodontidae, Pomacanthidae, Pomacentridae, Labridae, Scaridae, and Acanthuridae. Local fishermen exploit 55 of these species (McKenna et al., 2005).

A later update of the research predicted higher marine biodiversity for Madagascar as a whole with 380 species of scleractinian corals, 788 species of fishes (Obura et al., 2011, Botosoamananto et al., 2021).

Well-developed fringing coral reefs such as the reefs of Antanambe, Nosy-Antafana, Imorona, Ambitsiky, etc prevail in the North-East, in the Analanjirofo region, most particularly in Mananara-nord. There are also well-developed reefs in Masoala. Then there are rocky ecosystems and reefs (case of Cape Belone between Mananara-north and Antanambe).

Coral reefs are developing in several sites from north to south: Nosy Ankao, Vohémar, Antalaha, the east coast of the Masoala peninsula in the south towards the East Cape, Mananara-Nord, Ile Sainte Marie, Foulpointe and Toamasina.

Table 1: Distribution of coral reefs in the Western part of Madagascar

Localisation	Length in km	Max width in km	References
Great coral reef of Amboka Ambohibola in Cape Andiamanao	20	Non estimated	Battistini
Fringing reefs of Itampolo	10		Battistini
Reef of Lanivato in Besamata	55		Battistini
Reef of Besamata at St Augustin bay	45	3 at North of Beheloka	Battistini

Localisation	Length in km	Max width in km	References
St Augustin bay to the Mangoky delta	300		Battistini
Coral reefs of Belo sur mer:			Solomon, J.N
Andriamitoraka	5	1.5	
Mahalolo	1.25	0.6	
Angotahoka	1	1	
Andriangory	2.2	1.6	
Tania	1.5	0.4	
Groupe Bawden	1.3	0.5	
Barrier reef on the outside lane of the North Western plateau	600		

Among these different sites, only Masoala and Mananara-Nord are subject to systematic scientific studies, especially at the level of the Marine Biosphere Reserve of Mananara-Nord. On 50 km of coast of this Reserve, the flat reefs are narrow with exceptions in Antanambe (11.8 km²), Imorona (4.5 km²) and the marine park of Nosy Atafana (1.8 km²). These reefs are dominated by the community of Acropora corals, massive and submassive colonies of *Porites sp.*, *Lobophylla sp*. Part of the Reserve is covered by soft corals, namely the *Dendronephtya genus*, which indicates the condition of the turbulence of the water.

In addition, 179 species of fish, 132 species of corals, 63 species of mollusks, 34 species of echinoderms and 72 species of other organisms are also present in the Biosphere Reserve.

The southwest coast from Mahafaly to the Mangoky delta is also bordered by fringing reefs (Gough et al., 2009). They however disappear from the Mangoky delta because of the turbidity of the coastal waters that is favorable to mangroves. Numerous cay reefs then replace them in the open sea, in front of Morondava, Maintirano, and up to Cape Saint André, on a continental platform, wide of a hundred kilometers. In the South-West the big reef of Toliara, and the reef of Ifaty, are barrier reefs.

From Androka to Anakao, a narrow reef fringe runs along the coast with narrow lagoon. Nosy Ve has well-developed external reef and a real barrier called the Great Reef of Sarondrano towards the mouth of the river Onilahy.

In the South-eastern part of the island, in the Anôsy region, the coral reefs in the region of Taolagnaro that extend between Ehoala and Sainte-Luce can be classified as fringing coral reefs. The surface area of the coral reefs extending between Evatraha Point and Androka is estimated at 1,850 ha.

A high proportion of living hard corals (more than 40%) indicates that the environment is in good condition (especially of the genus Acropora). While the presence of soft corals and dead corals covered with an algal veil express how much the environment has deteriorated (REPC, 2006).

The Anosy region contains numerous species of euryhaline fish such as *Anguilla bicolor bicolor*, *Liza macrolepis*, *Mugil cephalus*, *Gobius fusca*, *Eleotris fusca*, *Gerres acinaces*, *Gerres filamentosus* for their seasonal migrations. It is also rich in Crustaceans, which include:

Shrimps: there are several species of shrimps such as *Penaeus monodon*, *Penaeus indicus*, *Penaeus japonicus*, *Penaeus monoceros*, *Macrobrachium lar*, *Palaemon concinnus*, *Macrobrachium idella*, *Macrobrachium idae*, *Macrobrachium equidens*, *Macrobrachium lepidactylus*, *Metapenaeus monoceros* ;

- The green mangrove crab, *Scylla serrata* (Portunidae) can be caught in this area by using crab scales. There are also many beach crabs such as the *Uca sp.*
- Cirripedes: the barnacles *Balanus* sp which hide in the roots of mangroves.

Challenges: coral bleaching

Coral reefs are vulnerable to the increase in surface temperature (Bleuel et al., 2021), leading to bleaching episodes and to the increase in CO_2 concentration causing acidification of waters (Obura, 2011; Ahamada et al, 2008, Obura 2005; Harris et al; 2010). The bleaching phenomenon occurs when the increase in the temperature of marine waters exceeds the tolerance limit of corals. The zooxanthellae are thus expelled (Fitt et al., 2001; Head et al., 2019) and only the white calcareous skeleton remains.

The 2012 State of the Environment Report reported on the damage caused by the rise of sea level in several reef areas where it has exceeded their vertical growth rate.

The majority of Madagascar's most accessible corals are already damaged (Maharavo, 2009), but degradation due to natural disasters, particularly cyclones, is very significant, in addition to coral bleaching (Gabrié et al., 2000).

Coral bleaching following the 1998 El Niño event (Quod et al. 2002; NOAA 2007; Obura 2009; Maharavo et al. 2011) and the other one in 2016 (Gudka et al. 2017) caused reef mortality in several regions of Madagascar.

Several research works have shown the change of habitat in the great reef of Toliara, especially in the shallow areas or Reef flats (Andrefouet et al. 2013; Bruggmann et al. 2012). This area is covered mostly by brown algae (Rasoamanendrika, 2014).

Sedimentation is also a major threat to the reefs of southwest Madagascar (Rakotondralambo, 2008 ; Maina, 2009 ; IH.SM, 2009 ; Payet et al. 2012).

2.1.5. Seagrass beds

2.1.5.1. Marine phanerogam meadows

"Marine phanerogam" is a generic term for flowering plants that usually grow in the soft-bottom regions of the oceans from the tropics to temperate zones (some marine phanerogams may be found on the solid ocean floor, but they usually only occupy small areas).

Marine phanerogam meadows are highly productive areas. They provide an important food source for many species of coastal and marine organisms in tropical and temperate regions (Gray et al., 1996). Marine phanerogams also play a significant role in sediment trapping and coastal stabilization.

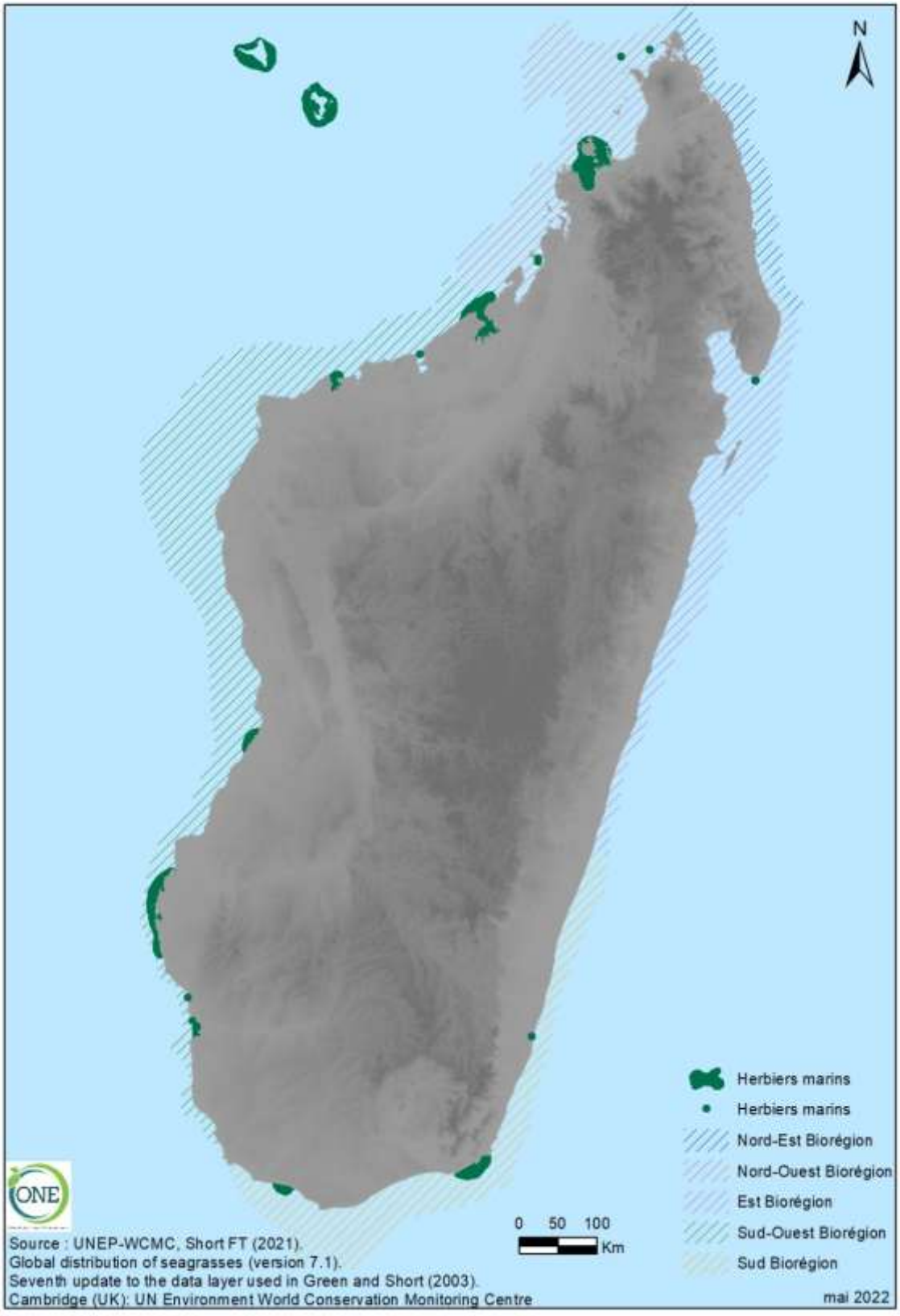
12 to 24 species of marine phanerogams are found in Madagascar. They include *Enhalus acoroïdes*, *Thalassia hemprichii, Halophila ovalis*, *Halophila decipiens*, *Halophila stipulacea*, *Halodule wrightii*, *Halodule tridentata*, *Halodule uninervis*, *Thalassodendron ciliatum*, *Cymodocea rotundata*, *Cymodocea serrulata* and *Syringodium isoetifolium*. These species are generally found in the western coasts of Madagascar where coral reefs are most often found.

Distribution of sea grass beds

The exact surface area of seagrass bed is unknown. However, studies conducted at the level of some marine parks have made it possible to estimate their extent:

- Nosy-Ve area: around 2,000 ha;
- Nosy Hara: 1,442 ha;
- Sahamalaza: 6,465 ha.

Map 3: Distribution of seagrass beds in Madagascar



Dans In the North (Nosy Be Region), from the deepest to the highest horizons, the most dominant marine phanerogam meadows are:

- A monospecific formation with *Cymodocea serrulata* (Zanichelliaceae);
- A monospecific formation with *Syringodium isoetifolium* (Zanichelliaceae) which is just above the *Cymodocea serrulata* formation;
- A formation with *Thalassia hemprichii* (Hydrocharitaceae) which is often associated with *Cymodocea serrulata*, *Cymodocea rotundata* (Zanichelliaceae), *Diplanthera beaudettei* and *Diplanthera univervis* (Zanichelliaceae);
- A formation with *Zostera capensis* (Zosteraceae).

The seagrass meadows of Narindra Bay and around Nosy Lava, located in the northwest are of mixed formation with a domination of the *Thalassodendron ciliatum* species on the eight other species *Cymodocea serrulata*, *Halodule wrightii*, *Syringodium isotifolium*, *Halodule uninervis*, *Cymodocea rotundata*, *Halophila ovalis*, *Halophila stipulacea* and *Enhalus acoroides* (Ralainandrasana et al. 2016).

In the South (Toliary Region), studies conducted by SPROGES and IHSM in 2007 have identified a monospecific marine phanerogam meadow formation with *Thalassodendron ciliatum* (Zanichelliaceae).

Madagascar has a diverse fauna of marine phanerogam meadows which consists of reef fish and invertebrates including:

- the big Actinia ;
- corals of the genera Porites, Psammocora, Favia, Turbinaria, Platygyra, Stylophora, Pocillopora, Acropora ;
- sea urchins: *Tripneustes gratilla*, *Diadema setosa*, *Toxopneustes pileolus*, *Salmacis bicolor*;
- holothurians: *Holothuria scabra*, *Synapta maculata* ;
- the starfish *Protoreaster nodosus*, *Linckia laevigata* and *Culcita schmidelliane*

At the edge of mangroves, marine phanerogams appear to be particularly important in providing for the spawning areas in the tropics, as they supply much needed refuge for coral reef fish and invertebrates (Gray and al., 1996 ; Heck and al., 1997).

Marine phanerogams continue to play an important ecological role even after the blades of the grasses are cut and float on the water. The beds, composed of marine phanerogams mats, which float and drift at or near the surface provide food and important shelter for young fish (Kulczycki & al., 1981). In addition, the deposition of marine phanerogams and macrophytic algal debris on beaches is an important means of providing nutrients to many coastal invertebrates, shorebirds, and other organisms.

2.1.5.2. Seaweeds

In addition to seagrass beds, in terms of species, seaweeds also deserve special attention, given their diversity and proliferation.

The seaweeds in Madagascar are in three major taxonomic groups:

- Rhodophytes or red algae, the largest group with 44 species from 12 families;
- Chlorophytes or green algae, with 32 species from 10 families dominated by Rhodomelacea and Hypneacea;
- Pheophytes or brown algae, with 11 species from two families: Dictyotacea and Sargassacea.

There are also some seasonal species or species at different phases of their life cycle.

Species that indicate ecological disturbances are listed in several places, namely, *Tydemania expeditionis* and Microdyction.

Seaweeds are found on rocky facies, mangrove roots, seagrass beds, coral reefs, on muddy bottoms and in coastal lagoons. They play an important role in maintaining the ecological balance of the aquatic environment and are sources of food for many organisms.

Seagrasses and seaweeds often settle in coastal lagoons and act as buffer zone for nutrient recycling, while improving water quality and modifying water circulation and stabilizing sediments, with beneficial consequences for coral habitats.

2.1.6. Mangroves

It is a shrubby formation of salt or brackish water reaching 6 to 10m, which is periodically flooded by the tide. It consists of a limited number of halophilic species common to all the shores of the Indian Ocean: *Rhizophora, Bruguiera, Ceriops* (Rhizophoraceae), *Avicennia* (Acanthaceae), *Lumnitziera* (Combretaceae), *Sonneratia* (Lythraceae) and *Heritiera littoralis* (Malvaceae)

Madagascar has the second largest expanse of mangrove in the western Indian Ocean, accounting for 2% of the world's mangroves (Bosire & al. 2015).

2.1.6.1. Types of mangroves

There are three types of mangroves in Madagascar

- *Estuarine mangrove*: which is found at the mouth where a watercourse (river) opens or at an estuary. It is characterized by the meeting of sea water with fresh water.
- *Lagoon mangrove*: located at the edge of the channels that contain the rise and fall of sea water at high tide, inside which ancient cordons bed can be found as well as large expanse of tan during low tide. Undreground flows provide fresh water supply.
- *Littoral mangrove* or intermediate mangrove which is in direct contact with the sea front and running parallel to the sea shore.

Mangroves generate nutrients that feed the seagrass beds, therefore their destruction has an impact on the state of the seagrass beds.

2.1.6.2. Mangroves distribution

Mangroves are located in the intertidal zone on the seashore and along estuaries, in areas sheltered from the strongest waves, and where a fine sedimentary contribution, often rich in organic matter can be found. They are much more frequent and extensive on the west coast.

In Madagascar, mangrove areas are found in the following places:

1. They are more frequent and extensive on the western coast (map 4)
2. Mangrove areas situated on the eastern coast are unknown; facts are not enough or even missing.
   - DIANA and SAVA regions both mainly include the Ambohivahibe – Rigny and Irodo complex. It represents 90% of the mangroves located in the eastern part of Madagascar.
   - In the Analanjirofo region, there is the Sainte Marie – Manompana – Mananara complex.
   - In the east and south-east, there are scarce mangroves (Tampolo, Mahavelona, Farafangana and Taolagnaro)

Map 4: Localisation of mangroves in Madagascar



2.1.6.3. Surface areas of mangroves

The mangrove forests of Madagascar are part of about 400,000 ha of maritime marshes. They currently occupy an area between 300,000 and 390,000 ha. They are located largely on the western coasts of the country, which is about 98% of all Madagascar's mangroves (RAEM, 2017). They are inserted in the sedimentary basins forming dense forests in the northern and western coastal part of the island, they are found at the bottoms of bays.

Only 5,000 ha are located on the east coast, more precisely in the northeast, between Mananara-Nord and Antsiranana.

Table 2: Total surface of mangroves

Regions	Geography		Mangrove surface (ha)
	Districts	Communes	
DIANA	Antsiranana I-II, Ambilobe, Ambanja and Nosy Be	15	81,724
Sofia	Antsohihy, Analalava	07	76,932
Boeny	Mahajanga I-II, Soalala, Mitsinjo	09	103,222
Menabe	Belo sur Tsiribihina, Manja and Morondava	06	66,638
Melaky	Maintirano, Antsalova, Besalampy	10	54,332
Atsimo Andrefana	Toliara I- II, Morombe	15	10,505

Source: Mangrove inventory report, MEDD, 2019

A decline in the total surface of mangroves

Giri et al. (2007) consider that mangroves lost approximately 7% of their total surface between 1975 and 2005. In 2012, an estimate of 7,000 to 8,000 ha of mangroves are lost every year in Madagascar (Ranoelison et al., 2017). A 21% loss of mangroves total surface was noted between 1990 to 2010 in the southwestern part of Madagascar (Randrianandrasaziky et al., 2017).

Table 3: Change in the surface of mangroves over the years

Extent	Year	Source
[142,500 – 170,944]	2018	Laboratoire d'Observation des Forêts de Madagascar
282,231	2013	ADRA and IH.SM
16,877	2013	PERR-FH
327,000	2012	Cooke
299,100	2010	Splading et al.

The decline rates of mangrove surfaces of Ambanja, Mahajanga and Morombe were respectively 24.62%, 21.34% and 19.12% (Ranaivoson et al., 2017).

This loss is due to the cutting of mangrove wood for building and charcoal purposes. There is also silting and clearing for salt production. This is what is happening to the mangroves located between the rivers of Manombo Sud and Onilahy where 80% of the mangrove of Ambondrolava was destroyed in 2008 (Ratrimomanarivo et al., 2017). The same situation can also be seen in the mangroves of Antrema and Ampampamena (Vavindraza et al., 2017), or in that of Ankivonjy, despite the implementation of a protected area and co-management with local communities (Bezafy, 2017) ; of Bombetoka, (Andriamanantena et al., 2017).

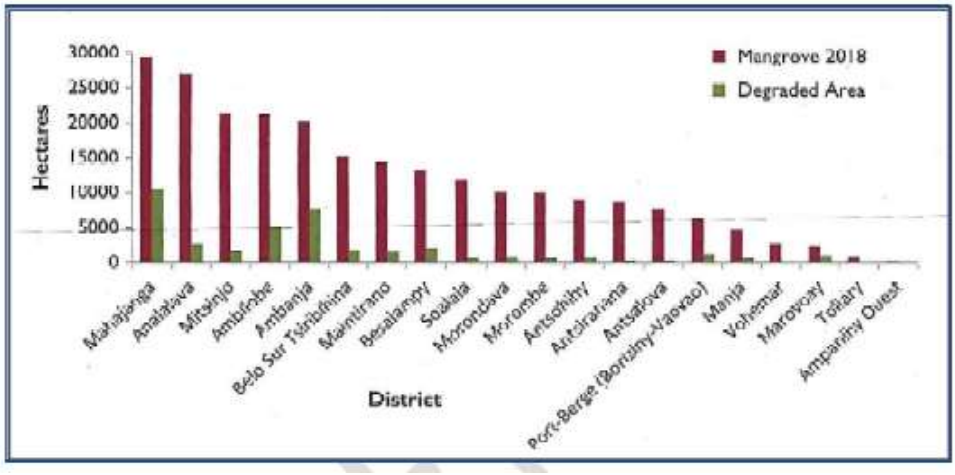
In addition, pressures also affect the marine fauna, especially the fishing of crabs of the *Scylla serrata* species. In the last ten years, the capture of live crabs for export to Asia has significantly increased since 2011 (Ranaivoson et al., 2017).

The decrease in the surface area is also due to many other reasons such as:

- Global warming which leads to the modification of the physicochemical properties of mangroves, from abiotic factors. (Roger, 2008)
- The overexploitation of wood resources, upstream agriculture from which the sedimentation phenomena originate and the overexploitation of fishery resources

Nevertheless, mangroves play a major part in fishing by relieving damages caused by cyclones and erosion. At the same time, they are also needed for the supply, the regulation, carbon sequestration, and filtration of pollution in the same way as other marine ecosystems.

Figure 1: Mangrove damage compared to 2018



Source: WWF 2019

2.1.6.4. Threats on mangroves

Mangroves are exposed to continuous threats ranging from being changed to rice fields, to selective cutting for fuelwood and timber, or sedimentation due to upstream deforestation.

The district of Mahajanga has the largest degraded area, which is estimated at 40% of the total mangroves in the whole district. The northwest of the province of Mahajanga, being identified as potentially degraded, has the largest mangroves surface but is also the most degraded area.

The filling of tannes, or even mangroves, is increasingly common in the vicinity of large coastal towns for house building. This is the case of the mangroves of Nosy-Be, Mahajanga, Toliara and Morondava.

Mangrove soil can only be used for agriculture when it is completely desalinated. The process is possibe by accumulating the sediments from upstream, and by placing then the selected area out of reach of the tides; it is then cleared for agricultural purposes. The surface where *Avicennia marina* grow can be used for grazing with *Sporobulus virginicus* grassy tannes in the dry season.

Job losses due to political crises in large cities increase pressure on natural resources. Free access to marine resources makes coastal areas, especially those near mangroves, privileged migration zones. Indeed, this ecosystem offers the needed materials for human settlement and firewood.

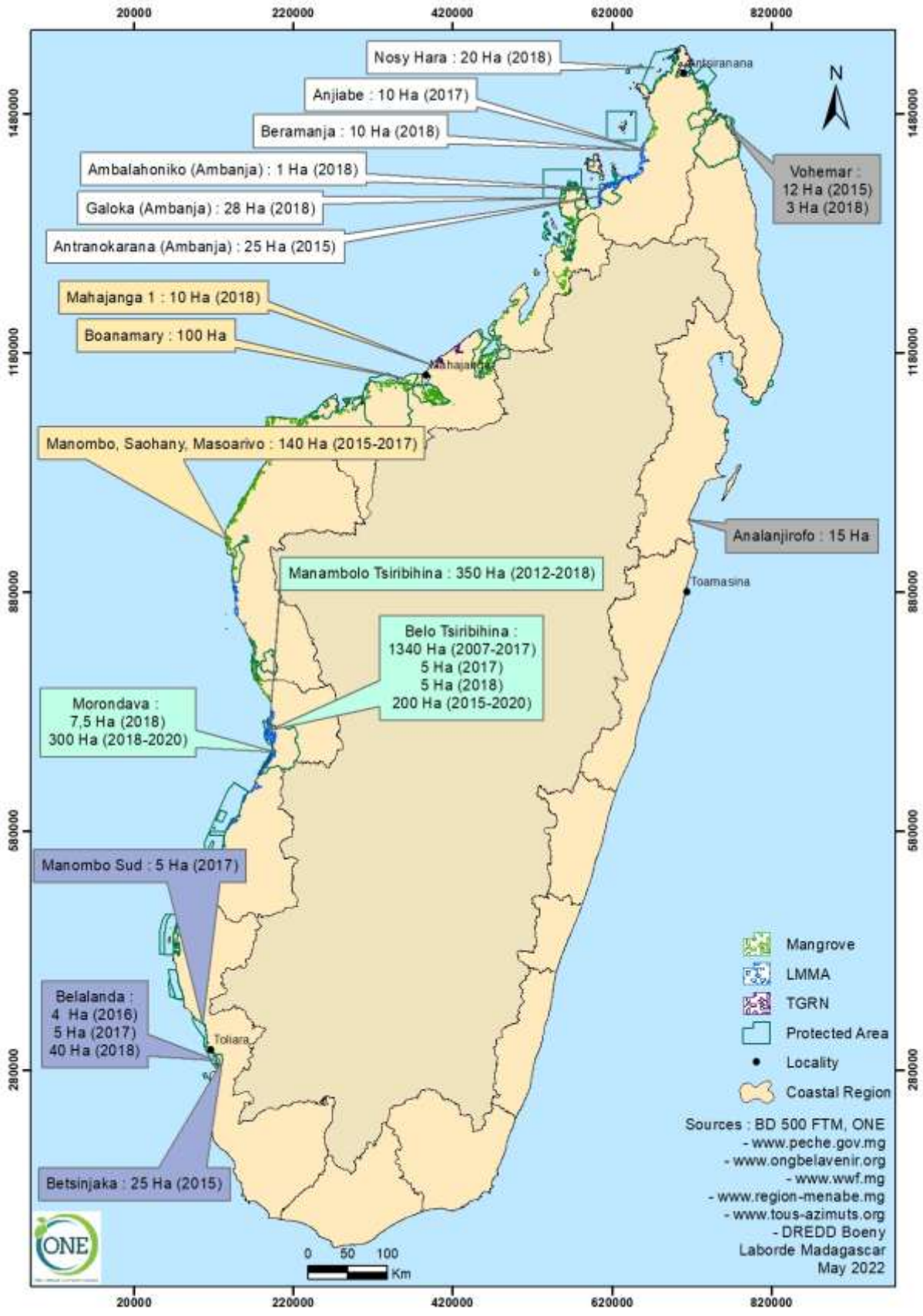
Exploitation of mangroves for the wood energy production is an important factor of deforestation in the coastal areas of the West.

Variation in water regime also has direct effects on mangroves, phanerogam meadows and other plant communities through downstream sediment transport. Some areas of the mangrove can only be flooded by high spring tides and the surface soil is often dried out. This phenomenon prevents the regeneration of the mangrove, as is the case of Antsoherimasiba Antrema. As a whole, these impacts are of great concern.

2.1.6.5. Restoration and reforestation of mangroves

Compared with other forest ecosystems, mangroves are fast growing, easy to plant, and less prone to fire. Thus, the objective of mangrove restoration is to preserve the biodiversity that is particular to this ecosystem, as well as the ecological services they provide.

Map 5: Total surface of restored / reforested mangrove sites in Madagascar



18.2% of the mangroves in Madagascar are presently protected. Most of the protected areas are undergoing a clear decline in the surface of mangroves, except the mangrove of the Réserve spéciale Analamerana which has increased. The mangrove of Menabe Antimena has incurred the most comprehensive loss.

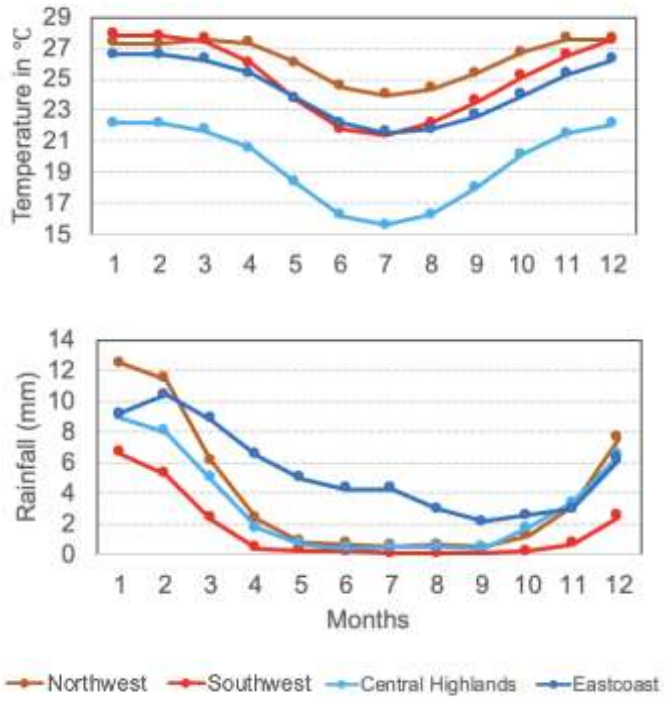
2.2. General description of the climate

Current and future climate trends are part of the information that any National Meteorological Service must regularly provide to decision makers and the public. This book on climate trends and future climate change in Madagascar provides the current state of knowledge based on the observed evolution of the climate in Madagascar and the future changes we should expect under two global greenhouse gas emission scenarios. The results presented in this publication are from a study conducted in collaboration with the Regional Integrated Multi-Hazard Early Warning System (RIMES & DGM, 2019).

Two seasons prevail in Madagascar: wet from November to April and dry from May to October.

Four main climate zones are found in the country: i) the humid east coast, ii) the central highlands, iii) the northwest, and iv) the semi-arid southwest over which observed climate trends and future climate changes are presented.

Figure 2: Monthly temperature and rainfalls in the four climate zones.



Historical disaster data for the 1961-2017 period indicate the presence of the following climate-related disasters: cyclones, drought, floods, landslides, locusts, and epidemics. Of these, cyclone-related damage has been the most significant. Between 1961 and 2017, cyclones caused 1193 deaths, destroyed 0.6 million homes, and directly and indirectly affected 4 million people. Floods were the second highest impact disaster, affecting more than 0.3 million people during this period according to the Desinventar website:

https://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=mdg&continue=y

The study used the latest techniques for developing climate projections that provide regional-scale information to enable decision making which requires the integration of climate dimension and climate changes.

2.2.1. The wind

In general, the winds along the east and south coasts are strong and blow from the south, while on the west and northwest coasts the winds are variable and less strong. Antsiranana, in the north, and Tolagnaro in the southeast, are the most windy coastal sites of Madagascar, while Nosy Be, protected by the highlands of the Tsaratanana massif, is less windy.

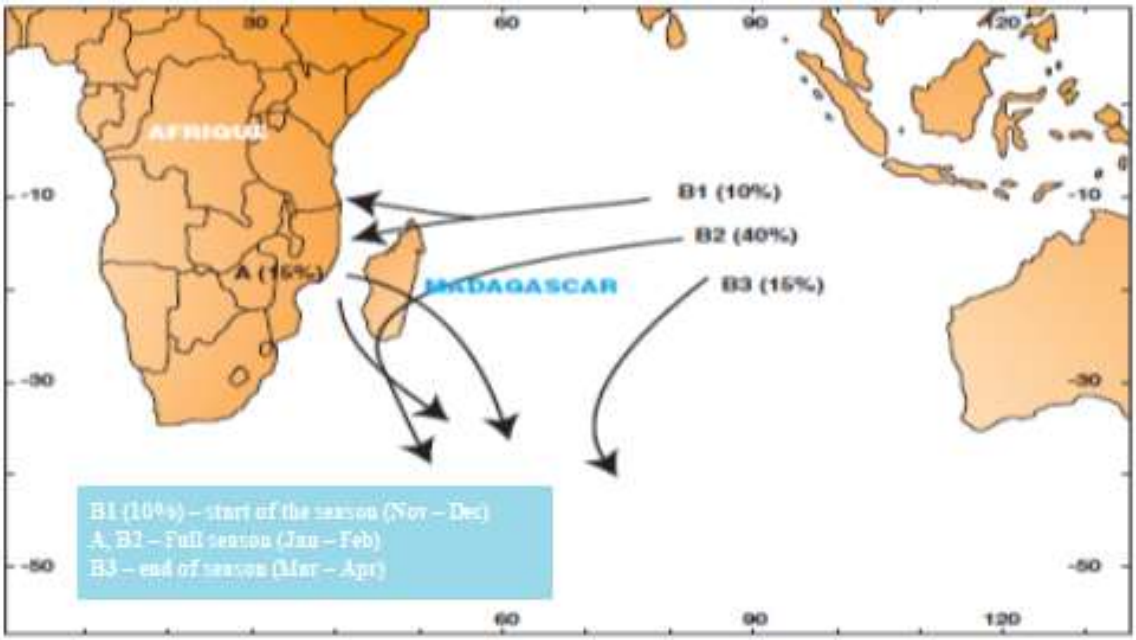
In addition to this general wind regime, there is a daily cycle of onshore and offshore breezes that can dominate during the morning or evening, especially in the south and western part of the island. In the morning, cooler air from land displaces warmer air from sea (causing an onshore breeze), and with the opposite effect in the evening (causing an offshore breeze).

The prevailing winds around Madagascar are due to the alternating influences of permanent high pressure areas centered over the Mozambique Channel and the Mascarene Islands (Seychelles, Mauritius, Reunion). During the cooler months (April to October) the Mascarene anticyclone dominates, reinforced by low pressure over the Mozambique Channel, causing southeasterly trade winds to blow over the entire coast of Madagascar. During the summer months (November to March), the northern monsoon system moves southward, generating northerly winds in the northern part of the island, which become changeable further south. (Marine Guide, 2008).

In Madagascar, **tropical cyclones** represent constant threat to the security and well-being of the population because they create numerous damages both in terms of human lives and economy. Each year, the country is a potential target for tropical cyclones that form in the southwestern basin of the Indian Ocean. Indeed, the cyclones that affect the island are born either in the Indian Ocean or in the Mozambique Channel. By its extension from North to South and its geographical position in the west of the basin, the island stands on the privileged trajectory of these cyclones. On average, out of the ten or so cyclones that form in this zone, 3 or 4 hit the country during the cyclone season which runs from November to April.

In general, the cyclones that form at the beginning of the season (November-December) pass to the north of the island (Figure 3). Approximately 60% of the cyclones that form in the middle of the season (January - February) cross the country. At the end of the season, cyclones from the Indian Ocean rarely reach the island. The most intense cyclones hit Madagascar in January and February. In general, they originate from the East in the Indian Ocean. Cyclones originating in the Mozambique Channel constitute the 15% of the Indian Ocean cyclones. Although of lesser intensity, they are no less a danger for the country because they form most often near the west coast of the island.

Figure 3: Typical route of cyclones from 1959 to 1989 according to Malick and Mercusot



2.2.2. The rain

Detecting changes in rainfall is generally more difficult than detecting changes in temperature. This difficulty is even greater if the study involves regions where the rainfall is very variable (West and South of Madagascar for example). For example, one or more days of heavy rainfall can contribute significantly to the annual total. In addition, local climatic factors contribute to the creation of microclimates.

Around 2055, rainfall would increase over a large part of Madagascar with the exception of the extreme south-east (decrease in June) and east (decrease in July).

The projections in Figure 2 suggest that rainfall would increase from January to April. The projections are somewhat contradictory and therefore inconclusive for some regions of Madagascar (North, Northwest, Northeast). One station shows a decrease in rainfall in March (4 out of 6 models). For the months of May and June, the projections towards 2055 suggest increases in rainfall for most of Madagascar, except for the South-Southeast region, where there is a decrease. Towards 2055, projections show a decrease in rainfall for the eastern part (July) and the southern half of the eastern part (August-September); the rest of the country will be wetter. In October, only one station (extreme Southeast) shows a decrease in rainfall, with the rest of the country becoming progressively wetter in November (particularly in the North) and December.

2.2.3. Air temperature

The average air temperature has been rapidly increasing over the past 40 years. Global warming is unequivocal and largely due to human activities.

The average air temperature of the southern region of Madagascar has been steadily increasing since the 1950s. The average temperature of the northern part of Madagascar has begun to rise since the early 1970s. The warming in Madagascar is significant. Increase of extreme temperatures (especially minimum temperatures) mainly demonstrate this warming. However, it is consistent with global observations.

2.2.4. Sea surface temperature

The southwestern sea surface of the Indian Ocean has an average temperature of 27.6°C ranging from 25.5 to 28.7°C (Locarnini et al., 2013).

2.2.5. Water column temperatures

The thermocline in the Indian Ocean has an average depth of about 110 m (Locarnini et al., 2013).

2.3. Coastal and marine geology and geomorphology

2.3.1. Coastal zones

The littoral ecosystems of the big island are generally represented by:

- Coral reefs: barrier reefs, reef bottoms, with the bottoms of bays and the large bays on the northwest coast (Ampasindava Bay, Narinda Bay, Mahajamba Bay, etc.), and on the west coast: Betsiboka Bay and the Bay of Assassins
- Maritime marshes including mouths, deltas, estuaries and lagoons. The deltas are very numerous on the northwest coast of Madagascar, such as the Mahavavy and the Loza is an example of estuary marsh. The surprising example of a delta is that of the Tsiribihina which forms a lobe of about 60,000 ha.
- And there are also some artificial sites such as the port of Toamasina which is being extended, the port of Mahajanga, and the dike or jetties or wharf in Toliary; or urban protection such as the groynes of Morondava.

The coastline of Madagascar undergoes a phenomenon of accretion which is defined as **the progression of land space on the marine space, thus pushing back the shoreline on the sea side and raising the substrate.**

Deforestation in the highlands of Madagascar has resulted in massive soil stripping, with erosion rates sometimes reaching up to 400 t/ha/year. Coastal accretion reflects this major geomorphological crisis which is linked to deforestation in an environment in fragile equilibrium, with high alterite cover, steep slopes and a climate with contrasting seasons (notably the intervention of devastating cyclones). Man seems to play a major part in this case.

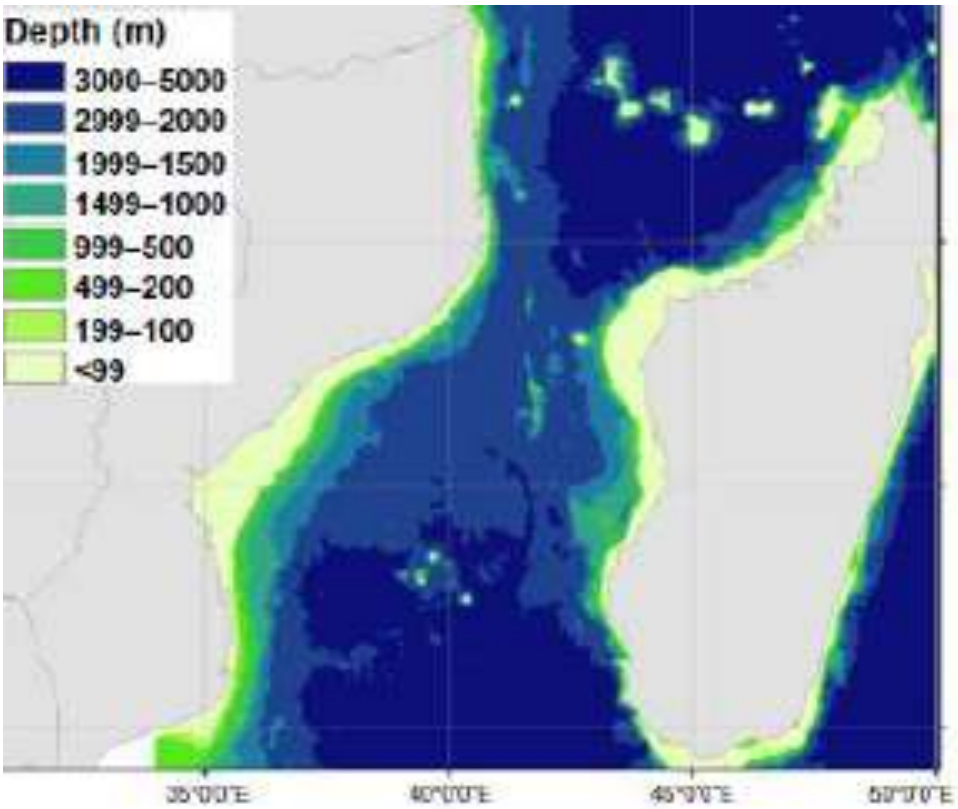
As for the maritime parts of the deltas, accretion cannot be separated from the translation of the mangroves which colonize the new mudflats (at speeds ranging on an average of 2 to 3 m per year on the Malagasy west coast, but up to 100 mm/year on the Mahavavy..., while leaving behind vast oversalted surfaces: the tannes ("sira-sira" in Malagasy).

2.3.2. Bathymetry

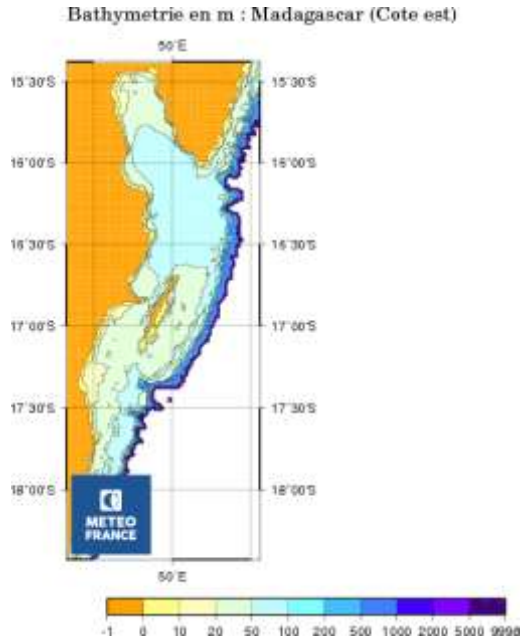
Madagascar's continental shelf extends progressively offshore on the western coasts, and is very narrow and steep along the eastern coasts.

The south and southwest bathymetric map below shows the narrowing and extension of the continental shelf to the south (Bemiasa, 2007).

Map 6: Bathymetry around Madagascar

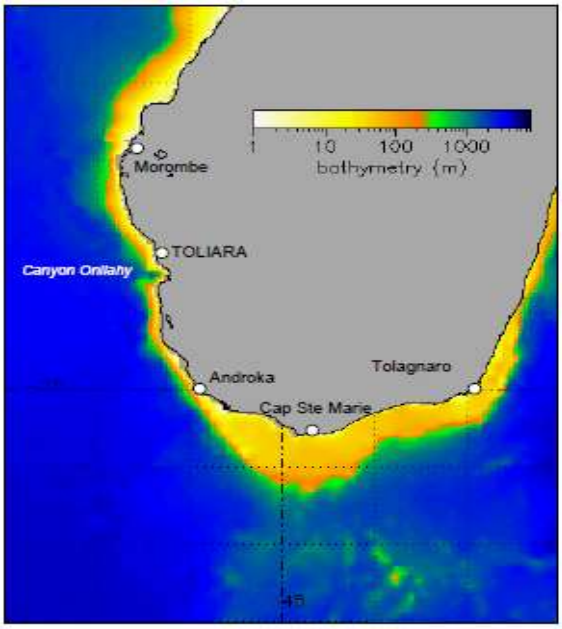


Map 7: Bathymetry on the eastern coast of Madagascar



Source: http://www.meteorologie.eu.org/mothy/bathymetrie/html/ba_made.html

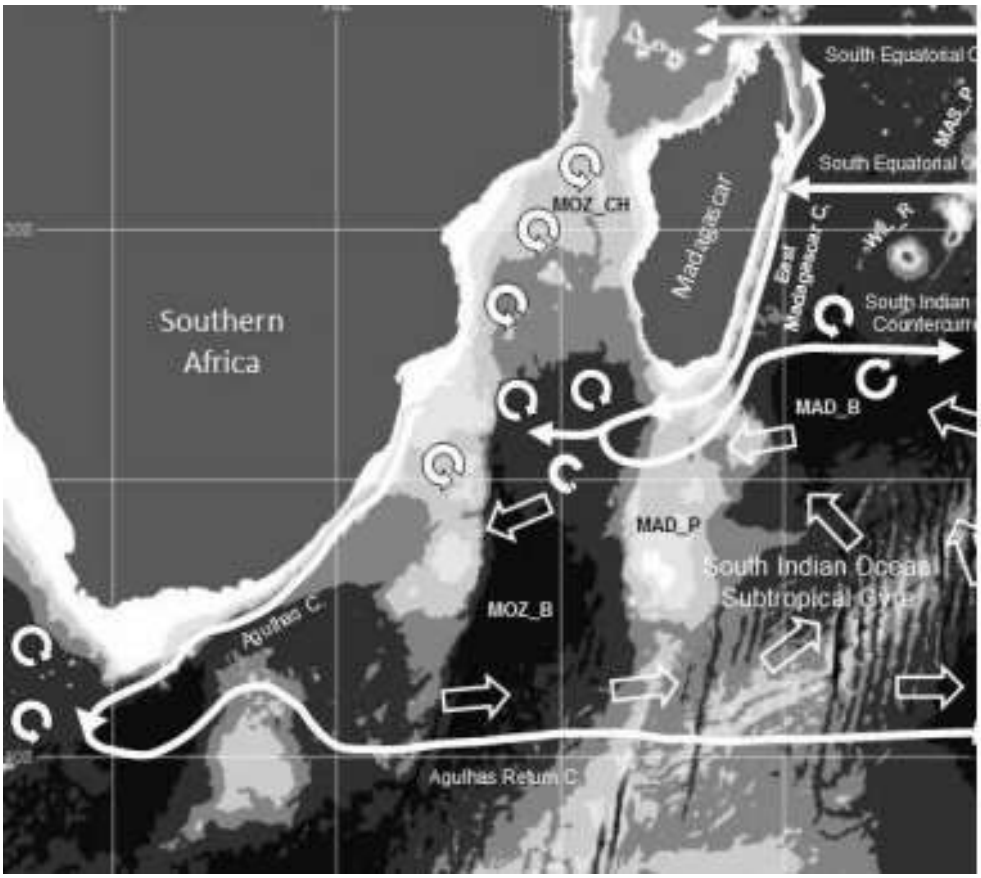
Map 8: Bathymetry of south and south-western Madagascar



2.3.3. Ocean current

The South Equatorial Current (SEC) is the main engine of surface water circulation in the Western Indian Ocean. Located between 10 and 20°S and coming from the east, it divides into two branches when it reaches the north of Madagascar. One branch goes north and bypasses the Cap d'Ambre to go down the Mozambique Channel. The other branch goes south along the east coast of Madagascar and then up the Mozambique Channel to join the Agulhas Current. This surface oceanic circulation is also influenced by the monsoon regime which causes a reversal of winds twice a year. During the austral summer, the northeast trade winds push the north and south equatorial currents westward. The waters of the SEC enter the Mozambique Channel and feed the Agulhas Current. The north and south equatorial currents meet at the Tanzanian coast and then form the Equatorial Counter Current (ECC) heading east.

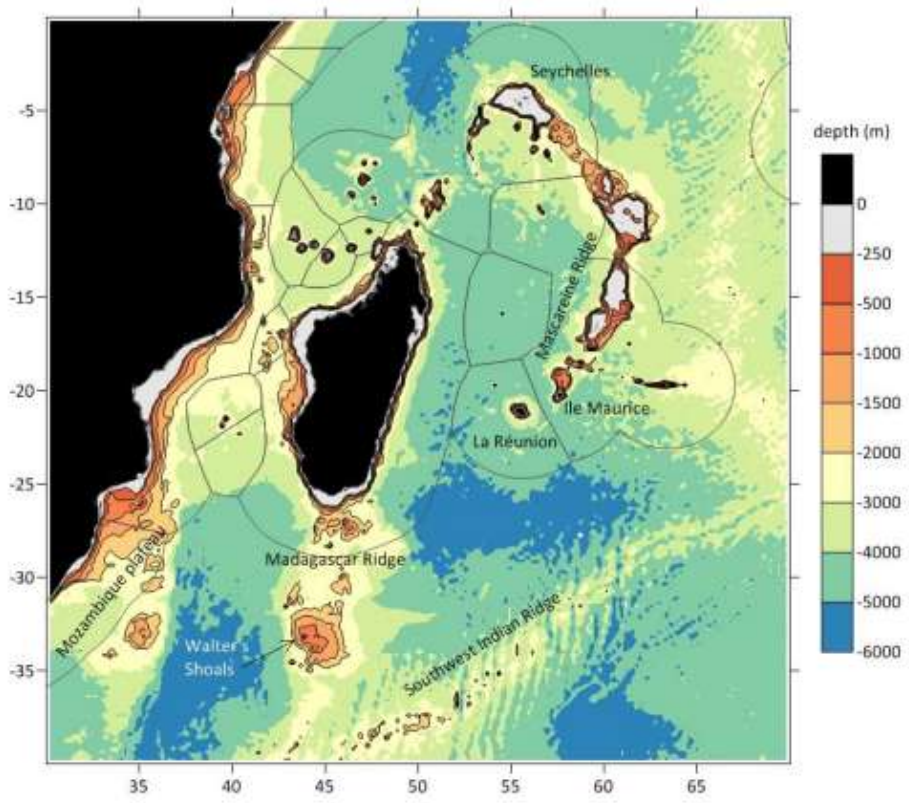
Map 9: Ocean current around Madagascar



2.3.4. Type of ocean floor

Seamounts are active or extinct volcanoes located on mid-ocean rifts or on intraplate hotspots. It has been estimated that there are 1,090 large seamounts (height > 2 km) in FAO Area 51 of the Indian Ocean (West of 80°E), of which 414 are located within the EEZs. Seamounts are concentrated along the Southwest Indian Ridge (7,700 km from Bouvet Island to Rodrigue), on the Mozambique Plateau and on the plateau that extends over 1,100 km south of Madagascar (Madagascar Ridge). Some seamounts outcrop very close to the surface, such as Walters Shoals which is 15 m deep. Other mounts closer to Madagascar are located at a depth of about 300 m. To the north of Mauritius, and up to the edge of the Seychelles, is the Mascarene Ridge with, from south to north, the St Brandon, Nazareth and Saya de Malha plateaus. The map No. 9 presented below highlights mainly the submarine reliefs rising to less than 2 km below the surface. The vast majority of the seamounts in the SOOI are located outside the EEZ. Because of their magmatic origin, the seamounts harbor mineral resources. Around the oldest reliefs, a crust made of ferromanganese oxide enriched in cobalt, copper, manganese and sulfur has accumulated. These reserves could surpass the quantities currently present on the continents, but their extraction cost is still prohibitive to be profitable. However, the situation could change in the coming decades as these resources become scarcer in continental areas.

Map 10: Ocean floors of south western Indian Ocean



Submarine features of less than 2 km deep are shown in orange and delimited by isobaths. The plateaus located at a depth of less than 250 m are indicated in gray.

Fish resources associated with seamounts have sustained significant development of deep-sea commercial fisheries since the 1960s. At the global level, the analysis of the catches, in addition to scientific campaigns, have allowed the identification of 535 species of fish associated with seamounts, 370 (70%) of which are of the demersal type, i.e. living near the bottom.

Soviet fisheries carried out from 1969 to 1998 in the SOOI involved 81 families of fish, including 4 species of Beryx (alfonsino) and the orange roughy (*Hoplostetus atlanticus*) of very high commercial value, as well as at least 13 species of endangered sharks. In addition to fish, benthic (bottom-dwelling) resources such as crustaceans (lobsters, crabs), mollusks, sponges and cold water (slow-growing) corals are also exploited. Since a large part of the seamounts are located in the open sea, their exploitation is poorly or not at all controlled which opens the way to illegal fishing activities.

2.3.5. Land elevation

Seen as a whole, Madagascar's relief is characterised by a dissymmetry along its length: (i) a narrow band with a steep slope towards the East and (ii) a wide space with little slope on the West side. This dissymmetry influences the climate, the hydrography and the vegetation.

2.3.6. Type of soil

i. Madagascar can be schematically divided into two main zones:

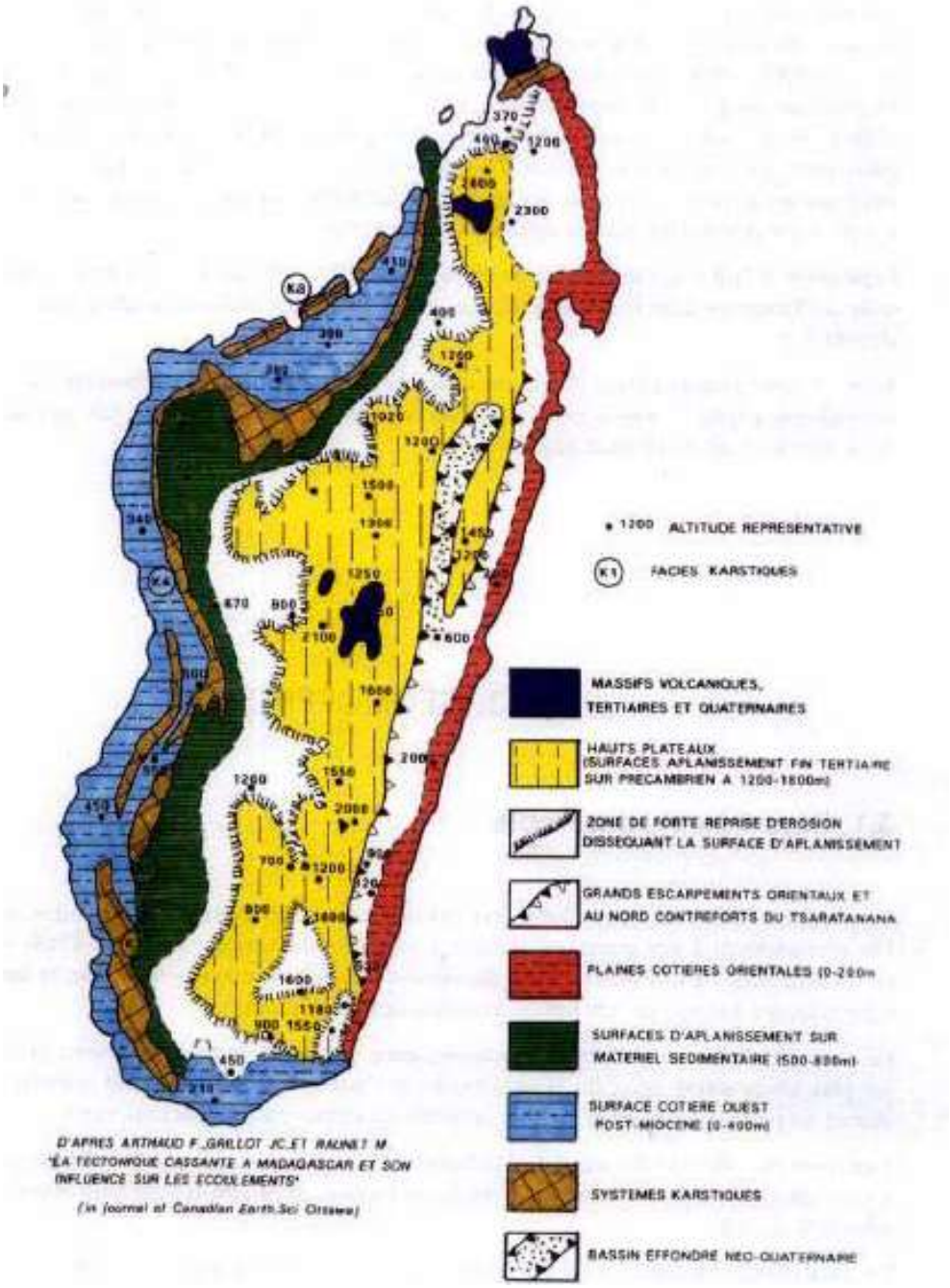
- The sedimentary formation zones located mainly in the western regions, which cover about one third of the island, and
- The "Precambrian" complex zone of igneous and metamorphic rocks, which covers about two-thirds of Madagascar and in particular the central highlands.

ii. Five basins of sedimentary formations covering a total area of 820,400 km² extend from the edge of the basement to the Exclusive Economic Zone (EEZ) off the coast. The three main basins of Ambilobe, Mahajanga and Morondava are located in the western part of the island. The two remaining small basins are both marine, namely the Cap Sainte Marie basin in the south and the East Coast basin. The sediments of Madagascar are made up of two major systems: (i) the Karroo Formation of Permian-Eo-Lias age containing thick continental sediments and (ii) the Post Karroo mainly deposited in a marine environment.

iii. Volcanism, Evidence of Cretaceous volcanism is seen in the sedimentary basins, with layered Turonian and Campanian flows. The Androy massif also results from volcanism from this era. The eastern coast, dating from the Turonian between Vohémar and the southern tip of the Masoala peninsula, is mainly made of basalts, sakalavites (silica basalt), tholeites (supersaturated quartz basalt). But in South Vohémar, there are some nepheline basalts. The flows are sometimes covered with rhyolitic flows. From the summit of Ambre; the volcanoes of the tertiary and quaternary are represented in the islands of Nosy-Be, Nosy Mitsio, the massif of Ankaizina; Tsaratanàna, Itasy and Ankaratra. In Nosy-Be, two types of ancient emissions are observed: the first of Hawaiian type with long very fluid spills, and the second giving numerous strombolian cones with ankaratrite lavas. The projections are certainly abundant, the craters-lakes being so numerous. At Nosy Mitsio, basalt, basanite and andesite flows are also observed.

The soils reflect how the geological substrates have evolved. Thus in Madagascar, they are presented in two major types: ferruginous soils for sedimentary rocks, and ferralitic for the crystalline basement (Raharimalala, 2013). In general, the soils in priority areas are conducive to certain crops, allowing the population to practice agriculture and farming.

Map 11: Geomorphological schema of Madagascar



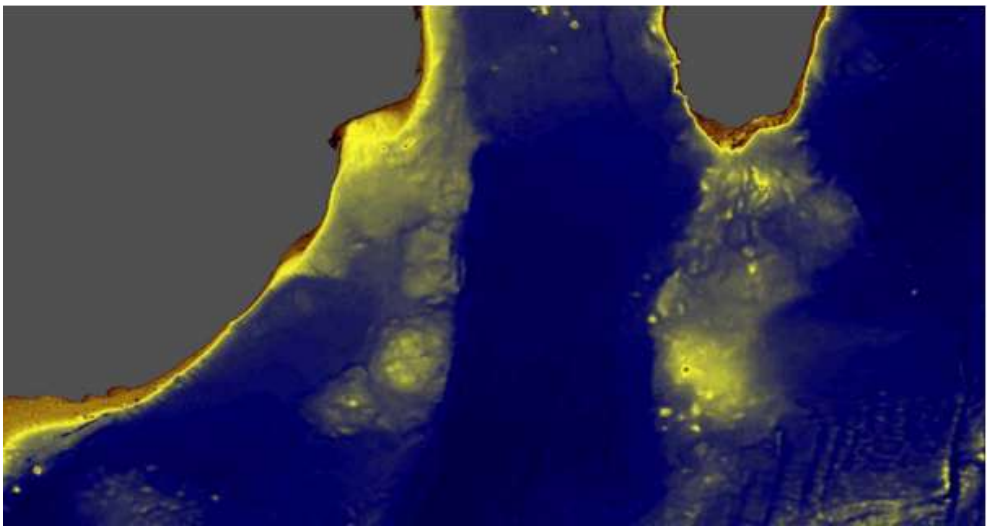
2.3.7. Seamounts/Knolls

A system of three mid-oceanic ridges (MOR) of active accretion, the Central Indian Ridge (CIR), the Southwest Indian Ridge (SWIR) and the Southeast Indian Ridge (SEIR) (Das et al, 2005) characterizes the Indian Ocean with its total area of 74 × 106 km².

The South West Indian Ocean (SWIO) region corresponds to the marine ecoregion of the western Indian Ocean that includes mainly one island, Madagascar, and several archipelagos such as the Comoros, Mascarene Islands and Seychelles, each with different origins and ages (Spalding et al., 2007). The African landmass, the Madagascar microcontinent, and the northern Seychelles Bank are fragments of the supercontinent Gondwana, which dates from the Precambrian era over 650 million years ago and began to break away 180 million years ago.

Madagascar's Rift comprises a massive bottom rise, which extends between the Madagascar Island microcontinent and the SWIR for a distance of nearly 700 miles. The ridge of the oceanic rift is broad and displays depths of 1,000 to 2,500 m (up to 567 m at seamount locations). Walters Bank (less than 20 m) is the minimum depth. It was discovered in 1963 by the South African hydrographic frigate SAS Natal, and is named after its commandant.

Figure 4: Illustration of Walters bank



This Walters Bank is located on the Madagascar Rift, 450 nm south of Madagascar and 700 nm east of South Africa, Bathymetry in m. © IRD Sète, Hervé Demarcq. ETOPO1 (one arc minute resolution). Logarithmic scale for depth.

2.3.8. Hydrothermal vents

The hydrothermal food web is based on the production of chemoautotrophic microbes (Cavanaugh, 1983; Jannasch, 1984), which use reduced compounds from the fluids produced by hydrothermal springs to fix carbon dioxide contained in seawater.

Hydrothermal plumes (indirect evidence) were first identified along the Southwest Indian Rift (SWIR) in 1997 (German et al., 1998), but the first source was only discovered by an autonomous underwater vehicle in 2007 (Tao et al., 2007). Two separate sites were recently discovered in the SWIR (Rogers et al., 2012; Tao et al. 2012). Tao et al. (2012) discovered for the first time an active source on the SWIR rim, which strongly supports the hypothesis that a high-temperature hydrothermal circulation is widespread along all ultralong oceanic rims (German et al., 1998; Baker et al., 2004). Indeed, four hydrothermal sites and two hydrothermal anomalies have been identified in the SWIR section between 49°E and 52°E (Tao et al., 2012). During a 2007 expedition, the Autonomous Benthic Explorer (ABE) recorded several organisms, including mussels, *Chrysomallon squamiferum*, pedunculids, and sea anemones. *Chrysomallon squamiferum* is currently only known from hydrothermal springs on the Central Indian Rift (CIR) (Hashimoto et al., 2001; Van Dover et al., 2001). Furthermore, the apparent absence of shrimp, which dominate the springs studied on the Mid-Atlantic Rift (MOR) and Central Indian Rift (CIR), would suggest that the full suite of biomass-dominant taxa present at this site has not been observed. Large gastropod species *Alviniconcha* spp., *Ifremeria* spp. were not also found.

As noted by Rogers (2012), our knowledge of the distribution of seamounts and hydrothermal springs remains poor; it is unfortunate that there is a lack of sampling on seamounts at equatorial latitudes.

2.3.9. Extent of the continental shelf

The ocean floor is reached at a depth of about 4,000 meters and extends over the ocean basins to depths of up to an average of 5,000 meters. This is the abyssal plain. The area between the continental shelf and the abyssal plain is the bathyal zone. In some places, the ocean floor forms elongated

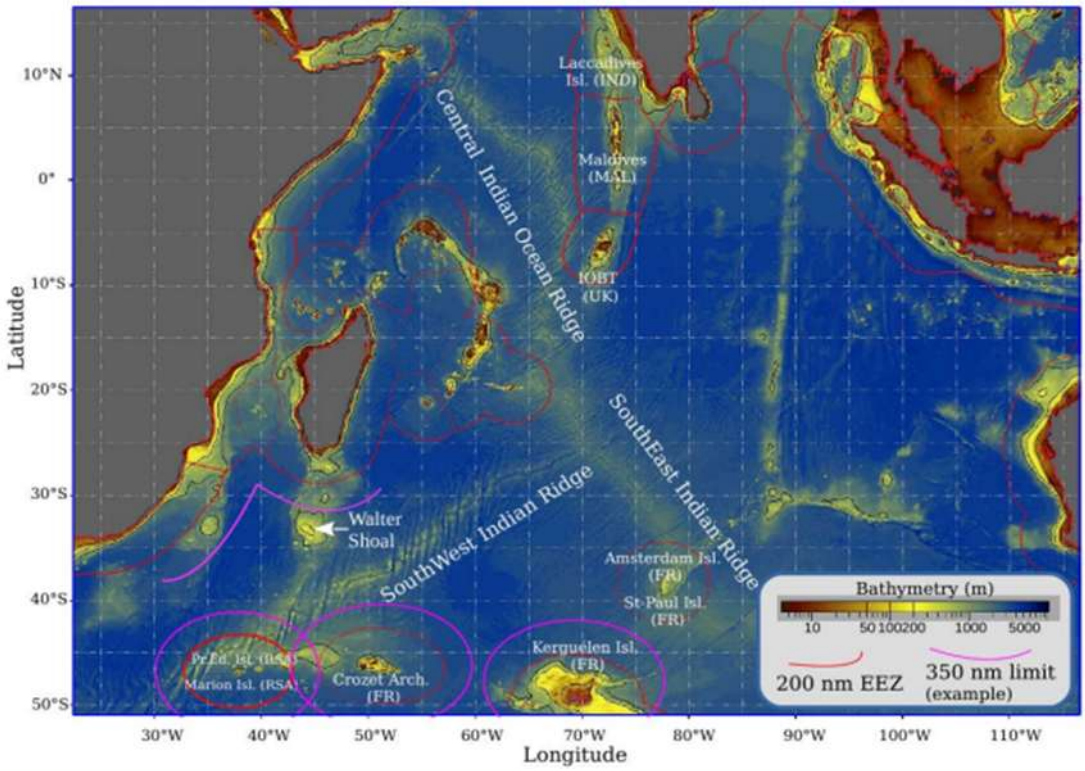
trenches at 10 to 11 km depths. This region is the hadal zone. Interrupted by a mountain range known as the mid-oceanic rift, the ocean floor also has other formations: seamounts and hydrothermal vents (Kaiser et al., 2005).

A seasonal upwelling also develops on the continental shelf south of Madagascar (Machu et al., 2002), which can provide biological production (plankton) to the northern part of the Madagascar rift.

2.3.10. Extent of 350 nm

The main bathymetric features of the western Indian Ocean are presented in Map 11 with the 200 nautical mile (nm) exclusive economic zone boundaries as well as the 350 nm limit considered for the extension of the exclusive economic zone. The Madagascar rift, south of the island of Madagascar, is of particular interest in the SWIO. It consists of several seamounts, including Walters Bank, whose summit (located at 32°30'S / 44°E) reaches 18 m below the sea surface. An isolated and remarkably high structure, Walters Bank lies outside the current (and potentially extended) exclusive economic zone.

Map 12: The extent of 200 nm and 350 nm



2.4. Freshwater resources and drainage, including rivers, groundwater, springs, estuaries, deltas and coastal lakes

2.4.1. Freshwater resources and drainage

The shapes of the Malagasy hydrographic network present a very great variety as a result of the geomorphological context of the Big Island. Its essential features are the following (Chaperon and al, 1993): (i) protrusion of the most resistant rocks and structural lines by prolonged differential erosion on the old basement which is made of metamorphic rocks and intersecting volcanic veins ; (ii) presence of a polycyclic relief with ancient flattening surfaces, the Tampoketsa, currently shaped by recent erosion resumption on the Central Highlands, often very thick alteration mantle, deeply attacked by accelerated erosion forms (Lavaka). Its presence sometimes attenuates, to a large extent, the structural influences; (iii) sedimentary basin of the West presenting a weak dip towards the sea and its series of concordant layers taken up by the differential erosion gave a relief of "cuestas" characteristic ; (iv) continuous peripheral depression, in the West of the basement, due to the erosion of the discordant layers of the sedimentary cover or sometimes, also, to faults; (v) finally, fundamental geological and geomorphological dissymmetry perpendicularly to the great axis of the island immediately visible on physical maps.

2.4.1.1. Major natural hydrological units

On the eastern slope, the main rivers and streams that flow into the sea are: the Mananara and the Mangoro running from the central land and crossing the eastern coast towards the sea. The Maningory takes its source on Lake Alaotra. The Bemarivo, the Ivondro and the Mananjary are also other rivers of the eastern slope that reach the Indian Ocean. Due to the steep slopes on the cliffs, which give the rivers of the slope an important hydroelectric potential (already well exploited) and despite a dense forest cover, the flood flows are very high. The median specific peak flows are between 300 and 1,200 l/s/km², and the decennial flows are between 1,000 and 2,700 l/s/km². Even higher values are observed in the small high altitude basins of the extreme south of the slope (Efaho 2,200 l/s/km², median and 4,900 l/s/km², decennial).

The unit corresponds to the basins of the western slope located on the edges of the ancient basement at an altitude below 1,000 m and on the sedimentary cover. It includes the Sambirano, Mahajamba, Betsiboka (the port of Mahajanga is located in the mouth), Mania, Mahavavy South and North, Mangoky and Onilahy. The Ikopa, which flows through Antananarivo, feeds the Betsiboka. Regarding the watershed, the Mangoky occupies 50,000 km² (19,000 sq mi); the Ikopa and the Betsiboka have respectively 18,000 and 11,000 km² (7,170 and 4,560 sq mi). The Mandrare, which is the major river in the south has a 12,435 km^2 (4,803 sq mi) watershed though it is intermittent.

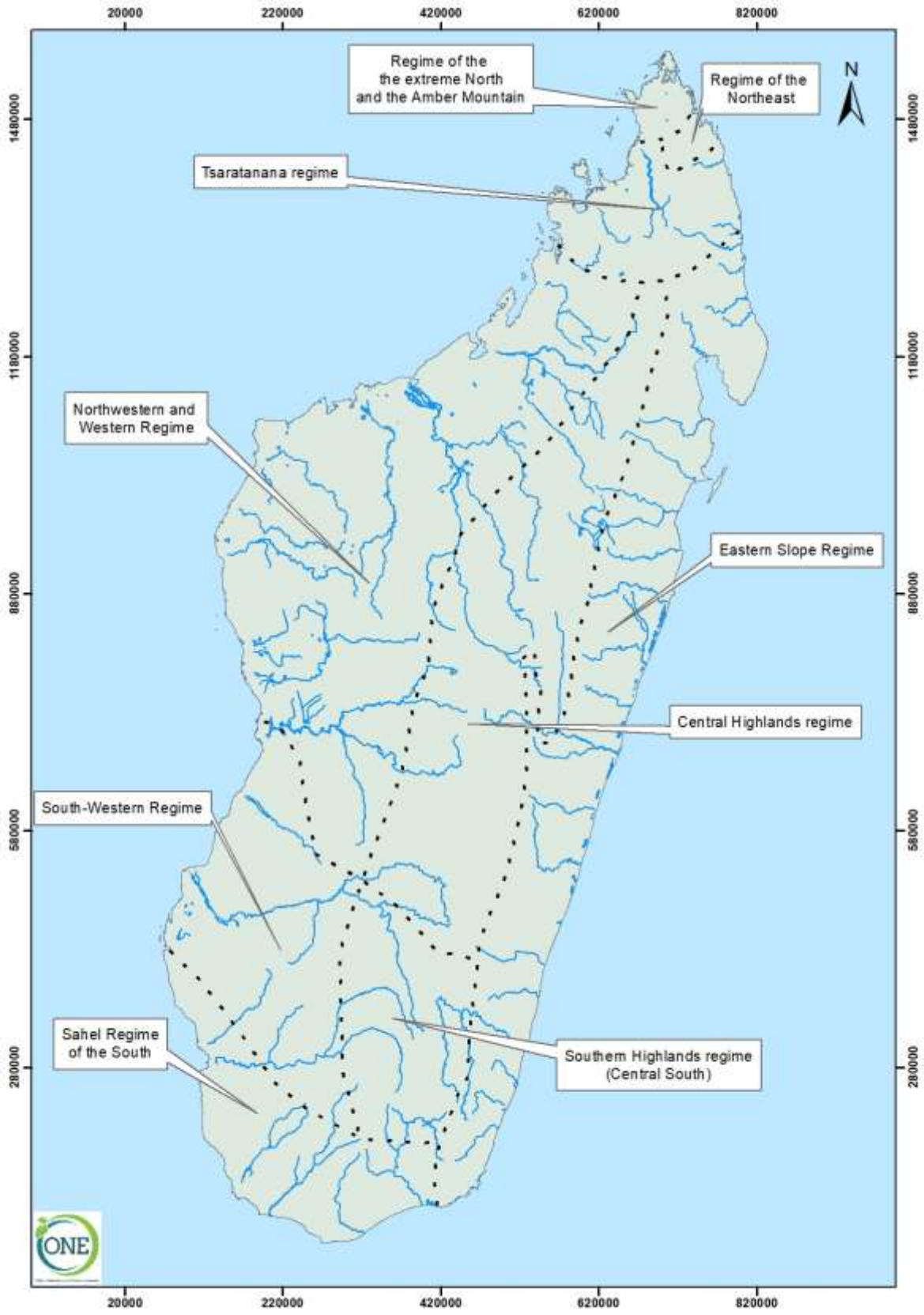
2.4.1.2. Drained reserves and Drainage rates

The geographical distribution of drained reserves matches the distribution of rainfalls: the highest values (100 to 200 mm) are located on the basins of the eastern slopes, then on the eastern highlands and the western slopes of Tsaratanàna. Intermediate values (50 to 100 mm) are for the western and southern sectors of the highlands; the reserves of the southwestern basins (Mangoky) are even lower (25 to 70 mm). Finally, these reserves are practically non-existent in the South. As for the drainage rates, they are also, but to a lesser extent, diversified and regionalized. The highest rates (Tc less than one month) are observed for the poorly developed aquifers of the southern basins of the West (Mandrare) ; on the basins of the West and the high plateaus as well as for Tsaratanàna, the characteristic times range from two to three months whereas they are between three and four months on the eastern slope. It seems, however, that the slowdown observed on this slope is mainly due to the disruption of the natural drying up caused by the numerous partial recharges of the waterground during the cool season than to the nature of the storage. In this case, it is not real drying.

Five major hydrological regime units can be identified (Chaperon et al, 1993):

- Northern regimes, where one can distinguish: i) the extreme North and the montagne d'Ambre; ii) the Tsaratanàna massif and its borders; iii) a small intermediate Northeast sector between these two massifs.
- The regimes of the eastern slopes,
- The highland regimes, where one can distinguish: i) the central highlands between Tsaratanana in the North, Andringitra in the South and generally grouping the edge of the great cliffs of the West with the "high plateaus" situated at an altitude of more than 1,000 m; ii) the southern highlands (central South) between Andringitra in the North, Ivakoany in the South, Ambalavao in the East and Isalo in the West. At a more moderate average altitude, this sector corresponds to a relief that is still quite stressed and more contrasted than in the Central Highlands, with alternating mountainous chains and massifs and deep valleys;
- The regimes of the western slopes, where one can distinguish: i) the North-West and the West, from the Maevarano basin in the North to the Tsiribihina basin in the South; ii) the South-West, from Morondava in the North to the Mangoky basin in the South, mostly on sedimentary formations.
- The southern regimes, from the Lower Mangoky to the Mandrare.

Map 13: The main hydrological regimes of Madagascar



Source: Fleuves et rivières de Madagascar, 1993

Table 4: Characteristics of the main hydrological regimes of Madagascar

Characteristics of the regions	Climate	Rainfall (mm)	Humidity (mm)	DE (mm)	Ke (%)	Median flood discharge	Median low flow	Year-on year irregularities (M/m)	Observations
Extreme north and Montagne d'Ambre	Perhumid	1,500 to 3,300	6 to 700	1,500 to 1,900	25 to 30	100 to 300	5 to 6	8 to 10	Steep slope by permeation, rainfall ranging from 500 to 800mm
Massif of Tsaratanana	Perhumid	2,000 to 3,500	1,200 to 1,800	850 to 1,200	50 to 60	300 to 800	3 to 7	15 to 20	Hydrological features lower on NS axis compared to SW axis.
Eastern slope	Perhumid	2,000 to 3,000	1,300 to 3,000	1,100 to 1,200	50 to 70	300 to 1,200	15 to 30	5	Weaker low-flow outputs and inter monthly irregularities stronger in the South
Central high lands	Humid	1,200 to 1,500	800 to 1,000	800 to 900	30 to 50	120 to 300	3 to 8	5 to 10	Weakening of the hydrological features from East to West
Southern high lands	Subhumid to semi-arid	800 to 1,000	380 to 700	600 to 700	30 to 45	100 to 200	Around 1	10 to 20	Take note of the east-west gradient as H.T.C
West and North West slopes	Humid to subhumid	1,200 to 1,800	390 to 900	700	35 to 40	100 to 500	1 to 2	15 to 25	Flood and low-flow inputs are higher on the reliefs (Bemaraha, Kamoro)
South-Western slope	Semi-arid	500 to 800	100 to 200	600	10 to 20	Uneven	0 to 1	35 to 40	Low-flows outputs are very low except in the Isalo region (strong low- flows)
South	Arid	350 to 600	50 to 150	400 to 600	10 to 15	150 to 300	0 to 1	50 to 100 and more	Very weak low-flows outputs on the basement and

									none on the small bassins.

Source: Fleuves et rivières de Madagascar

Nota: The figures for the southern flood outputs are given as indicators (estimates). The figures that are available are uneven within a region and depend mostly on local features (relief, geomorphology, vegetation, etc). Yearly P.: average annual rainfalls (mm) ; Humidity per year: the sum of the surface and through drainage runoff (mm); DE: runoff deficit (in mm) ; Ke(%): runoff coefficient.

2.4.1.3. Lotic environments

Lotic environments correspond to running water environments such as rivers and streams. The hydrographic network of Madagascar covers a total length of more than 3,000 km if we only take into account rivers above 10 m wide (Source: RAEM, 2017).

Table 5: State of some rivers in Madagascar

Type (rivers or very long rivers)	Length (in km)	Time of floods	Time of low flows	Present condition (stream bed change, drying up or silting)	Pollution: (discharge of polluting or non-polluting substances)
Ivondro	150	February, March	August – December	Stream bed change, drying up or silting	Waste oil or hydrocarbon
Ivoloina	90	February, March	August – December	Stream bed change, drying up or silting	Waste oil or hydrocarbon
Onibe	180	February, March	August – December	Stream bed change, drying up or silting	Faeces
Ifontsy	87	February, March	August – December	Stream bed change, drying up or silting	Faeces
Namaharana	59	February, March	August – December	Stream bed change, drying up or silting	Faeces

2.4.1.4. Coastal lakes

The main bodies of stagnant fresh water are mainly from continental and coastal lakes. They presently cover a total area of about 2,000km². There are about 1,300 lakes (lagoons included) listed on the

Malagasy territory. The main coastal lakes are located in the eastern region of the island. It is actually a chain of lakes which are linked by artificial channels and which build up the ***channel of Pangalanes*** that flows all along the coast, over a distance of more than 600 km.

(Source RAEM 2017 – chapitre 5: Eaux douces)

2.4.1.5. Freshwater marshes and swamps

They are spaces where shallow water masses from water tables, springs, streams or runoff water accumulate in more or less permanent way. These marshes and swamps are mainly present among wetlands because of their large number and surface area.

2.4.2. Groundwater

There are eight groups of groundwater in Madagascar according to their location (Table 6). Each group counts about 3 to 10 aquifers. They are in large numbers within the sedimentary basins of the West and South of the island. In the same axis and along with that of the East coast, the dominant lithology is of sandy, argillaceous and sandstone type while there is a crystalline basement in the high plateaus and in the extreme South. Depending on the lithology of the water table, the porosity type can be porous, fissured and karstic whereas the watertable type can be captive, free and artesian. The water quality changes for each aquifer.

The table below is a summary of **Appendix 1** and gives details on the groundwater.

Table 6: Summary of groundwater

	Number of groundwater	Lithology	Porosity type	Type of the ground water	Water quality
Highlands with high rainfalls rates (north and center parts)	4	Clayey sand, crystallin basement and volcanic projection	Porous	Captive and free	Fresh water, high proportion of iron content
Highlands with weak rainfalls rates (southern parts)	3	Clayey sand, crystallin basement	Porous and cracked	Captive and free	Brackish to saline water; high proportion of iron content, saline water
Sedimentary basin of the extreme south	8	Sandy sandstone, clayey sand, crystallin basement	Porous and cracked	Captive and free	Fresh, brackish to saline water, high proportion of iron content
Sedimentary basin of toliary	10	Clayey sand, fine sand, sandy sandstone, limestone, sandy sand	Porous and karstic	Captive and /or free	Fresh, brackish, bicarbonate-calcic
Sedimentary basin of morondava	9	Fine sand, clayey sand, sandy sand ; marly sandstone, sandy sandstone	Porous and karstic	Free or captive or artesian	Fresh, brackish to saline

	Number of groundwater	Lithology	Porosity type	Type of the ground water	Water quality
Sedimentary basin of mahajanga	9	Clayey sand, fine sand, limestone, sandy sandstone, sandy sand	Porous and karstic	Free or captive or artesian	Fresh, brackish, bicarbonate-calcic
Sedimentary basin of antsiranana	5	Clayey sand, fine sand, basalt, limestone, sandy sand	Porous and cracked	Free or captive or artesian	Fresh to brackish, bicarbonate-calcic
Sedimentary basin of the east coast	3	Clayey sand, fine sand, clayey sandstone	Porous	Free or captive or artesian	Fresh to brackish, high proportion of iron content

Source: RAEM 2017 – Chapter 9 – Seas, Oceans and coastal zones

2.4.3. Estuaries and deltas

By definition, an estuary is the downstream part of the river bed as far as the limit of influence of the tides (Larousse), or the lower course of rivers carried over a certain distance by the tide (Francis-Boeuf, 1947), or a form of coastline characterized, depending on the tide, by a penetration of marine waters in the downstream zone of rivers (Paskoff, 1985). This refers to the zone of influence of marine waters on fresh waters. UNESCO defines an estuary as "semi-enclosed volume of coastal water that connects freely with the open sea, at least intermittently, and within which the salinity is measurably different from that of the adjacent sea water".

A delta or a mouth, is the roughly triangular shaped alluvial accumulation area built by a river upon its arrival in a low tide sea or lake. To distinguish between an estuary and a delta, it is essential to look at the amount of material brought by the river or stream to the coast/sea as well as the marine and fluvial hydrodynamics. (www.u-picardie.fr/beauchamp/cours-sed/sed-10.htm).

This dissociation cannot be maintained in western part of Madagascar. Indeed, both estuaries and typical deltas can be seen; if not both at the same time (examples: Betsiboka and Mahajamba). "The estuary of Betsiboka can be considered as double, formed by a deltaic zone with mangrove followed by a deep marine bay corresponding to an ancient submerged valley" (Lafond, 1957). In addition, the tidal range reaches 3 m during spring tides on the west coast and more than 4 m on the northwest coast. Moreover, the influence of the tide is felt as well in the estuaries as in the arms of deltas with much weaker slope, especially during the dry season when the low water level is pronounced (Hervieu, 1966). Thus, the importance of the sandy bars, making the whole formation prograde towards the sea, transforms the estuary into a delta.

Depending on the tidal range at the mouth, the estuaries of Madagascar are classified into:

- Microtidal estuaries: tidal range less than 2 m; the estuary is dominated by the action of wave agitation. Case of the estuaries on the eastern coast of Madagascar.
- Mesotidal estuaries: tidal range between 2 and 4 m, case of the estuaries of the southwest and west coast.
- Macrotidal estuaries: tidal range higher than 4 m, dominated by tidal currents; case of the estuaries of northwestern Madagascar.

As for deltas, Wright (1985) acknowledged that no classification could adequately encompass the wide variety of environments and structure which are found in deltas all over the world because each delta is unique.

2.5. The main hydrographical basins, factors that influence the output of water course, impact on the downstream ecosystems, management interventions

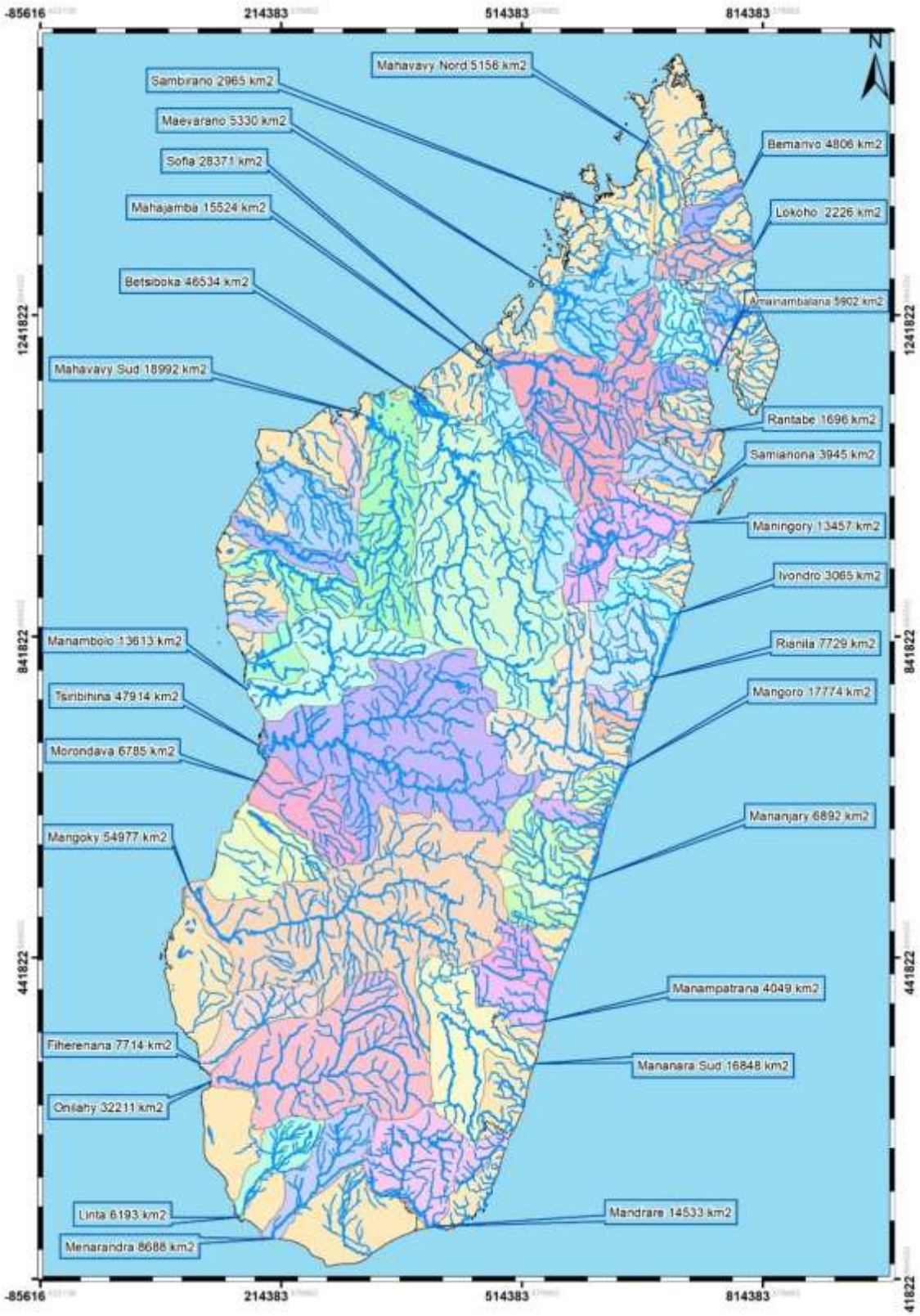
Madagascar is naturally divided into 5 large basins whose surfaces are largely unequal. These 5 big basins are linked with, or even similar to the climatic regions of Madagascar. Each of them has its own hydrological regime.

Map 14: Delimitation of the five natural slopes of Madagascar



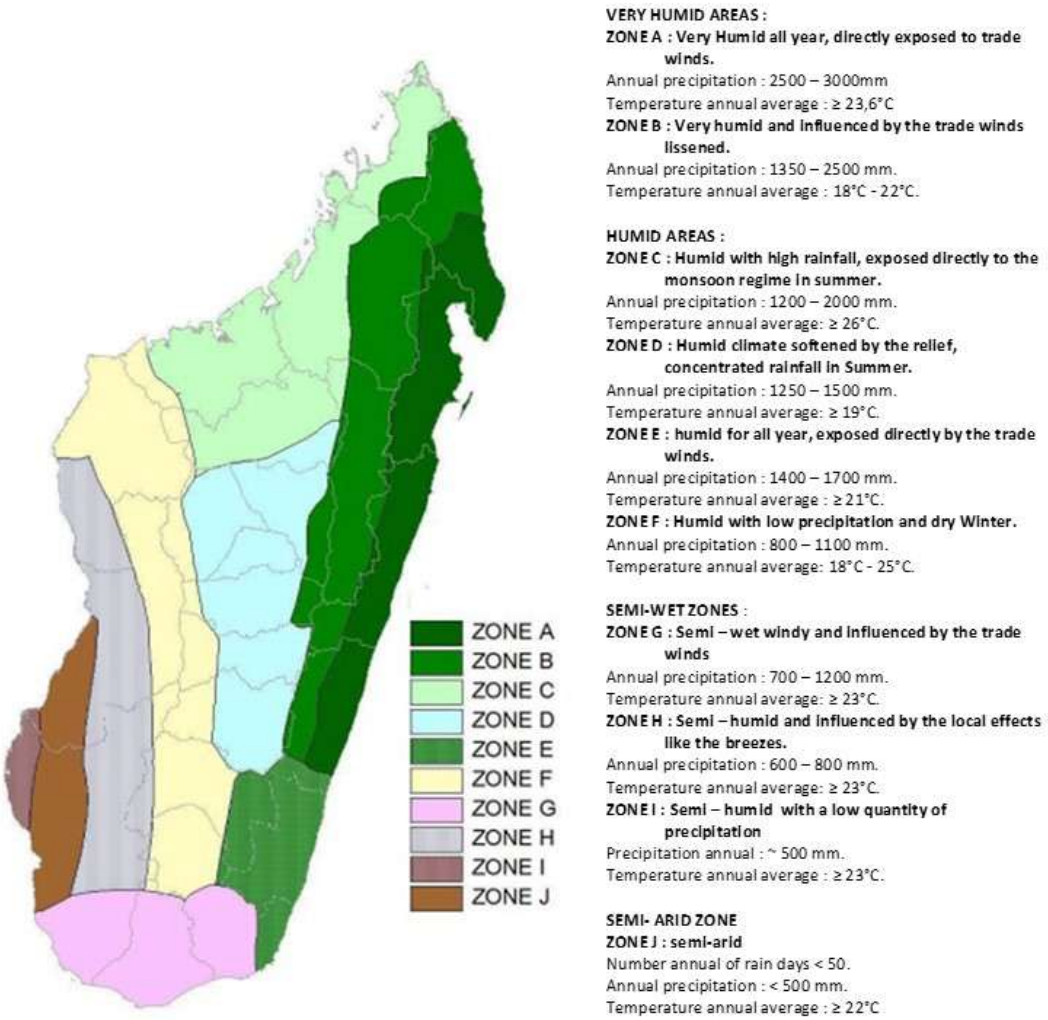
Source: General Direction of Meteorology, Antananarivo-2012

Map 15: The main hydrographical basins of Madagascar



Source: General Direction of Meteorology, Antananarivo -2012, republished by ONE - 2020

Map 16: Climatic delimitation of Madagascar



Source: General Direction of Meteorology, Antananarivo-2012

2.5.1. Montagne d'Ambre slope (RAEM 2017)

This volcanic massif is drained by small torrents which have not really developed and which have no notable tributaries flowing in beds cluttered with basalt blocks. The main rivers on the frontage are the Irodo, the Saharenene and the Besokatrae and in the western frontage are the Sandrapia, the Andranojaby, the Sahinana and the Antsandrotoana. The whole slope represents approximately 11,200 km², that is to say 1.8% of the surface of the island.

2.5.2. Tsaratanana slope (RAEM 2017)

The rivers affect a device radiating around the peaks and then head east towards the Indian Ocean and west towards the Mozambique Channel. The slopes are steep (30 km to 40 km) but in contact with sedimentary formations. The main rivers are the Mahavavy with only one affluent (Atsiatsia), the Sambirano which joins the Ramena, the Maevarano which flows into the LOZA bay, the mother branch of the Sofia which first flows towards the South and finally the Bemarivo and Lokoho. The whole of the slopes represents approximately 20,000 km², that is 3.3% of the surface of the island.

2.5.3. Eastern slope (RAEM 2017)

The rivers are mostly of fairly short length and present very accentuated profiles before running, on the narrow coastal plain, to the dune ridge that limits the Canal des Pangalanes, parallel to the coast. The main rivers are the Ivondro, the Rianala, which is joined by the Vohitra, the Iaroka and the Rongaronga, the Mananjary, joined by the Ivoanana, the Namorona, the Faraony, the Matitanana and the Manampatrana. Three rivers have a particular layout: the Maningory from the outlet of Lake Alaotra, the Mangoro with its main affluent the Onive, the Mananara Sud formed by the 3 rivers of the Ionaivo, the Itomampy and the Menarahaka. In the north where the rivers flow into or near the bay of Antongil are: the Ranofotsy, the Antainambalana, the Rantabe and the Mananara. The whole slope represents approximately 150,000 km² or 25.2% of the surface of the island.

2.5.4. Southern slope (RAEM 2017)

It includes the rivers coming from the southern end and heading towards the southern coast of Madagascar. These are the Mandrare, joined by the Manombolo and the Mananara, the Manambovo, the Menarandra with the Manantanana and the Menakompy, the Linta. The whole of the slope represents approximately 48.800 km² or 8.2% of the surface of the island.

2.5.5. Western slope (RAEM 2017)

This is the most developed slope. It includes the largest Malagasy rivers; those with a triangular shape basins, a base located on the highlands and a top that rests on the coast of the Mozambique Channel. The big rivers are:

- The Sofia with its main affluents: Mangarahara, Anjobony, Bemarivo
- The Mahajamba
- The Betsiboka, with the Mananara and the Isinko. Its main affluent being the Ikopa.
- The Mahavavy South
- The Tsiribihina with its main affluents: Sakeny, Mahajilo-kitsamby, Mangoky
- The Mangoky formed by the union of Zomandao rivers joined by the Ihosy, the Manantanana and the Matsiatra.
- The Onilahy from the union of the Isoanala, the Ihazofotsy, the Mangoky and the Imaloto.

The slope as a whole represents approximately 365,000 km or 61.3% of the surface of the island.

The present evaluation is about the quantity of fresh water that goes to the outlet of sub-watershed. This quantity is composed of water runoff during rainy periods and groundwater that constantly feeds the networks through the existing springs.

Table 7: Quantity of water flowing to the outlet in some sub-hydrographical basin of Madagascar

Watershed	Area (km²)	Outlet	Longitude	Latitude	Quantity of water available (m3/year)
Betsiboka	11,800	Ambodiroka	46°56'55"E	16°55'20"S	8,969,364,000
Ikopa	18,645	Antsatrana	46°52'33"E	17°25'04"S	14,676,854,400
Sambiano	2,830	Ambanja	48°28'00"E	13°41'00"S	4,191,300,379
Mangoky	53,810	Bevoay	43°52'18"E	21°50'10"S	18,180,504,000
Tsiribihina	45,014	Betomba	44°58'00"E	19°42'00"S	33,116,913,391
Onilahy	27,815	Tongobory	44°19'00"E	23°21'00"S	3,794,175,000
Menarandra	5,328	Tranoroa	45°04'00"E	24°42'00"S	809,615,127
Manambovo	2,712	Tsihombe	45°30'00"E	25°18'00"S	144,883,023
Mandrare	12,435	Amboasary	46°22'38.41"E	25° 2'24.07"S	2,212,187,328
Ivondro	2,580	Ringaringa	49°15'00"E	18°10'00"S	3,515,852,661
Morondava	4,638	Dabara	44°51'22.02"E	20°27'31.02"S	1,695,936,000
Rianila	5,996	Brickaville	48°56'51.96"E	18°58'54.73"S	11,144,034,000
Mangoro	3,600	Mangoro Gare	48° 6'51.39"E	18°52'42.06"S	2,961,821,700
Mananjeba	1,140	Marivovonana	49°07'00"E	13°05'00"S	754,761,600
Mahavavy Nord	3,210	Niveau canal GR	49° 3'0.04"E	13°12'4.80"S	2,972,793,600
Maevarano	2,585	Ambodivohitra	48°32’00"E	14°36‘00"S	1,386,883,200
Maningory	6,855	Andromba	48'38'20"E	17"24'10"S	2,906,042,400
Onive	3,225	Tsinjoarivo	47°40'9.18"E	19°37'53.61"	2,416,870,523
Mananjary	2,260	Antsindra	47°43'38.28"E	20°59'3.17"S	4,207,352,914
Faraony	2,005	Vohilava	47°56'37.05"E	21°46'45.10"S	4,078,393,200
Mananara Sud	14,160	Marangaty	46°58'24.71"E	22°56'27.47"S	7,306,891,200
Efaho	196	Fanjahira	46°53'46"E	24°54'36"S	381,769,560
Sofia	4,100	Antafiantsalana	48°37'55.42"E	15°29'1.96"S	2,171,516,400

The indicated 23 hydrographical basins have 133,996,715,607 m^3 of fresh water per year. The total area of these sub-basins measures 236,939 km², or 40.34% of the surface area of Madagascar.

The sub-basin of Ivondro located in Ringaringa and that of Maevarano in Ambodivohitra have the same surface. A comparison of the water available in the two sub-basins shows the abundance of water in the eastern slope. In the south, the small watershed Ifaho in Fanjahira (196 km²) has 2.6 times more water than the Manambovo in Tsihombe which measures 2,712 km².

The analyses carried out in the 4 sub-basins mentioned above justify how much the climate impacts on water resources.

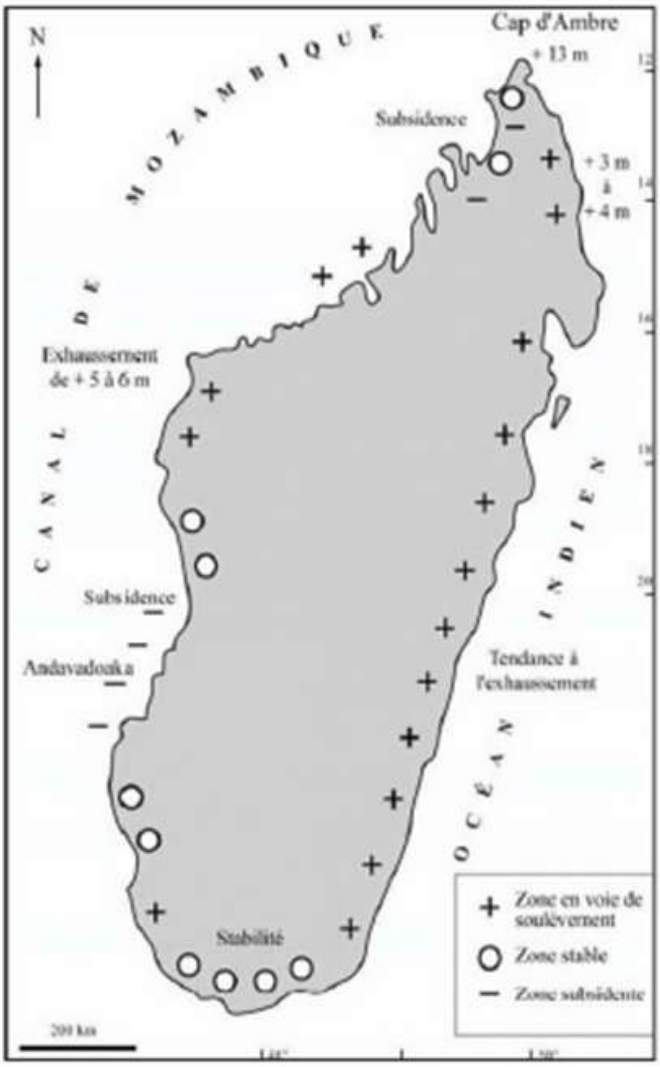
2.5.6. Effects of climate change

2.5.6.1. Erosion and coastal degradation (Source: RAEM 2017)

The variability in climatic seasons, surface temperature and sea level rise, the frequency of high intensity tropical cyclones as well as the existence of subsidence and backwater areas on the coasts of Madagascar model the current situation of the different coastal areas. They pose as many particular cases on the problems generated by climate change and the responses of the local population as well as the regional or national governments.

The eustatic and tectonic movements as well as the relative variation of the sea level influence the future of the coasts. Salomon (2009) described the general trends of the first factor (Map 17).

Map 17: Tectonic movements on the coast of Madagascar



Source: SALOMON, 2009

2.5.6.2. Erosion and degradation of the eastern coastline

On the eastern coast, the trade wind blows all year round and the swell and the waves it generates do not allow the sediments to progress. This constant swell has built an immense and perfectly regulated coastline behind which marshy areas and ponds have established. During the arrival of cyclones, the waves can completely modify the profile of the coast.

The phenomenon of marine erosion due to frequent cyclones combined with intense anthropic activities, notably destructive fishing methods, constitutes the main threat to the coral reefs of the East coast. Every year, the coastal areas of Toamasina undergo several cyclones which are accompanied by heavy rainfall, and cause coastal erosion phenomena. The global erosion between 1986 and 1996 contributed to the recession at sea of 125 m to 160 m, that is to say an average erosion of 12.5 to 16 m per year over ten years.

2.5.6.3. At the level of Toamasina

The results of hydrodynamic studies have shown that the closure of the Southern Pass and the intensification of cyclones have caused coastal erosion and sedimentation of the roadstead. In addition to the phenomenon of coastal erosion, soil degradation is also happening within the city limits. The

flow of water from the Pangalana canal is partly blocked, even if it has been able to absorb stagnant water from the surrounding neighborhoods (Tanamakoa, Ankirihiry Est, Analankininina, Hôpital Be).

Figure 5: Erosion of the coast in Toamasina (East coast of Madagascar)



Source: Razafindrainibe, 2016

2.5.6.4. At the level of Mahanoro

The coastal forest that protects the coast and the town of Mahanoro has disappeared. Therefore, the coastline is directly exposed to marine erosion and flooding (in case of heavy upstream rainfall). The erosion has attacked the basement of the large bridge which links the city to the other districts Marolambo, Nosy Varika, Mananjary located at the mouth of the river. The southwestern part of the city is often submitted to the advance of the river through the Pangalana canal (loss of 10m of land) and will potentially disappear within the next ten years. The Fokontany Salehy located at 10km south of Mahanoro is threatened by the silting up (caused by the erosion of the bare soil) which blocks the entrance of the Mangoro River in the Pangalana canal.

2.5.6.5. Erosion and degradation of the Boeny coastline, western coast

On the western coast, the multiple cuts and indentations open up to sediment accumulation, particularly in the northwest. The strong tidal currents (tidal range up to 5m) can take up the already settled sediments (hence the problems of coastline recession in some places), but the swells, affecting the western shores are more modest and less regular. At the end of the morning, the sea breeze develops short waves that can shape the beaches. The erosion phenomena on the Boeny coast after the change of Antsahanibingo river bed have affected inhabited coastal areas and destroyed part of tourist villages. Violent cyclones cause significant damage or even flooding as was the case in 1984 (cyclone KAMISY). The coastal protection works along the Boulevard Poincaré in Mahajanga were destroyed on 1,7 km after the ELITA and BONITA cyclones in 2004.

Figure 6: Erosion around the tourist village and the development of a sandy spit



2.5.6.6. Erosion and degradation of the Morondava, Menabe coastline, western coast

In Madagascar, the case of the City of Morondava, located in the south of the Tsiribihina and Manambolo mangroves, clearly depicts the effects of climate change. A modeling that was carried out shows that an annual rise of more than 7mm of the sea level will lead to the flooding of an area of 76.99 km² in the year 2025, 82.69 km² in the year 2050 and 91.29 km² in 2100 (Raharijaona, 2002). It was estimated that in 1997, the recession of the coast varied from 5.71m to 6.54m. About 225m of coastline is thus likely to be swallowed up by 2100. This suggests that major part of the coastline of this region will likely disappear in the next few years (Raharijaona, 2002).

Figure 7: Erosion of the coastline of Morondava, Menabe (western coast of Madagascar)



*Figure 7:
Epis de protection (Protective spikes)
Ancienne route du littorale (Old coastal road)
Bâtiment admnistratif en zone d'éroion (Admnistrative building in erosion zone)

The city center of Morondava is built on the barrier beach. It is accessed by a dike road that cuts through the tanne and the area formerly occupied by mangrove, remnants of which are still visible in the south of the city. For the last few years, the acquisition of land for construction by filling in this tanne has been increasing, while this area is subject to flooding during spring tides and especially during heavy rains in the cyclone season.

Figure 8: A flood in Morondava



*Figure 8:
Route nationale (National road)
Contruction sur la tanne (zone inondable) (Construction on the tanne (flood zone))
Reliquats de mangrove (Mangrove relics)
Tanne: zone inondable (Tanne: flood zone)

Source: http://www.morondava-autrement.com/medias/images/morondava-amenagement-du-littoral.jpg

2.5.6.7. Coastal erosion and sediment inputs

Coastal erosion, which is amplified along the west and east coast of Madagascar (Mahajanga, Maintirano, Morondava and Manakara regions), happens because of changes in coastal hydrodynamic conditions. The most spectacular of these phenomena are located on the northwest coast of Madagascar. The Betsiboka estuary (in the northwest) is considered as the "mouth" of the largest rivers in Madagascar and one of the most unstable coastlines. The spectacular development of mangrove

formations in this area results from the effect of coastal sedimentation due to the erosion of inland lands. During the rainy season, the reddish soils are washed away and carried by rivers to the coast. From the air, it looks like "Madagascar is bleeding" into the ocean (NASA, 2004). The Betsiboka estuary illustrates this phenomenon which is particularly intensified during a tropical cyclone (e.g. Gafilo, March 7, 8 2004). Publications on lagoons are rare, especially those that give complete details on these ecosystems. On this subject, we note the work done in 1909 on the east coast of Madagascar.

2.5.7. Sustainable management of marine resources

2.5.7.1. Seaweed farming

Seaweed farming is a practice that is now well known in Madagascar and is beginning to develop. It currently occupies 500 ha, and focuses on alginate brown algae (*Euchema cottonii* and *Euchema spinosum*).

2.5.7.2. Sea cucumber farming

Sea cucumber farming is developing in Toliara and after an initial experimental stage, it has now moved to the productive stage. The Indian Ocean Trepeng (IOT) was created to develop sea cucumber farming. It focuses on breeding *holothuria scabra*. The company benefits from the exclusive use of a patented know-how of "in vitro" artificial reproduction and also aims to optimize the growth of sea cucumbers during their juvenile phase to the required size at their sale (20 cm and 300 g).

This sea cucumber farming is developing in partnerships with coastal fishermen from local villages.

2.5.7.3. Conservation agriculture

Conservation Agriculture is part of the climate-smart agriculture techniques. It is based on three fundamental principles: minimum tillage, crop association and rotation and permanent soil cover. The other techniques of Climate-Intelligent Agriculture are: Agroforestry, reforestation, integration of livestock in the production cycle (natural fertilizer, composting, fodder crops, etc.), the intensive rice growing system (SRI), etc…

2.6. Physical oceanography

2.6.1. Coastal hydrodynamics and ocean current systems

The Madagascar Environmental Future 2017 Report explains that Madagascar is located in the middle of a westward moving surface current. Known as the Southern Equatorial Current (CES), it hits the east coast of Madagascar at a latitude of about 17°S (off Toamasina) and then splits in two with one branch flowing north and another flowing south. These two branches make up the Eastern Current of Madagascar (ECM). The fast-moving southern branch is strong and tapered (80 km); this current follows closely the east coast until Tolagnaro where it ends in an area of turbulent flows, associated with an upwelling of cold water between Tolagnaro and Cape Ste Marie. Sometimes this current may rebound towards the East by returning to the Indian Ocean in a retroflection process (Ramanantsoa et al., 2021).

This ECM associated with mesoscale eddies are two sources that feed the Agulhas Current (ASCLME / SWIOFP, 2012). This current runs along the East African coast flowing southward with an average velocity of 200 cm.s-1 along the continental slope of the East African coast. The Agulhas Current then leaves the continental shelf at 36°S to be reflected eastward into the Indian Ocean (Elodie Gutkneght, 2011).

Regarding the west of Madagascar ocean current systems, Chapman et al. (2003) studied the characteristics of the currents around Madagascar by using drifting buoy data. When drifters are driven southward by the ECM, they bypass Cape St. Marie and move westward with an average speed of about 13.4 cm/s. Ruijter et al (2004) state that at this level the ECM is the origin of the eddies moving westward at a speed of 5 to 15 m/s. During the austral winter, the waters of the ECM appear to cross the southern Mozambique Channel towards the African coast, but often move northwards along the west coast of Madagascar (Lutjeharms et al. (2000) ; DiMarco et al. (2002)) (ASCLME/ SWIOFP, 2012).

2.6.1.1. New ocean current discovered in Madagascar

The ocean current that a team of scientists composed of Malagasy, South Africans and French found in the Mozambique Channel is one of the rare discoveries of the 21st century. The results of their work were published in the Geophysical Research Letters journal in mid-March 2018.

Dubbed the "Southwest Madagascar Coastal Current," it is quite modest in size: 100 km long, flowing at a depth of about 300 meters, it carries the equivalent of 1.3 gigaliters of water per second.

It is also described as a missing piece in the understanding of the planet's climate by scientists.

2.6.2. Tides and wave regime

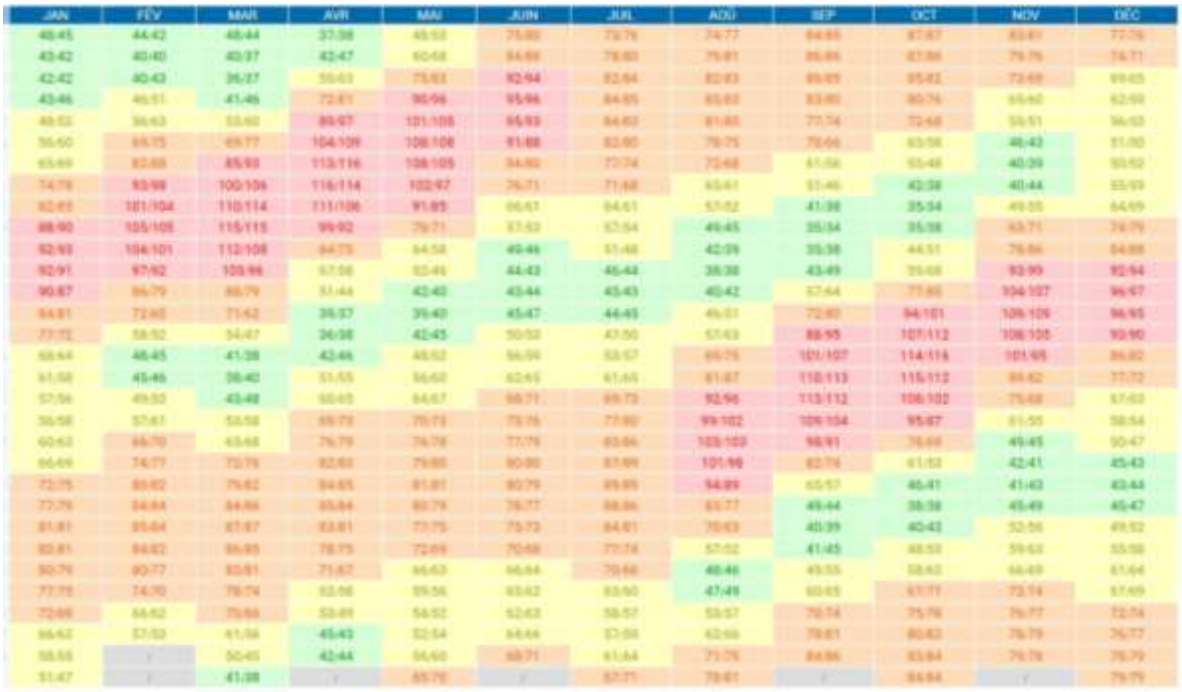
2.6.2.1. Tidal coefficient

As described in the first version of MEDA 2012 (ASCLME/ SWIOFP, 2012), the tide in Madagascar is of the semi-diurnal type. That is, there are two low tides and two high tides of approximately equal amplitudes per day.

To illustrate this, the tidal coefficients of Madagascar during the year 2020 is described in the following table. These values give an approximate idea of the amplitude of the tides and are affected by meteorological effects. On its importance depend the currents and movements of the generated seabed.

For the first twelve hours, the coefficients are between 36 and 116. Then it changes to range between 37 and 116. Thus, these coefficients confirm that the tidal range of Madagascar greatly varies.

Table 8: 2020 Tidal coefficient of Madagascar



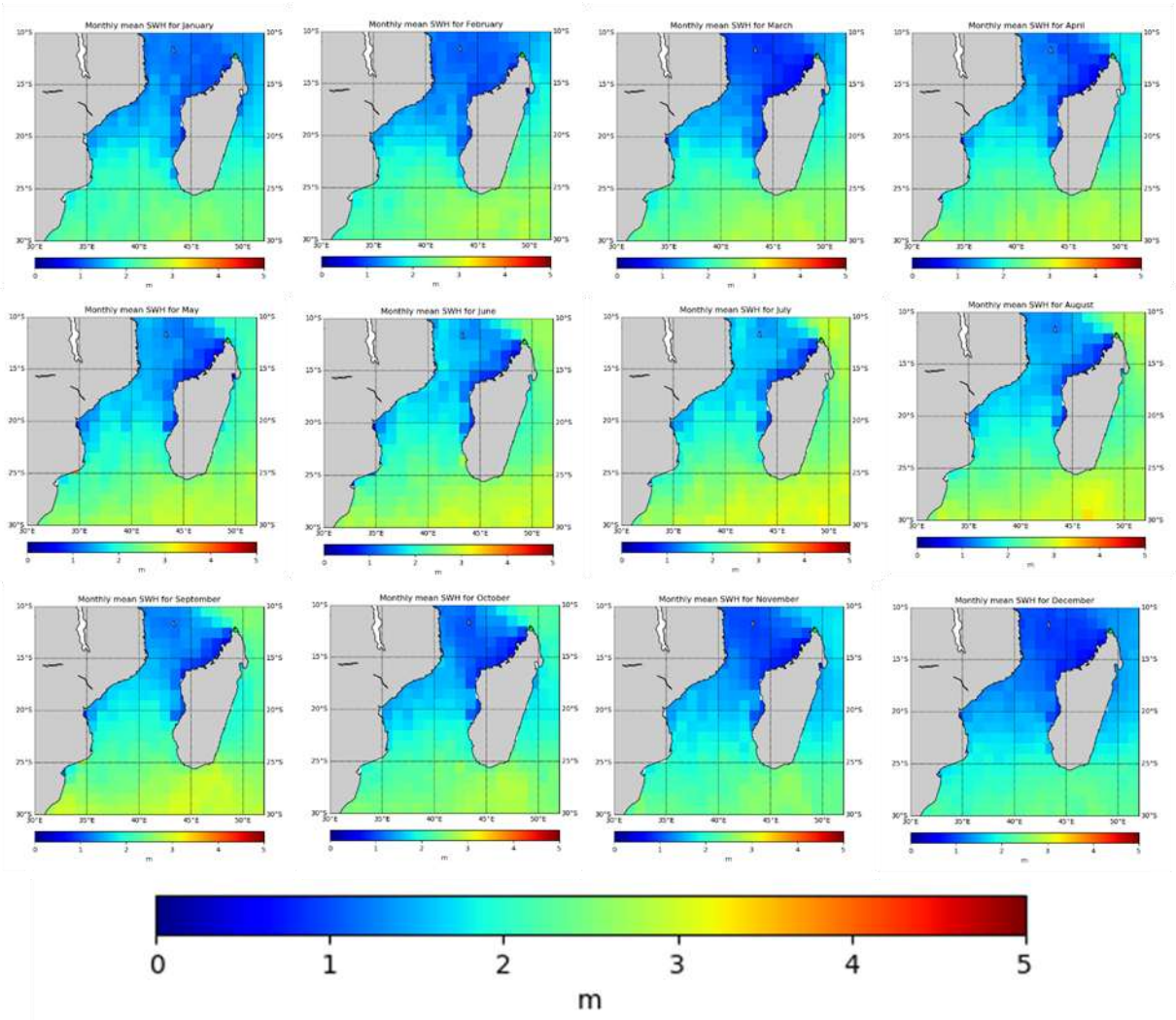
2.6.2.2. Significant wave height

The wind plays a very important role in the generation of a wave. There is an interaction between the wind and the wave. We could see in the pictures below that:

- From April to October, the wave is so high that it can go as high as 2 to 3 m high on all areas of Madagascar except in the northwestern part of the island, ie in winter;

- In the months of November and December: the wave is weak in almost all the regions. Its height then ranges from 0 to 1.5 m except in the Southern part where the wave can reach between 2 to 3 m and attenuates less and less. This happens during the rainy season ;
- From January to March, the height of the wave averages between 1 to 2 m on the East, South-East and South-West but it is predicted at a height of 0 to 1 m on the North-West and West coast.

Map 18: Height of the waves all year round

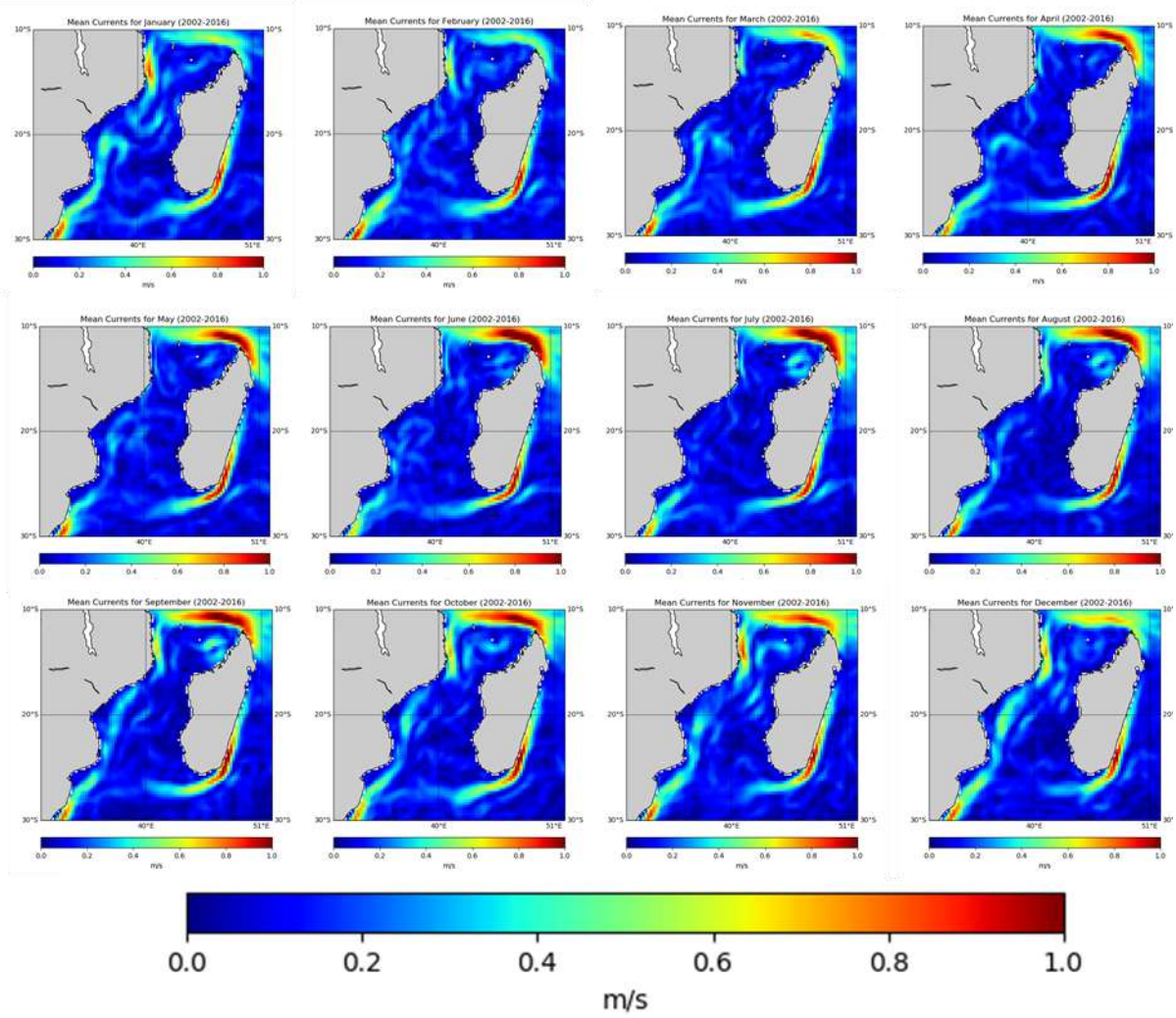


Source: DGM, 2020

2.6.2.3. Ocean currents

The following images (Map 18) show us the direction and strength of ocean currents of our island from January to December, the force varies from 0 to 1m/s. The maximum value is observed in April until October on the northern tip and on the southeast coast of Madagascar, during the winter period. Thus, the marine power is found on these coasts. On these points, the force is between 0.6m/s to 1m/s. It is lower in November and December. From January towards March, the force of ocean currents from the northern tip and the southeastern part begins to manifest itself.

Map 19: Ocean currents



Source: Traitement: DGM, 2020

2.6.3. Sea level change

Various satellite data show the global sea level rise. The trend is 2.7 mm /year (Madagascar Environmental Future Report, 2017).

Due to the warming of the oceans and the melting of glaciers and sea ice, the sea level is expected to continue to rise throughout the 21st century. According to the IPCC, a global temperature rise of 2° could cause the sea to rise by 300 mm to 930 mm by 2100.

In addition, studies conducted by a few O.R.S.T.M. researchers show a small variation in dynamic surface height (local rise in ocean level relative to a baseline) compared to 500deciBars for a year. However, during the last three as well as the first three months of the year (that is according to the rainy season of Madagascar), it reaches its maximum height. [B. Piton et al: "Atlas Hydrologique du Canal de Mozambique", Travaux et documents de l'O.R.S.T.O.M]

2 cases from Madagascar showcase this rise in sea level during the rainy season:

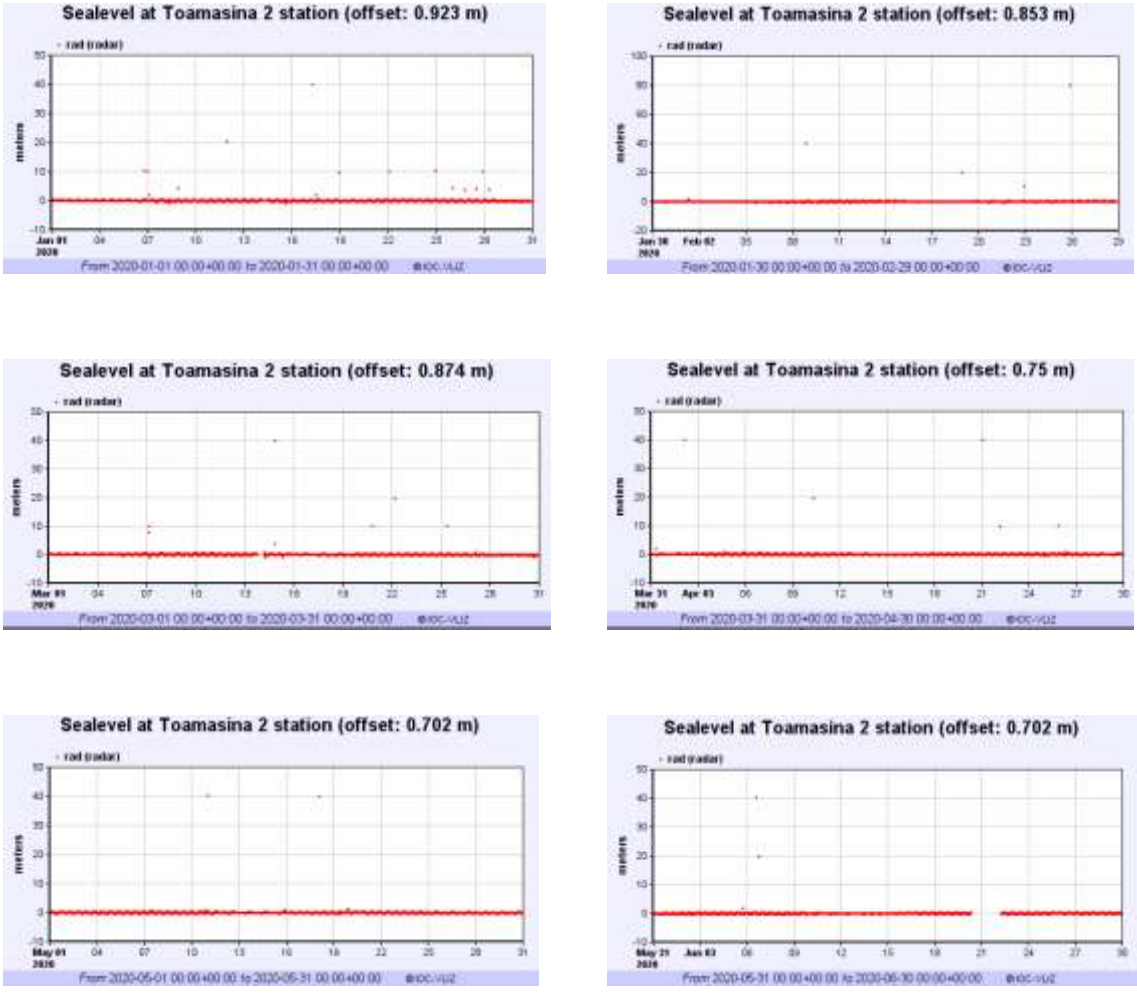
- The island of Nosy-Be where despite the roughness of the sea during the first three months of the year, the abundance of rain makes the sea level rise. But during the last three months of the year, there is a considerable inflow of sea. This input is governed by ocean currents such as the Needle Current, the Mozambique Current, as well as mass transport caused by the wind

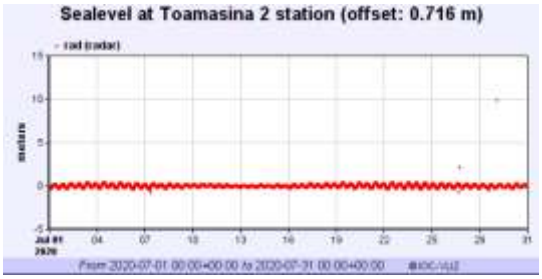
(southeast trade winds of the Indian Ocean and northern monsoon during the winter) (Rasolozaka, 2016).

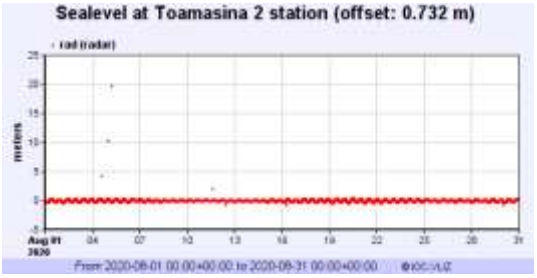
- And in Toamasina, where a permanent tide gauge has been established since 2010. The Toamasina tide gauge transmits data via Meteosat satellites and now participates in the network of tide gauges that feed data to regional warning centers and contribute to the warning system by confirming the existence of a tsunami. They allow, especially during strong earthquakes, to confirm the arrival of a wave in regions or countries potentially on alert. It is the only one operating in Madagascar and is important for the monitoring of the sea level in this part of the Indian Ocean (http://refmar.shom.fr/fr/sea_level_news_2010/installation-d-un-maregraphe-a-toamasina).

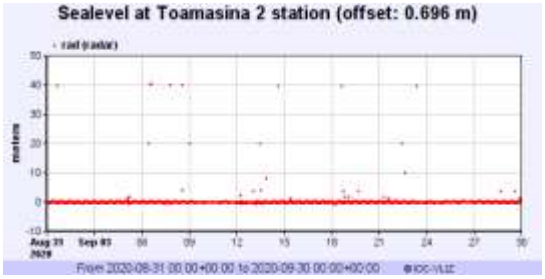
Below are presented its 2020 monthly data during which the sea level rises are frequent in January, February, March, September, October and November.

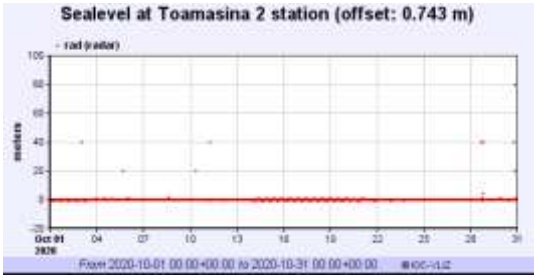
Figure 9: Sea level at Toamasina

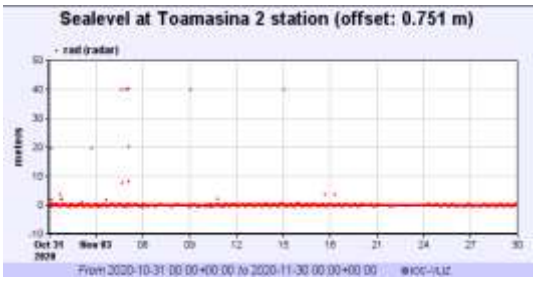


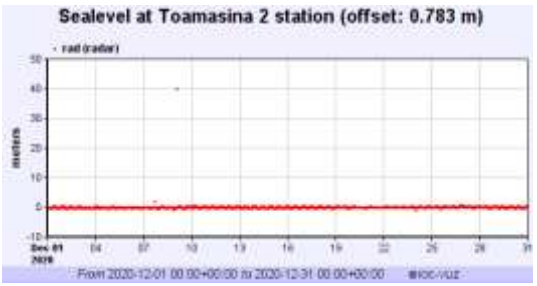












Source: http://www.ioc-sealevelmonitoring.org/station.php?code=toam2

To sum up, the sea level at the coast continuously varies and is increasing over time due to climate change impacts. Sea level in the SWIO rises at up to 6 mm per yr-1. Risks to coastal populations and habitats are increasing with rising sea levels and additional climate change-induced changes in tidal range and extreme events. Coastal sea level can be measured by tide gauge or satellite altimetry.

The C-RISe project (c-rise.info) provided processed altimetry data from the Jason-1, -2 and -3 satellites from 2002 to 2021. These data were approved, using software developed for the project, against existing tide gauges, whenever sufficient data was available. For Madagascar the tide gauge at Toamasina (data available from 2010 to 2020) was used.

Figure 10: Comparison of sea level measured by altimetry and tide gauge

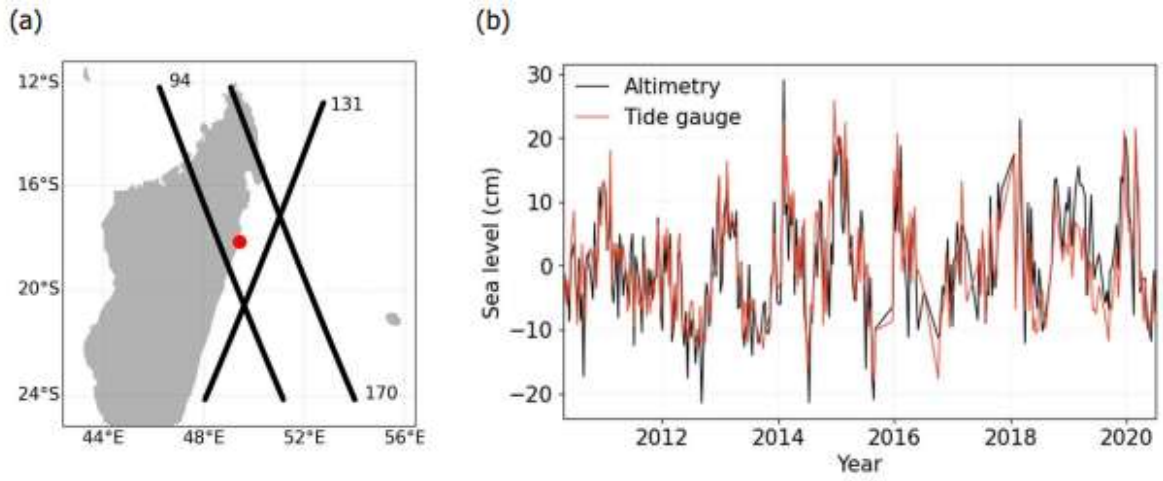


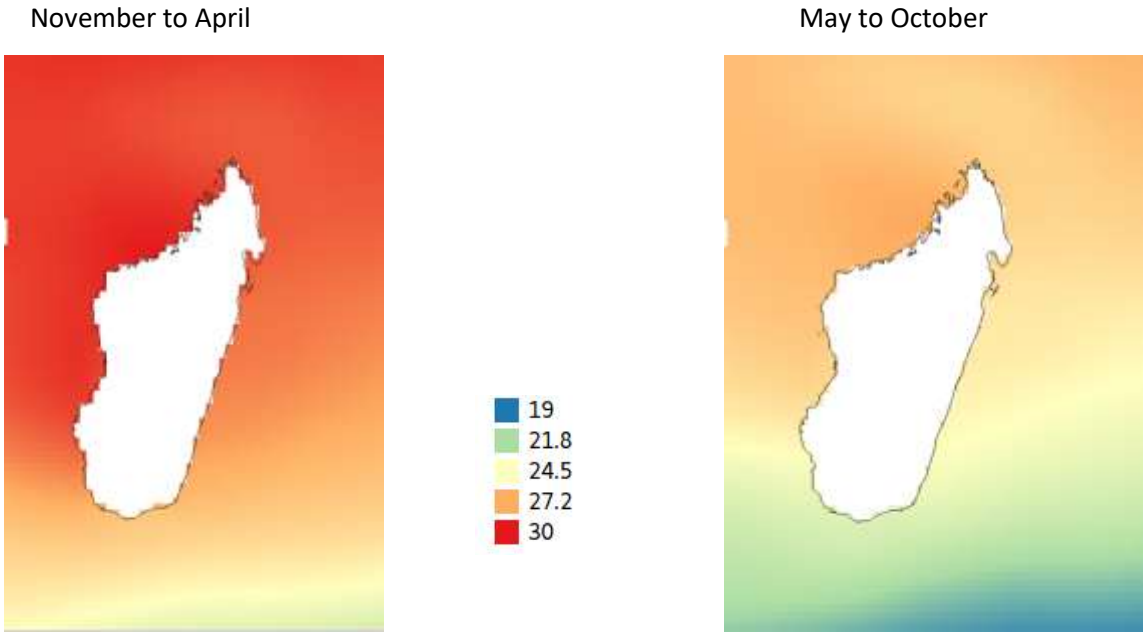
Figure 10 (a): Location of tide gauge at Toamasina (red dot) in relation to the Jason satellite tracks (black line) and (b) comparison of sea level mesured by altimetry and tide gauge (correlation: 0.82, rms difference: 0.05, distance from coast: 6.40 km).

2.6.4. Ocean temperature

From November to April, from 1981 to 2018, the temperature at sea level is rather hot everywhere in Madagascar, reaching up to 30° C especially on the northwestern part, on the northern tip, also on the coast of Mahajanga and Menabe Region. In the South, and the South-East part, it varies between 24.5°C and 27.2°C. On the East coast, this temperature at sea level reaches 27.2°C under the influence of atmospheric circulation modes, convective mixtures of thermohaline circulation.

On the other hand, from May to November of 1981 to 2018, the Sea Surface Temperature (SST) is less cold on all parts of the island due to the persistence of the Mascarene anticyclone from the South and also by the influence of the blow of the South-East ocean current. The SST is between 21.8°C and 27.2°C. The western part is warmer than the eastern coast which is slightly colder. Moreover, the southern part is colder than any other part of Madagascar.

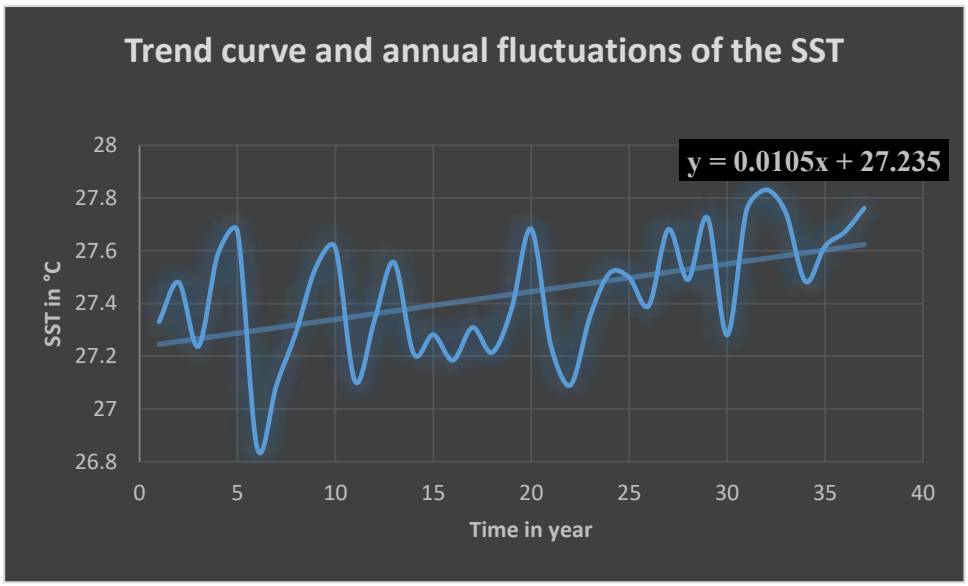
Map 20: Sea surface temperature (1981-2018)



Source: DGM, 2020

The trend curve shows that the Sea Surface Temperature (SST) around Nosy-Be tends to increase in the time interval from 1979 to 2015 (Figure 10). It increases of 0.01°C per year.

Figure 11: Trend curve and annual fluctuations of the SST in Nosy Be

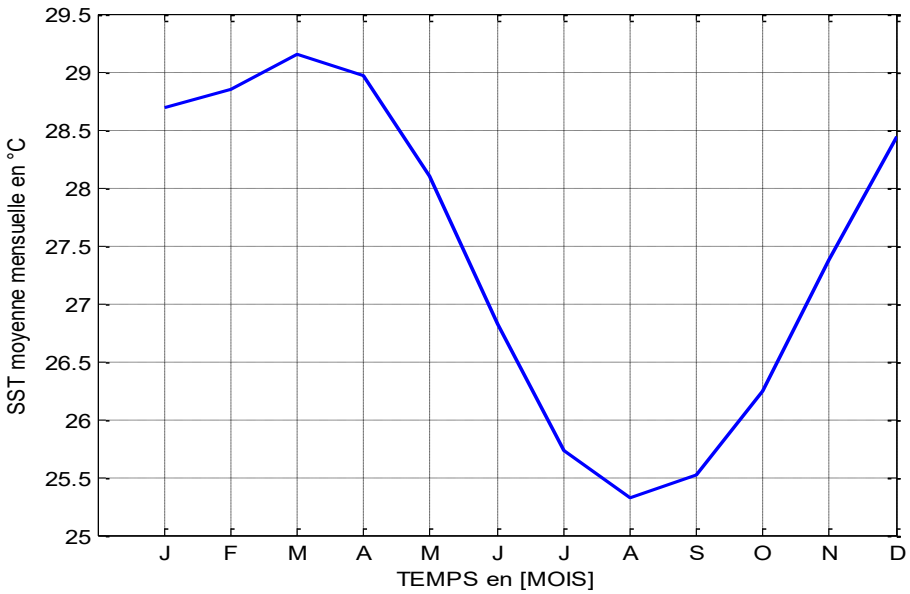


Source: Rasolozaka, 2016

The SST is minimal from July to September when it is less than 26°C. On the other hand, during the hot seasons, it can reach more than 29°C.

And during the climatic period (1979-2015), the sea surface in Nosy Be has a temperature around 27.43°C.

Figure 12: Trend curve and monthly fluctuations of the SST in Nosy Be during the year

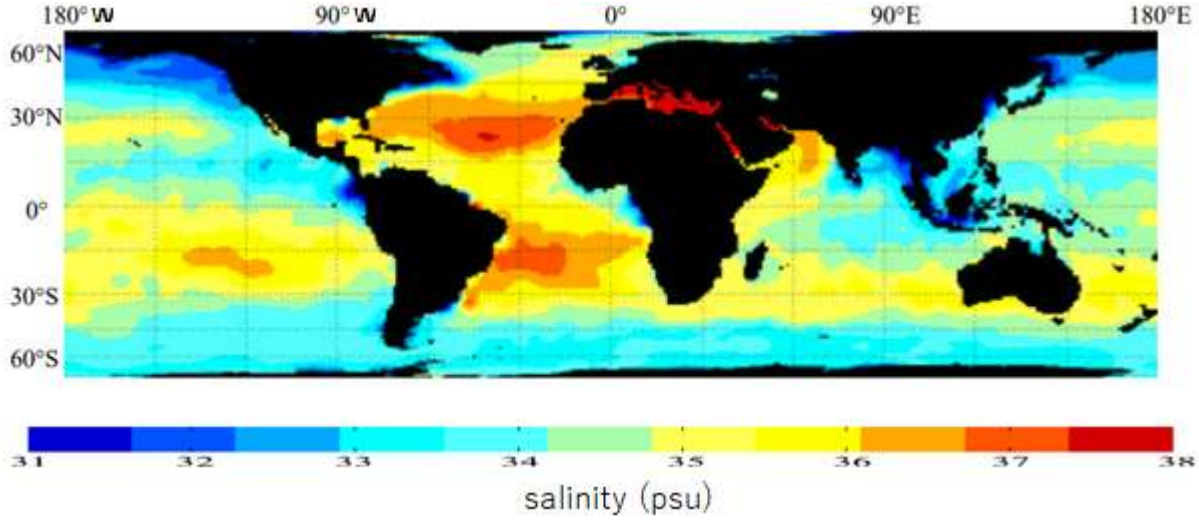


Source: Rasolozaka, 2016

2.6.5. Salinity models

A study on how to determine the surface salinity of the oceans from microwave radiometric measurements in L band by Emmanuel P. Dinnat was conducted and submitted in 2003. It came out that the salinity model in the world varies between 31 and 38 psu while for 75% of the countries in the world, Madagascar included, salinity is between 31 and 36 psu. (Below figure).

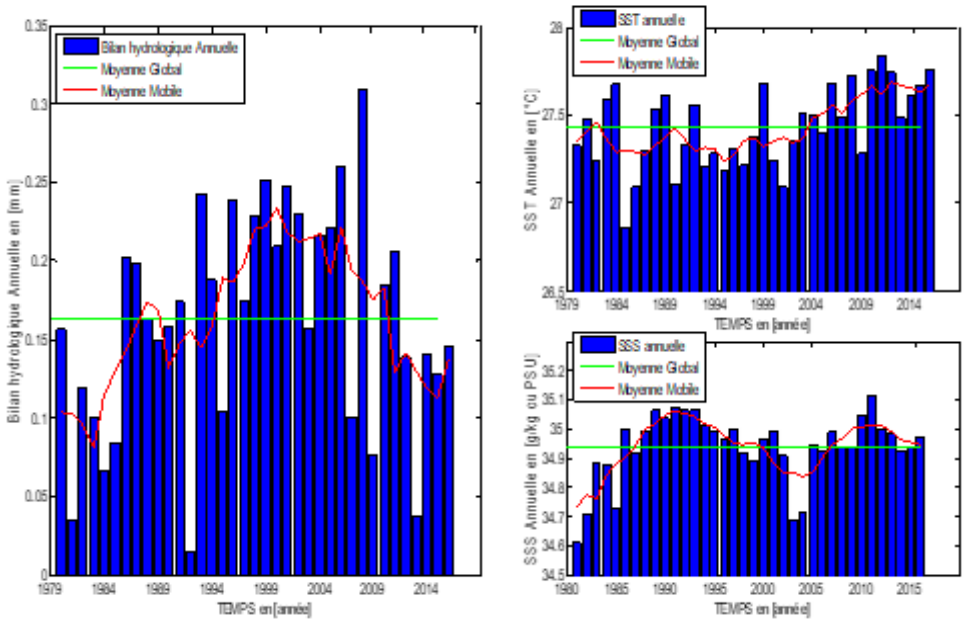
Map 21: Climatological salinity at the ocean surface for January



Source: Emmanuel, 2003

A recent case is that of Nosy Be Island where the salinity of the ocean has an overall average of 34.94 psu between 1980-2015. However, no trend was found for this parameter (Figure 13).

Figure 13: Annual average, global average, and moving average of the Water Balance (a), SST (b), SSS (c)



Source: Rasolozaka, 2016

2.6.6. Ocean-atmosphere interaction

In this work, the ocean-atmosphere interaction model was subject to a linear model (Rasolozaka, 2016). This interaction was quantified by the E-P (evaporation-rainfall) deficit named water balance. The created model links the water balance with the sea surface salinity by the following equation:

$$Water\ balance\ = -0.27 + 0.52 * SSS$$

The author thus notes that the water balance increases as the amount of salt increases. Note that the increase in the water balance means an increase in rainfall or a decrease in evaporation in the region.

In addition, the author has shown the mechanism of exchange between the atmosphere and oceans during a year. Indeed, during a year, after a long dry and cool period, the sea temperature increases in parallel with the arrival of the rainy season. The increase of the SST, the decrease of the water balance and the decrease of the SSS during the first months of the year (from January to April) are quite normal since it is the rainy season in Madagascar. The island of Nosy-Be and its surroundings receive abundant rainfall during this season. Evaporation decreases with the increase of rainfall, and there is desalination. Conversely, during the dry seasons, the high insolation in the northwest of Madagascar leads to considerable evaporation in June. This increases the concentration of dissolved salt and therefore the SSS.

In fact, there is a delay of 2 or 3 months for the extreme phenomena to have any effect since they are accompanied by thermohaline circulations. These latter slow down or contribute to the completion of the marine hydrological cycle.

From the first version of MEDA to this update, the research (or monitoring) carried out on the physical oceanography of Madagascar does not cover yet all Madagascar.

2.7. Chemical and biological oceanography

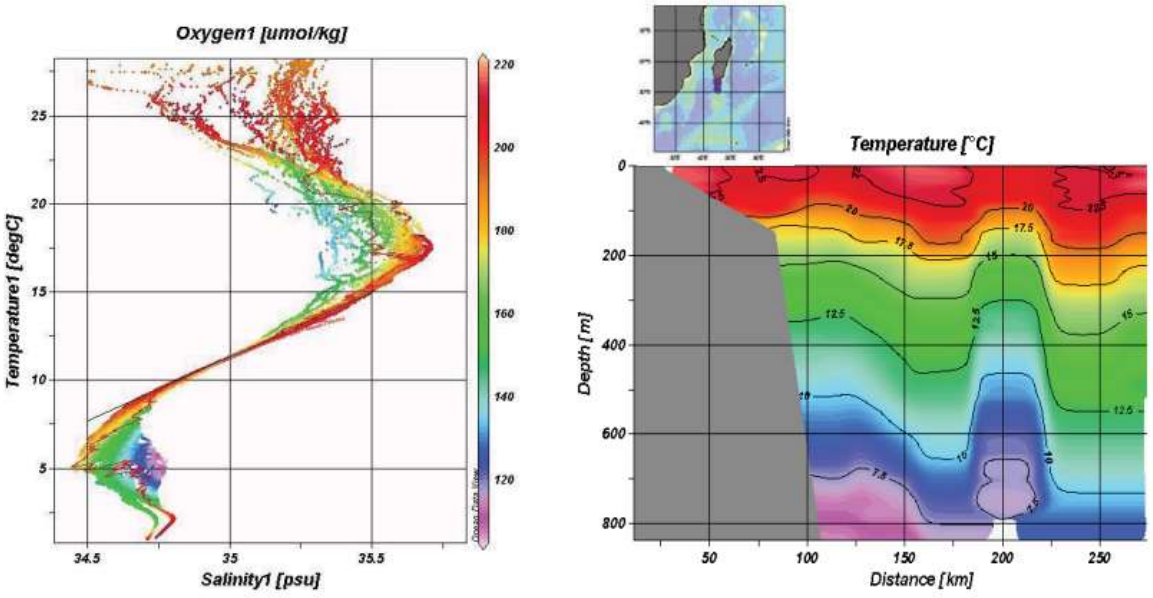
2.7.1. Nutrients

Nutrient data for Madagascar is presented in the form of atlases (Stephens et al. 2002, Boyer et al. 2002, Locarnini et al. 2002, Conkright et al. 2002 and World Ocean Atlas 1998 (WOA98) series). Among others, data from research conducted by Malagasy scientists are also available for several areas of the island, mainly in the south (Lope 2009). Similarly, a recent study undertaken by CNRE and IHSM in 2009, as part of the WIO-LaB project, is also available for two sites, Nosy Be and Mahajanga.

Lope (2009) showed that three lagoons, Ambinanibe, Andranasy and Andrantoloharano, have high nutrient concentrations throughout the year. This nutrient enrichment is due to the flooding of the Ifaho River. The average ammonium concentrations however differ between lagoons, with 1.2 ± 0.6 mol/l at Ambinanibe, 2.9 ± 2.0 mol/l at Andranasy and 4.8 ± 3.1 mo/l at Andrantoloharano. Nitrate enrichment began in January in Ambinanibe lagoon and gradually spread to the other lagoons after one-month interval. After a period of high flooding, a peak in nitrate concentrations is observed, with some significant variations between lagoons. Nitrate concentrations in surface waters range from 0.4 to 158.5 mol/l at Ambinanibe, from 1.7 to 299.7 mol/l at Andranasy and from 0.6 to 123 mol/l at Andrantoloharano. Nitrite concentrations for the three lagoons Ambinanibe, Andranasy and Andrantoloharano were respectively 0.15 ± 0.10 mol/l, 0.12 ± 0.07 mol/l and 0.21 ± 0.15 mol/l.

With the exception of data from recent oceanographic campaigns conducted by international research vessels (Fridtjof Nansen in 1993, 2008, 2009, Pelagia 2001), little in situ data have been collected on nutrients: nitrates, nitrites and phosphates. The data from these campaigns are kept in different data centers located in Norway, Madagascar, South Africa and Japan. The need to repatriate data kept in foreign institutions that are not easily accessible to Malagasy institutions has been felt.

Figure 14: Hydrological Profile and cross-section (sea water temperature) in the upwelling in the southern part of Madagascar



2.7.2. Persistent organic pollutants

In Madagascar, the main marine and coastal environment pollution is due to industrial, agricultural, port and mining activities. Their importance and consequences are not well quantified. Most pollutants are biodegradable but there are also persistent organic pollutants (POPs) such as highly toxic insecticides like DDT used in malaria control.

2.7.3. Land-based pollutants (sources, types, impacts, monitoring and institutional framework)

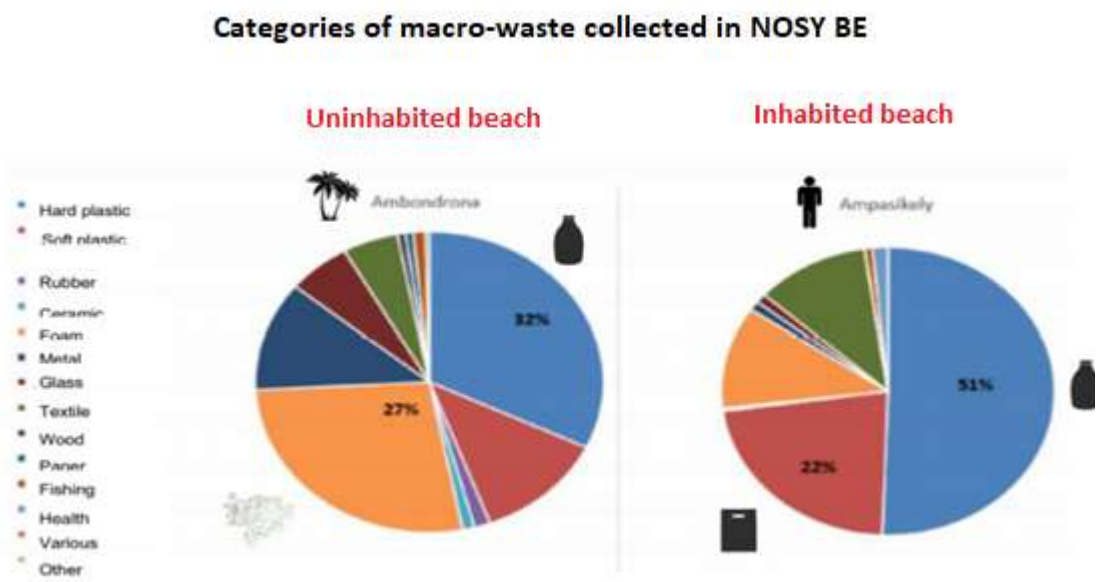
Land-based pollutants are domestic and industrial waste in urban areas such as Toliara, Toamasina, Antsiranana and Mahajanga.

According to CETAMADA observations:

- 80% of marine waste is of terrestrial origin and more than 80% is made up of plastic waste.
- A production of 19 kg per day on inhabited beaches and 0.8 kg per day on uninhabited beaches was recorded during their cleaning work on the beaches of Nosy Be, Sainte Marie, Toliara and Taolagnaro.

In general, plastic waste, packaging of food like cookies, fabric materials pollute beaches (in inhabited and uninhabited places). The graphs below illustrate the case of Nosy Be and show that most of the waste comes from the hinterland, carried by the rivers or dumped directly on the beaches. However, in the case of Sainte Marie, other foreign products coming from Asian countries thrown in the Indian Ocean have been brought by ocean currents and reach the inhabited or uninhabited beaches of the island.

Figure 15: Sampling result October 2019, case of Nosy Be



Source: CETAMADA, 2019

Moreover, several regions of the island still practice open defecation on the beaches. Actions have been undertaken to eradicate this practice, but much remains to be done.

In the Eastern Region, in the hinterland, the implementation of several industries, some of which have been established since the 2nd Republic, is frequently a major problem. A former oil refinery continues

to discharge hydrocarbons into the canal, which is a threat to the aquatic system along the east coast of Madagascar.

There is also a high rate of sedimentation brought by large rivers such as Fiherenana or Betsiboka. Sedimentation is particularly high during the rainy season when the flow can reach 3000 to 4000 m3/s compared to 40 to 60 m3/s in the dry season.

2.7.4. Marine litter (sources, types, impacts, monitoring and institutional framework)

The coasts of Madagascar are exposed to accidental oil spills due to either the obsolescence of land-based facilities or to maritime accidents, to which is added a marine cartography that is about a hundred years old and largely outdated. The last decade has been marked by several maritime accidents, some of which were sources or threats of oil spills.

In 2008, damage of the pipeline linking the former refinery of Toamasina and a tanker caused the fuel oil spill which happened in the vicinity of the port of Toamasina, on the east coast of Madagascar. In the same place, in 2011, leaks from the fuel tank of a company based in the port had the same consequences.

In 2009, the grounding of a ship with damaged hull caused pollution on the beaches in southern Madagascar; with the help of local communities, it took more than a month to remove as much tar as possible, but the rocky areas could not be cleaned (OLEP, 2009; RAEM, 2017).

In early March 2016, the Panamanian-flagged ship "New Mykonos" ran aground in front of Faux-Cap, with a cargo of 160,000 tons of land-based coal and 2,500 tons of fuel in its holds, causing sedimentation of land-based coal dust in this high rate of marine fauna and flora endemicity site (Source: http://www.linfo.re/ocean-indien/madagascar/688958-madagascar-risque-de-pollution-marine-a-faux-cap).

In May 2016, the European Maritime Safety Agency satellite spotted an oil slick, a 94 km wide oil puddle covering an area of 120 km² off the city of Mahajanga, threatening the coasts of Soalala, Katsepy, Mahajanga and the beach which is located near Analalava. It was then suggested that it was either caused by deballasting or cleaning the tanks of the tanker (an illegal method that consists of pouring polluting residues into the sea).

In April 2018, the cargo ship "La Sagesse" sank as it approached Besalampy, west coast of Madagascar, spilling 8,000 liters of fuel oil that was destined for the water and electricity company of Madagascar (JIRAMA) .

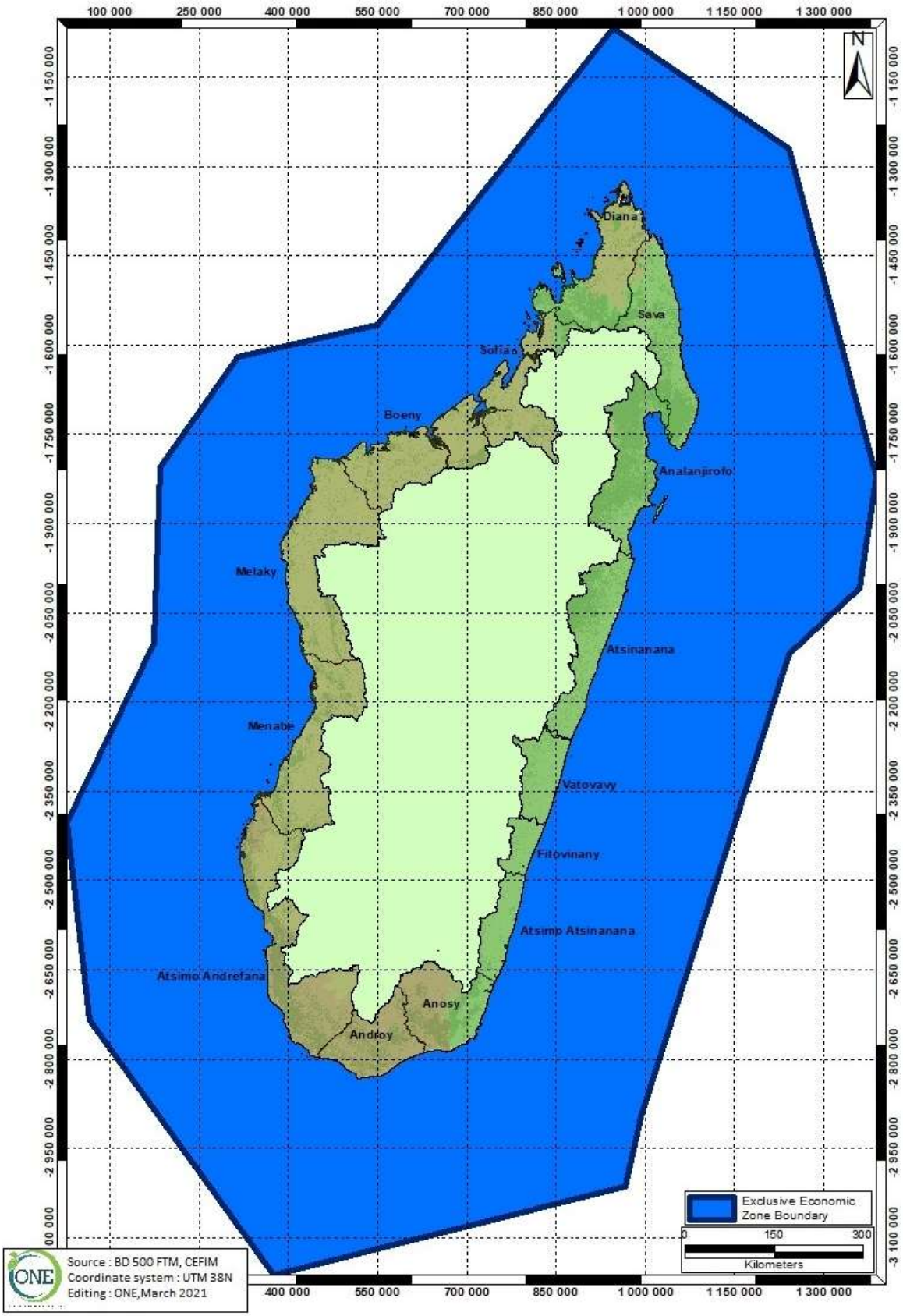
Source: http://www.linfo.re/ocean-indien/madagascar/canal-du-mozambique-un-cargo-sombre-avec-8-000-litres-de-fuel-au-large-de-madagascar

2.8. Coastal zone and continental shelf

2.8.1. Extent of coastal and marine habitats

Madagascar has about 117,000 km² of continental shelf and 1,270,000 km² of Exclusive Economic Zone (EEZ). Marine and coastal resources which are economic pillars of the country are found in the area.

Map 22: Delimitation of the Exclusive Economic Zone (EEZ) of Madagascar



Source: MPEB

2.8.2. Specific wealth of estuaries and deltas

A great number of faunas can be found in these ecosystems. Most of the mammals, birds and reptiles in these areas often come from neighbouring environments only to feed themselves. Several birds known as threatened species frequent them: *Ardea humbloti* (EN), *Anas bernieri* (EN), *Charadrius thoracicus* (VU), *Haliaeetus vociferoides* (CR), as well as migratory species (*Charadrius hiaticula*, *C. squatarola*, *Dromas ardeola*, *Platalea alba*, *Egretta alba*)

In 1984, thanks to the work of Bauchot and Bianchi, a list of the main indicator species of estuarine environments was drawn up. The table below summarises the characteristic biota.

Table 9: The number of species of commercial interest in the characteristic biota of the estuaries and deltas of the west coast of Madagascar (extracted from Bauchot and Bianchi, 1984)

Species of commercial interest	Number
Euryhaline sharks	5
Small coastal pelagic fish	9
Coastal benthic fish	19
Juveniles of coastal nectobenthic fish	7
Juveniles of coastal benthic fish	10
Estuarine coastal fish	13

On the floristic level, mangroves have developed in all the estuaries and deltas of the Malagasy west coast. In large estuaries and deltas, especially those protruding from the shoreline (such as Mahavavy du Nord, Sambirano, Mahavavy du Sud, Manambolo, Tsiribihina, Mangoky), they are all denser and more extensive as the arms are less functional and receive less freshwater inflow in the dry season. The 8 species of mangroves of Madagascar, common to the coastal region of East Africa, are listed there. Other species are also found: Scaevolasericeae, *Hibiscus tuliaceus*, *Derris uliginosa*, coconut trees found on the raised sandy banks of estuaries.

2.9. Microfauna and mesofauna

193 species of zooplankton were identified during the zooplankton inventory. They are classified into 11 groups as follows: - Foraminifera: 7 species and one Family - Acantharia: 14 species grouped in 6 Families - Radiolaria: 13 species grouped in 10 Families - Tintinnidae: 59 species and 12 Families - Scyphozoa: one species, one Family - Polychaete Annelids: 2 species and one Family - Copepods: 60 species grouped in 14 Families - Mysidaceae: one species and one Family - Chetognathes: 3 species and one Family - Appendicularians: 2 species and one Family - Planktonic larvae: 31 larval species.

By comparison, Gaudy (1967) recorded 123 species of copepods in the Bay of Toliara. After 39 years however, only half of the species of copepods have been counted in the bay of Toliara, which may be due to the destruction of the great reef of Toliara that caused the disappearance of some species. And Lope (1997) counted 14 species of Foraminifera, 11 species of Acantharia, 37 species of Radiolarians, 84 species of Tintinnids and 89 species of copepods at the mouth of the Mangoro (Mahanoro, east coast of Madagascar). The following tables (Table 10) give the list of species identified according to the sampled stations.

Table 10: List of microzooplanktons

1- Foraminifera		**Family: Globigerinidae**
2- Acanthaires		
	Order 1: Holocanthida	
	Family 1: Acanthochiasmidae	
Family 2: Acanthoplegmidae		
	Order 2: Chaunacanthida	Family: Gigartaconidae
	Order 3: Arthracanthida	
Sub-order: Sphaenacantha	Family 1: Acanthometridae	
Family 2: Dorataspidae		

Table 11: List of holoplankton species

HOLOPLANCTON	*Globigerina inflata*
	Globigerina bulloides
	Globigerinella aequilateralis
	Globigerinoides sacculifera
	Globigerinoides rubra
	Globigerinoides conglobata
	Globigerinoides helicina
	Acanthochiasma rubescens
	Acanthoplegma krohni
	Heteracon biformis
	Acanthometra pellucida
	Acanthometra tetracopa
	Acanthometra fusca
	Amphilonche elongata
	Dorataspis loricata
	Dorataspis gladiata
	Dorataspis costata
	Dorataspis micropora
	Coleaspis vaginata
	Coleaspis coronata
	Hexalaspis heliodiscus
	Thalassophysa spiculosa
	Collozoum inerme
	Siphonosphaera tenera
	Heliosoma echinaster
	Actinomma trinacrium
	Spongurus cylindris
	Archicircus hertwigi
	Semantis distephanus

2.10. Marine macrofauna

2.10.1. Invertebrates

The invertebrates contain a large number of recent and historical types and form one of the richest beds in the world both in diversity and abundance.

Table 12: List of invertebrates

List of Invertebrates (Macrofauna) Groups	Species	Distribution and / or observations
Sponges	*Strongylamma* sp.	Anakao (breeding site)
	About 300 species	(Raminosoa & Ratsifandrihamanana, 2012)
Cnidarians (corals and sea anemones)	314 species at the Great Reef of Toliara. 224 species in Nosy Be.	
Alcyonaria	71 species of soft corals (Pichon, 1978) in Mananara-Nord. 40 species in Nosy Be	
Scleractinian	200 species for Madagascar (Gabrié et al., 2000) 130 species for the Toliara region with 62 genera	
Antipathes	*Antipathes* spp. *and Cirripathes* spp. *(black corals)*	Abundant till 10 m wide in Nosy Tanikely 8 species in Toliara (Pichon, 1978 et Vasseur, 1981) 2 species in Mananara-Nord
Mollusks	About 1500 identified species (Cooke et al., 2004)	
Cephalopods	*Octopus cyanea* *Octopus aegina* *Octopus macropus*	Around Toliara
	Loligo spp.	Important food source around Toliara
	Sepiatheulis lessoniana	Nosy Be
	Sepia spp. *S. zanzibarica*	Nosy Be
Gastropods	Prosobranches	72 species at Masoala Peninsula (Andrianarivelo et al., 1998) 46 species in Mananara-Nord (Randrianamantsoa et Brand, 2000)
	Opisthobranches	175 collected species in Sainte Marie, Toliara, Taolagnaro and Nosy Be

List of Invertebrates (Macrofauna) Groups	Species	Distribution and / or observations
Crustaces	*Odontodactylarus scyllarus*	Commonly seen in the lagoons in Peninsula of Masoala and Nosy Be
	Odontodactylarus scyllarus *Lysosquilla maculata* *Gonodactylus smithii*	Listed in Anakao by Tanner (2000)
	Penaus indicus *Metapenaus monoceros* *Penaus semisulcatus*	Export shrimp (12,000 t per year)
	Periclimenes cf. *brevicarpalis* (crevette anémone)	Living in commensal with anemones
	About 782 species	(Raminosoa & Ratsifandrihamanana, 2012)
Echinoderms	Subgroup composed of crinoids, asteriids, ophiuroids, echinoids and holothurians. The total number is estimated at about 365 species.	(Raminosoa & Ratsifandrihamanana, 2012)
Chorded	About 89 species of the ascidians subgroup.	(Raminosoa & Ratsifandrihamanana, 2012)

2.10.2. Fish and fishery resources

2.10.2.1. Endemic fish numbers and discovery

An updated list of fish was published in 2018 (Fricke et al., 2018). In terms of Malagasy endemicity, 87 species of freshwater fish and 37 species of marine fish were observed in the publication.

Example:

- Freshwater fish: *Sauvagella madagascariensis*, *Sauvagella robusta*, *Ancharius fuscusn*, *Gogo* sp., *Betodia* sp., ...
- Marine fish: *Chiloscyllium caeruleopunctatum*, *Apristurus* sp., *Bythaelurus clevai*, *Narcine insolita*, Glaucostegidae Last, *Dipturus crosnieri*, ….

As for recent discoveries, a new study co-authored by Scripps Oceanography identifies the Corazon damselfish or "*Pomacentrus vatosoa*," a previously unknown species of damselfish found off Madagascar.

2.10.2.2. Coelacanth

According to Cooke (2004*), Latimeria chalumnae* is a crossopterygian fish that has lived on our planet for 300 million years. This species has been considered as having disappeared for about 70 million years, until an alive specimen was discovered in 1938 on the South African coasts, in particular in the North of the Mozambique Channel. Since then, more specimens have been found, namely in the Comoros in 1952, and in Madagascar since 1995 until now in the region of Toliara (Cooke, 2021).

Scientific observations from submersibles at hundreds of meters below the sea surface off the coasts of South Africa and Comoros have shown that underwater canyons and caves are the main habitats of coelacanths.

Frequent captures by bottom nets of Vezo fishermen off Saint Augustin (South of Toliara), which also harbors a submarine canyon, confirm the presence of coelacanth populations on the Malagasy coast. The coelacanths are likely to occur around the whole continental margin of Madagascar, it could be the epicentre of coelacanth distribution in the Western Indian Ocean and the likely progenitor of the younger Comoros coelacanth population (Cooke, 2021).

A canyon is also observed in Nosy Lava, off Maintirano according to marine maps. However, the coelacanth is not protected by Malagasy national law, but it is classified in the appendix of the CITES convention.

2.10.2.3. Sharks

Smale (1998) recorded 51 species of sharks including one endemic species *Chiloscyllium caerulopunctatum* living on the Malagasy marine coast.

The pantropical migratory species *Rhincodon typus* (whale shark) is found in Madagascar (Compagno, 1984).

The tiger shark *Galeocerdo cuvier* is present on the reefs of Toliara, Nosy Be and Sainte Marie Island. These places also shelter the Zambezi shark (*Carcharhinus leucas*), pig's eye shark (*C. amboinensis*) and the hammerhead shark (*Sphryrna mokarran*). Reef sharks such as *Triaenodon obesus*, *Carcharhinus albomarginatus* and *C. melanopterus* are also frequently observed. *Nebrius ferrugineus* and *Stegastoma fasciatum* are common around Toliara and Nosy Be.

2.10.2.4. Rays

The giant, guitarfish *(Rhynchobatus djiddensis)* is occasionally seen around Toliara (WWF, 1993), Nosy Be, and around the island of Sainte Marie.

Manta rays (*Manta birostris*) and white spotted rays (*Aetobatus narinari*) are also visible around Toliara and Nosy Be, and they are sometimes in groups. Other species are also present for breeding around Nosy Be like *Taenuria lymna*, *T. melanospilos*, *Dasyatis kuhlii* and *Torpedo sinuspersici*.

Taenuria lymna is common in Toliara, while the marbled electric ray (*Torpedo fuscomaculata*) breeds around the Masoala Peninsula (Mac Clanahan et Obura, 1998).

2.10.2.5. Sawfish

Two species of sawfish have been recorded in Madagascar: *Pristis microdon* which is a relatively common species and *P. cuspidatus*, an Indian species that has been rarely caught in the northwest (Kiener, 1964).

2.10.2.6. Tuna and mackerel (Scombridae)

The main species of tuna present in the pelagic and oceanic waters of Madagascar are *Katsuwonnus pelamis* (distribution in the north and east of Madagascar), *Thunnus obesus* (distribution in the north and south of Toliara), *T. albacares* , *T. alalunga*, *T. obesus* and *T. albacares*. They are allopathic species.

Mackerel, especially *Scomberomorus commerson* and *Acanthocybium solandri*, are common in coastal fisheries.

Pelagic teleost fish (other than Scombridae) are also found in some areas, as well as swordfish *Xiphia gladius*, blue marlin *Makaria mazara*, black marlin *M. indica*, sailfish (*Istiophorus platypterus*), spearfish (*Tetrapterus angulirostris*) and sea bream (*Coryphaena hippurus*).

2.10.2.7. Natural reef resources

Fish: They are the main food and income sources for the populations living in the coastal areas. The following table (Table 13) gives a list of the fish caught in Madagascar.

Details on the values and importance of these resources are given in the following chapters as well as their stakes.

Table 13: List of fish caught and recorded in Madagascar

Scientific name	Vernacular name	Vernacular name in English
Mugil strongylocephalus	Bika	Mullet
Sardinella sp.	Saripepy	Pilchards
Lethognathus equidus	Salelo	Sapsap
Otolithes ruber	Lemba	Three teeth
Rasnelliger kamargurta	Bemangily	Indian mackerel
Hilsa kelee	Pepy	Palli shad
Trichiurus lepturus	Vatritra	Sabre fish
Sauradi tumbil	Dangaliandrano	Anoli tumbil
Sillago sihama	Ambolotsiky	Peach Madam
Scomberomorus plurilineatus	Lamatra	Thazard
Nemipterus bleekeri	Sohana	Cohana
Carangoides chrysophrys	Lanora	Longnosed trevally
Caranx ignobilis	Kikao	giant kingfish
Terapon jarbua	Drihy	thornfish
Epinephelus tauvina	Alovo	Greasy grouper

Source: https://www.fishbase.de/

2.10.3. Marine mammals

About 36 species of marine mammals exist in Madagascar's marine areas including 10 species of whales, 23 species of dolphins, one sirenian (*Dugong dugon*) and two species of carnivores.

Studies undertaken on marine mammals combined with compilations of stranding data and bibliographies (Laran et al. 2012) have identified the following cetacean, sirenian and carnivore species:

Table 14: List of Malagasy marine mammals

Cetaceans Mysticetes	*Caperea marginata**, *Eubalaena australis**, *Balaenoptera acutorostrata**, *B. edeni**(DD), *B. physalus**(EN), *B. musculus**, *Megaptera novaeangliae**(LC), *Balaenoptera brydei**, *Balaenoptera physalus**, *Balaenoptera omurai**
Cetaceans	*Physeter macrocephalus**, *Kogia beviceps**(LR), *K. simus**(LR), *Ziphus cavirostris**, *Mesoplodon densirostris**(DD), *M. mirus**(DD), *M. hectori**(DD), *Sousa chinensis**, *Tursiops truncatus, T. aduncus**(DD), *Delphinus tropicalis**, *D. dephis** , *Stenella longirostris**(LR), *S. attenuata**(LR), *S. coeruleoalba**, *Grampus griseus** ,*Psuedorca crassidens*, *Orcinus orca**, *Globicephala macrorhynchus**, *G. melas**, *Mesoplodon pacificus**, *Peponocephala electra**, *Lagenodelphis hosei**,
Odontocetes	*Lobodon carcinophagus** , *Arctocephalus tropicalis**
Pinnipeds	*Dugong dugong**(VU)

Source: Rosenbaum, 2004, and Laran et al.2012, * have been seen

2.10.3.1. Dugongs

Dugongs are widely distributed in the tropical and subtropical protected coastal regions of the Indian Ocean and Southwest Pacific. The species' range extends from eastern Africa and Madagascar eastward to the eastern coast of Australia.

In Madagascar, this species was encountered in the Masoala Peninsula between 1973 and 1998 (Rakotonirina, 1999) and the Bay of Ampasindava. Nowadays, they have become increasingly rare in the Malagasy coastal areas.

The lack of data related to the Dugong and its habitats has been cited as one of the gaps on marine mammals in Madagascar (ASCLME, 2012). Efforts were made to address this during the Census of Marine Mammals and Other Pelagic Megafauna by Aerial Observation (REMMOA) in 2010 and 2011 and during the implementation of the GEF Dugong & Seagrass Project (2015-2018). This project confirmed sightings of a small population of dugong off the west coast of Madagascar. Eight dugong sightings were conducted off Mahajanga during REMMOA. Dugongs were directly observed off Nosy Hara and Sahamalaza Marine Parks during the implementation of the GEF Dugong and seagrass project (2014-2015). A total of 9 groups including 5 mother pairs and their calves were noted off Sahamalaza between 2016 and 2017 (Razafindrakoto & Raymond 2019). In addition, passive acoustic surveys in areas of suspected dugong activity confirmed extremely low numbers of dugongs (between 8-10 vocalizations).

These areas off Sahamalaza and Nosy Hara were dugong calving grounds.

No dugong mortality has been noted since 2015.

Dugongs are herbivores and generally feed on sea grass. They prefer "pioneer" species, especially those of the genus Halophila and Halodule. Local populations are a major threat for dugongs due to their excessive exploitation.

Among the threats are the following:

- By-catch in gillnets
- Loss of habitat
- Opportunistic fishing

Dugongs are endangered species (IUCN) and have been protected by national law since 1961 and classified in Appendix I of the CITES Convention.

2.10.3.2. Pinnipeds

They are occasionally present in the marine waters of Madagascar.

2.10.3.3. Cetaceans

The humpback whale is the best known of the baleen whales (Mysticetes). Every year from June to November, thousands of humpback whales visit the Malagasy coastal areas to court, mate and reproduce. During this period, the whales stop feeding and their activities are essentially linked to reproduction.

The Bay of Antongil, Sainte Marie Island, Taolagnaro, Cap Sainte Marie and Anakao are the best-known breeding grounds in Madagascar. Observations of a few individuals of Byscae's whales in the South and North-East of Madagascar in July and November may show that this species migrates to breed there.

In 2014, a small sedentary population of *Balaenoptera omurai* was identified in northwestern Madagascar. This species is considered rare and was the last marine mammal species identified in 2003 (Cerchio et al. 2015).

The majority of the dolphin species (Odontocetes) live around Madagascar throughout the year, and their sightings are frequently made on the west coast. Bottlenose dolphins and spinner dolphins are commonly seen along the reefs or close to the coastline.

Other whales and bottlenose dolphins, which prefer deep seas, are sporadically observed. The table 14 above gives us a list of Malagasy marine mammals.

2.10.4. Reptiles

2.10.4.1. Sea turtles

Five species of sea turtles are present in the marine and coastal waters of Madagascar: *Chelonia mydas*, *Eretmochelys imbricata*, *Lepidochelys olivacea*, *Caretta caretta* and *Dermochelys coriacea*.

Only the first four species nest on Malagasy beaches. The leatherback turtle, which is the largest, is only encountered offshore by local fishermen. Unfortunately, these sea turtles are highly threatened on a national scale due to human activities including hunting, egg collection, destruction of their habitat and pollution.

All five species are listed in Appendix I of CITES and are listed as endangered or critically endangered by the International Union for Conservation of Nature (IUCN).

Olive Ridley, Loggerhead and Leatherback turtles are classified as wildlife species requiring special protection, while Green and Hawksbill turtles are listed as harvestable species requiring protection and a management plan for any harvest.

Table 15: List of identified sea turtles of Madagascar

Species	Vernacular names	Distribution areas
Dermochelys coriacea	Leatherback turtle	North-west, west (off Maintirano), North-east and South of Madagascar
Chelonia mydas (EN)	Green turtle	North-West and Extreme North, South-West near Toliara, North East of Antsiranana till Masoala Peninsula
Eretmochelys imbricata (CR)	Hawksbill Turtle	Idem
Lepidochelys olivacea (EN)	Olive Ridley Turtle	Coast of Morondava, Taolagnaro, Nosy Radama, and Nosy sakatia
Caretta caretta (EN)	Loggerhead turtle	Southern part of Madagascar: north of Taolagnaro, Southern coast and north of Morondava

Source: IUCN Redlist 2022 ; EN: Endangered; CR: Critically endangered, VU: Vulnerable

2.10.4.2. Sea snakes

Among the sea snakes (Family Hydrophiidae), two (2) species are found in Malagasy coastal waters: *Pelamis platurus* and *Enhydrina schistosa* (Raxworthy, 2003).

2.10.5. Sea birds (Source: RAEM 2017)

Madagascar hosts a large number of migratory birds, living along its coastal wetlands, including Sanderling (*Calidris ferruginea*), Terek's Bargette *(Xenus cinereus*), Leschenault's Gravelot (*Charadrius leschenaultii*), and *Dromas ardeola*.

Two most important breeding sites for the seabirds in Madagascar were recently discovered in the North (Le Corre and Bemanaja, 2009):

- Nosy Manampaho, on the east coast 60 km from Antsiranana, hosts the largest colony of sooty terns *Onychoprion fuscata* in Madagascar with 21,800 pairs;
- Nosy Foty, on the west coast, 30 km from Antsiranana, is located in the central zone of the marine park of Nosy Hara. It is home to the largest colony of crested terns, *Thalasseus bergii*, in Madagascar and the entire Western Indian Ocean, its population having grown from 1,000 pairs in July 1997 to 10,840 in July 2008. Although ecotourism is not developed yet in this area, such an impressive colony of seabirds can be used by local authorities to promote the national park and increase the number of visitors to the area. However, access to the colony must be strictly regulated.

2.10.6. Exotic and invasive species

2.10.6.1. Green crab case

Source: Threat at sea « Invasive alien species in the marine environment », UICN

An adult rabid crab - or green crab - is about 6-7 cm long, but can grow larger. Green crabs can easily outgrow and outcompete other crabs. They feed on many shoreline organisms, especially bivalve mollusks such as clams, oysters and mussels, and small crustaceans. Green crabs are faster, more agile and can open shells more easily than other crab species. Green crabs are native to Europe and were first transported to the United States buried in small tunnels dug into the wooden hulls of ships by shipworms. Green crabs were first noticed on the east coast of North America in 1817, and are now found from Nova Scotia to Virginia. The green crab is thought to be at least partially responsible for the 1950s demise of the soft-shell clam fishery, which affected thousands of people. Catches dropped from 14.5 million pounds in 1938 to 2.3 million pounds in 1959, a period during which green crab spread throughout the clam fishery.

Green crabs have invaded South Africa, and have been observed in Australia, Tasmania and Victoria, Brazil, Panama, Madagascar, the Red Sea, Pakistan, Sri Lanka, Myanmar, Japan, Patagonia, and Hawaii, but it is not yet known whether they are invasive in all of these locations.

2.10.6.2. GloFouling partnership project

Madagascar, as of 2018, is among the 12 pilot countries of the GloFouling Biofouling Partnerships Project, which aims to build capacity in developing countries to implement the IMO Biofouling and other relevant guidelines for biofouling management and catalyze global reductions in transboundary introduction of biofouling-mediated EEE with additional benefits in reducing GHG emissions.

2.11. Natural and human-induced risks

Madagascar is a highly exposed to climatic hazards country such as to cyclones, floods, droughts, geophysical and geological hazards such as earthquakes, landslides, anthropogenic hazards such as house fires and bush/forest fires. The human and material damages caused by these hazards have been enormous on the whole national territory especially for these last years (2012-2017). To face the impacts of the above-mentioned hazards, structural, strategic and technical measures have been recently adopted by the Government of Madagascar. Upstream of these measures are the updates of the law on the National Policy for Risk and Disaster Management (Law No. 2015-031, PNGRC) and the National Strategy for Risk and Disaster Management (SNGRC).

From a technical point of view, the coordination of activities related to prevention, mitigation, emergency response, early recovery and rehabilitation/reconstruction is based on a "multi-risk and multi-hazard" approach with an emphasis on the multi-sectoral approach in the implementation of these activities.

2.11.1. Floods

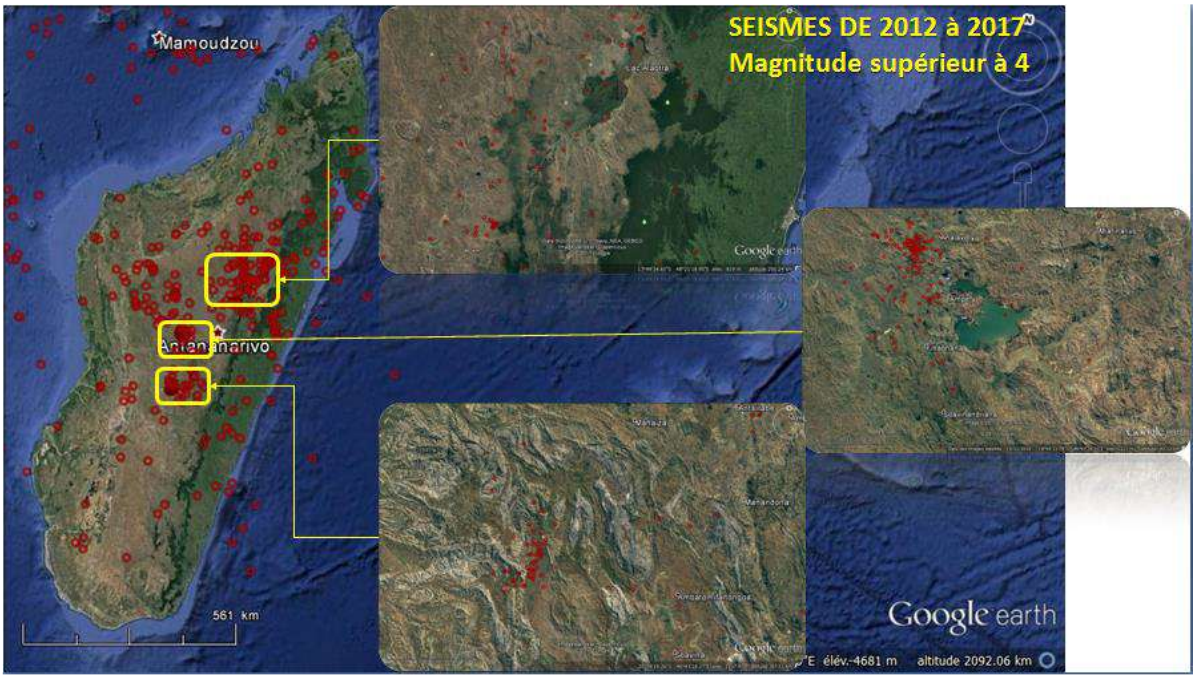
Driving forces:

- Environmental degradation, deforestation and forest degradation, slope erosion
- Non-application of the Guide to Road Protection Against Flooding in Madagascar
- Non-respect of the norms on the road sector against flooding for the construction of road infrastructures
- Non-respect of the Malagasy Standards of Construction of Hydroagricultural Infrastructures against Floods (NIHYCRI)

2.11.2. Earthquakes

Between June 22, 2012 and August 05, 2017, 523 earthquakes of magnitude greater than 4 on the Richter scale were recorded at the Institute and Observatory of Geophysics of Antananarivo (IOGA), 64 of which are of magnitude greater than 5 on the Richter scale.

Map 23: Geographical distribution of earthquakes



Source: IOGA, 2020

*Map 23:

Seismes de 2012 à 2017 – Magnitude supérieur à 4 (Earthquakes from 2012 to 2017 – Magnitude greater than 4)

This map (Map 23) shows that the occurrence of earthquakes of magnitude greater than 4 on the Richter scale in the Itasy, Vakinankaratra and Alaotra-Mangoro Regions is high compared to other Regions. The Districts of Miarinarivo (>100), Betafo (>50) and Soavinandriana (>30) have the highest number of earthquakes felt between 2012 and 2017.

2.11.3. Cyclones and floods

Between the years 2012 and 2020, Madagascar has been affected by 15 cyclones:

- 01 Intense Tropical Cyclone
- 05 Tropical Cyclones
- 01 tropical depression
- 03 strong tropical storms
- 01 Tropical Storm
- 03 Moderate Tropical Storms
- 01 Tropical Disturbance

The following table shows the order in which the cyclones occurred:

Table 16: List of cyclones from 2012 to 2020

Year	Name	Type
2012	CHANDA	Tropical depression
	GIOVANNA	Intense tropical depression
	IRINA	Moderate tropical storms
2013	FELLENG	Tropical cyclone
	HARUNA	Tropical cyclone
2014	HELLEN	Tropical cyclone
	CHEDZA	Strong tropical storm
2017	ENAWO	Tropical storm
2018	AVA	Tropical cyclone
	ELIAKIM	Strong tropical storm
2019	EKETSANG	Moderate tropical storm
	BELNA	Tropical cyclone
	DIANE	Tropical disturbance
2020	FRANCISCO	Moderate tropical storm
	CHALANE	Strong tropical storm

Source: DGM (Processing: ONE)

Regarding projections, the average annual number of tropical cyclones affecting Madagascar is not expected to change, but the number of intense cyclones is due to increase around 2100.

2.11.3.1. Impacts of cyclones and floods

Between 2012 and 2017, the followings were recorded at the BNGRC (5 years):

- 358 Deaths
- 1,163,620 Disaster victims
- 795 Injured
- 399,214 Homeless
- 13,112 Damaged homes
- 53,298 Flooded Cases
- 55,482 Destroyed houses



3. Chapter 3. Human Environment

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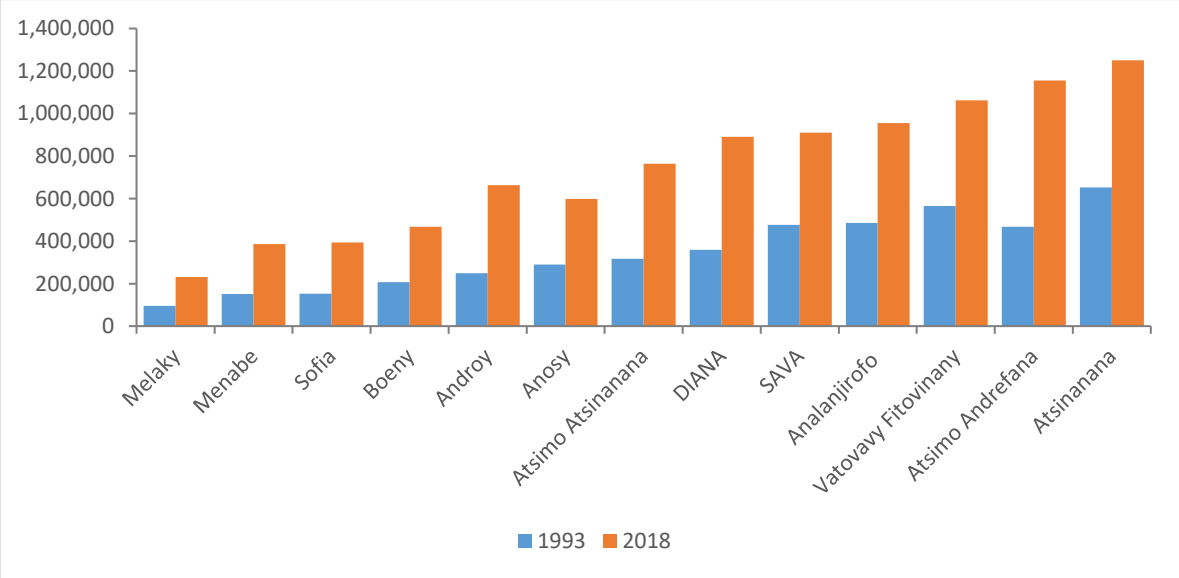
The purpose of this chapter is to analyze and provide an overview of the situation of Madagascar's marine and coastal ecosystems in relation to the following themes:

- The populations in coastal areas and small islands of Madagascar,
- Religious and culturally important sites,
- Health,
- Access to drinking water and sanitation,
- Education,
- And, infrastructure.

3.1. Populations in coastal areas and small islands of Madagascar: current situation and trends

The total population of Madagascar according to the collected data from the Third General Census of Population and Housing (RGPH-3) held in 2018 was estimated at 25,674,196 inhabitants. 37.89% of the population live in seafront districts. Between 1993 and 2018, the population living in coastal areas and small islands of Madagascar increased from 4,465,481 to 9,728,388 inhabitants, an average increase of about 210,516 people per year. They are spread over 14 coastal regions, subdivided into 45 coastal districts and occupy an area of 242,527 km² of the national territory of 587,041 km². The number of women is slightly higher than that of men. 4,981,089 women, compared to 4,747,474 men, that is, 51% of the population living in coastal areas.

Figure 16: Evolution of the population number in coastal areas by Region



Source: INSTAT Madagascar, 2021 (Data processing: ONE)

Between 1993 and 2018, the average population density of the coastal regions increased significantly. It went from 18 to 40 inhabitants / km² (Madagascar: 43 inhabitants / km² in 2018). However, this density varies from one region to another depending on the geographical location and especially on several factors such as:

- ecological factors: more or less hostile nature of soils and climate;

- socio-cultural factors: insecurity and the "dahalo[1]" phenomenon, inaccessibility to basic infrastructure (health facilities, schools, safe drinking water), food insecurity, ... ;
- economic factors: remoteness, unemployment.

Thus, the low density regions are mainly Melaky Region (8 inhabitants / km²) and Menabe Region (17 inhabitants / km²) whereas the Regions along the East coast of Madagascar are characterized by a high density (higher than 50 inhabitants / km²) namely Analanjirofo Region (50 inhabitants / km²), Atsinanana Region (73 inhabitants / km²), Vatovavy Fitovinany Region (78 inhabitants / km²) and Atsimo Atsinanana Region (100 inhabitants / km²).

This density also varies depending on the migration of coastal populations. Following are the reasons for migration:

- Mining migration: emigration to newly discovered mine sites of precious stones and to gold sites (the case of the rural municipality of Betsiaka – in Ambilobe District of DIANA Region);
- Labor migration: migratory flow from rural areas to areas of agricultural and/or mining economic growth ;
- Climate change: the direct or indirect impacts of climate change encourage migration (food insecurity, lack of water resources, farm land degradation, drought, floods, ...). For example, since 1990, Madagascar has been affected by 4 very severe droughts (1991/1992, 2001/2002, 2009/2010, 2015/2016) (Source: BNGRC, 2018). Drought mainly affects the Great South areas namely Anosy, Androy and Atsimo Andrefana regions.
- …

3.2. Religious sites or sites of cultural importance

Throughout Madagascar, all ethnic groups have set up religious and cultural sites that they jealously guard and protect, as they represent the indigenous modes of expression of their culture which they borrowed from their Asian, African or Arab origin. Everywhere, the abundance of places of worship and religious practices reflects the omnipresence of a faith which is based on God as the creator but also on the ancestors and other divine spirits with whom the living can communicate indirectly.

- Cultural sites and monuments:
    - DIANA Region: sacred lake, Route des Placers, Sacred cliff of Cap d'Ambre (in Antsiranana); Royal Palace of Ankify, Ambohibozy baobab tree stands (in Ambanja); Ankara Caves (in Ambilobe)
    - Sofia Region: Sakalava cemetery in Nosy Lava (in Analalava)
    - Boeny Region: Ampijoroa sacred lake (in Marovoay); Tourist village beach (in Mahajanga)
    - Melaky Region: Andranovorifaly sacred lake (in Besalampy); ancient gravesites of Bekopaka (in Antsalova)
    - Analanjirofo Region: historical sites of the Ilot Madame and the Ile aux Forbans, the Pirates' tombs, the Catholic Church of Ambodifotatra (in Sainte Marie); historical site

[1] « dahalo » is a Malagasy word referring to criminals that specialise in stealing cattles. They often operate in groups.

of Nosy Mangabe or of Ile Marosy (in Maroantsetra); ancient Betsimisaraka cemetery of Ambalatrano (in Mananara Avaratra)

- Atsinanana Region: Farafaty Historic Fort (in Toamasina); Foulpointe Historic Fort; Savaiza sacred eel pond (in Vatomandry)
- Vatovavy Fitovinany Region: Ambohitsara stone elephant (in Mananjary)
- Atsimo Andrefana Region: Saint Augustin Historic bay, Nosy ve historic island (in Toliary)
- Anosy Region: Pointe Flacourt Fort, Sainte Luce historic bay (in Taolagnaro)

- Natural sites and monuments:

  - DIANA Region: remains of Analamera primitive forest, Windsor Castle and Dower Castle ruiniform cliffs, Anosiravo cliff and panoramic views, Cap Diégo cliff and cave, Pain de Sucre islet, Aigrettes islet, Sépulere islet ; Orangea cave (in Antsiranana); the large waterfall and the Roussettes waterfall of the massif d'Ambre; Andranomandevy waterfall and thermal spring ; f Mahavavy falls (in Ambilobe); Volcano lakes of the massif d'Ambre ; Mahery Lake; Etape lake; Texier lake
  - Sofia Region: Andranolava capture phenomenon/ Andranolava bycatch (in Port Bergé)
  - Boeny Region: Mahajanga baobab trees ; Kipatso, Bekodoka rock piles, Andranojoby waterfall, Anaboriaka lake, Andranoboka caves, Belobaka caves, Cirque Rouge, clay massif (in Mahajanga II)
  - Melaky Region: limestone gorges of Manambolo, Ankondromena silicified trees; Tsingy de Bemaraha (in Antsalova); Andrafiavelo basaltic hill (in Maintirano)
  - Atsinanana Region: Antalavia waterfall, Manandra natural bridge (in Vatomandry)
  - Vatovavy Fitovinany Region: mountain and forest remains in Vatovavy (Mananjary) Andrambovato rocky cliff, Mandriampotsy waterfall, Namorona upper falls (in Ifanadiana); Sakaleona waterfall, Namorona lower fall (in Nosy VarikaFaraony fall (in Manakara)
  - Atsimo Andrefana Region: Mitoho chasm, Ambolisatra subfossil deposit, Sarodrano cave, Miary Banyan (in Toliara); Mount Eliva, Vintana natural well (in Ampanihy)
  - Anosy Region: Andrahomana subfossil deposit, Analamaska palm tree stands, Saint Louis peak, Antanifotsy rock (in Taolagnaro); Vohitsiombe de Tsivory volcanic massif, tamarind tree stands (in Amboasary)

- Traditions et rites:

  - Funeral practices and tombs called Aloalo in the Great South (Antandroy and Mahafaly)
  - Sacred woods: baobabs and tamarind trees in the Western, Southwest and Southern regions
  - Fandroana, the feast of the sacred bath of the Sakalava Tribes of Menabe and Boina (Fanompoambe and Fitampoha).

Source: National Imventory of sites and monuments of Madagascar – Heritage Directorate, 2013; Ministry in charge of Tourism, 2021.

Many other places of worship and tombs, cultural and religious sites (caves, caverns and other sites of archaeological interest) are erected in the coastal regions of Madagascar. However, no accurate records of their precise location, distribution and description is available yet.



Photo 1: Antagnavo Sacred Lake,Antagnavo (RM of AnivoranoNord, District Antsiranana II - DIANA Region)



Photo 2: Zomba where the royal relics of the Sakalava-Menabe tribes are deposited in Belo sur Tsiribihina (Menabe Region) (Photo: ONE)

3.3. Health

This section is a literature as well as communications review from key actors in the health sector and official documents from the Ministry of Public Health. The statistical data from the Ministry of Public Health result from a compilation of information/data collected from all of Madagascar's public and private health facilities, primarily data on activities undertaken at their level and data from the main health sector programs. The analysis focuses on the six main pathologies in the coastal areas of Madagascar during the observed period. It should be noted that the Covid-19 pandemic will not be particularly developed in the context of this chapter, even though it generated a global crisis and resulted in more than 64,246 cases of contamination (highest reported peak of 2,155 cases as of January 03, 2022) and 1,393 deaths throughout Madagascar up to July 31, 2022.

(Source: World Health Organization or WHO, May 2022)[2]

[2] https://www.who.int/countries/mdg/ , dated May 10th, 2022

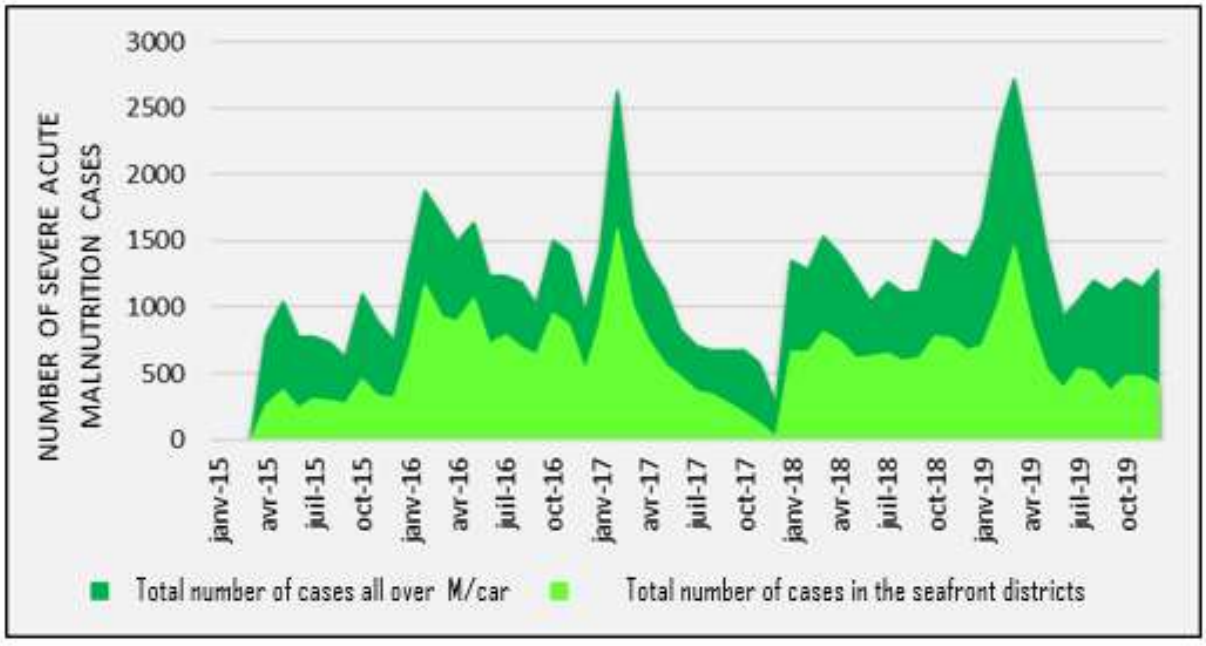
3.3.1. Main pathologies

3.3.1.1. Malnutrition

Acute malnutrition is almost present all over Madagascar but is more visible in the southern part of the island due to the high risk of recurring drought that is more or less prolonged, leading to acute food insecurity. In 2018, according to the Multiple Indicator Cluster Surveys (MICS)[3] survey results, acute malnutrition affects 6% of children under five, compared to 8.6% in 2012 (ENSOMD[4], 2012-2013). Nearly 1% of which are in its most acute form.

Data from the Health Statistics Service show that the coastal areas alone record an average of 48% of the monthly cases of severe acute malnutrition seen in outpatient clinics at the Basic Health Centers. The districts of Amboasary Atsimo, Ampanihy, Tsihombe, Farafangana and Manakara Atsimo are the main seafront districts which nutritional situation is of particular concern. The Amboasary Atsimo district, which has recorded more than 1,430 cases of Severe Acute Malnutrition annually over the past five years, remains by far the worst affected district. Thanks to the various multisectoral interventions in the south of Madagascar, the number of new cases of Severe Acute Malnutrition (SAM) in Amboasary Atsimo has decreased from 2,821 cases in 2016 to 1,705 cases in 2019, with a 50% decrease in cases in 2018.

Figure 17: Evolution of the number of cases of the Severe Acute Malnutrition



Source: Health Statistics Department / Ministry of Public Health (Data processing: Health and Environnement Service)

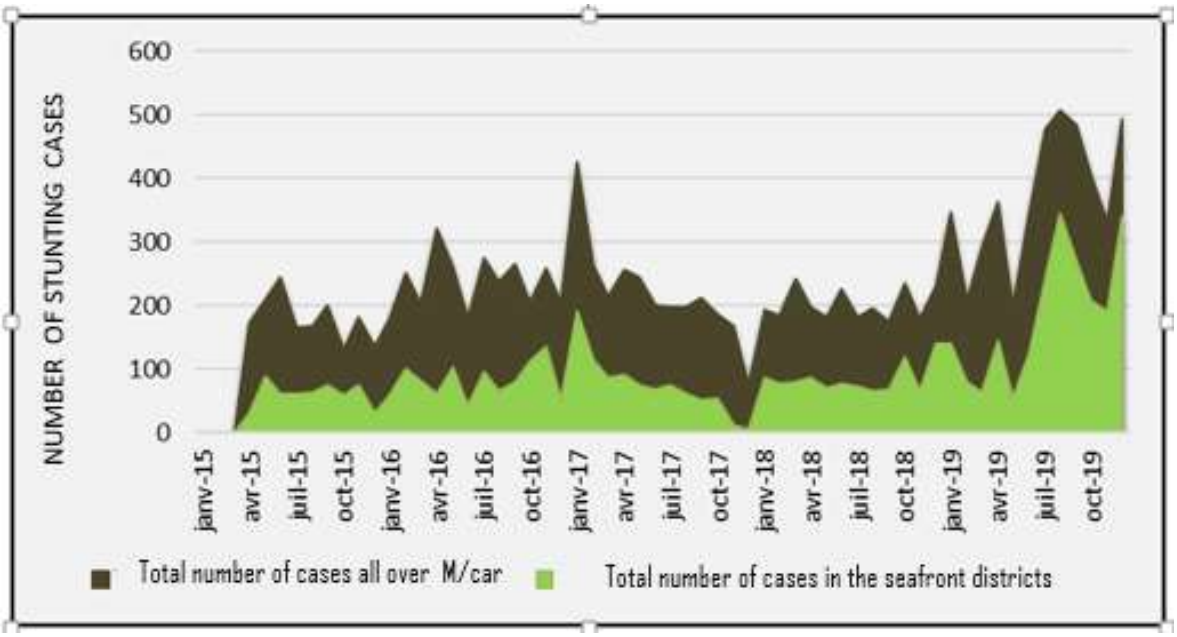
In addition, about 3% of Malagasy children suffer from stunting, weight loss and underweight at the same time, indicating the interaction of various determinants which affect children's nutritional status and have a significant impact on their cognitive development and learning capacity. The stunting rate

[3] Multiple Indicator Cluster Surveys

[4] National Survey for the follow up of the Millenium Objectives for Development

averages 42%[5] and reaches 37% for the coastal areas. With regard to coastal areas, stunting affects mainly and by far Amboasary Atsimo district from 100 cases in 2016 to 1,412 new cases in 2019, followed by Antalaha, Mahajanga I, Manakara Atsimo and Vohimarina districts. Underweight particularly affects the districts of Amboasary Atsimo, Toamasina, Vohibinany, Mahajanga I and Mahanoro. In 2016, the Amboasary district recorded almost 4,765 cases, compared to 828 cases in Toamasina. The main causes are the lack of service coverage and the failure of the population to adopt practices that are health and nutrition friendly.

Figure 18: Evolution of the number of stunting cases



Source: Health Statistics Service/Ministry of Public Health (Data processing: Health and Environment Service)

Since the end of 2019, the food security situation has somewhat deteriorated due to the rise in food prices as a result of the Covid-19 pandemic, the inadequacy of multisectoral aid due to rural insecurity, and the concomitance of several hazards such as intense drought, sandstorms, and the invasion of plagues that affected the few crops that could be saved. The current situation is worse than the one caused by the El Nino phenomenon in 2016, especially for the districts of Amboasary Atsimo, Ambovombe Androy, Beloha, Tsihombe and Ampanihy. According to the results of the Consumer Price Index (CPI) analysis of acute food insecurity, these districts in the Grand Sud are classified as being in an Emergency (CPI Phase [6]4) situation for the period running from April to September 2021. More than half of the households undergo severe degraded food consumption and are adopting emergency livelihood strategies such as selling their house or land (adopted by 50% of households in Amboasary Atsimo and Tsihombe), engaging in illegal or risky activities (45% of households in Amboasary Atsimo and 38% in Ambovombe), migrating (47% of households in Ambovombe), and begging (70% of households in Ambovombe and more than 30% in Amboasary Atsimo).

(Source: IPC, 2021).

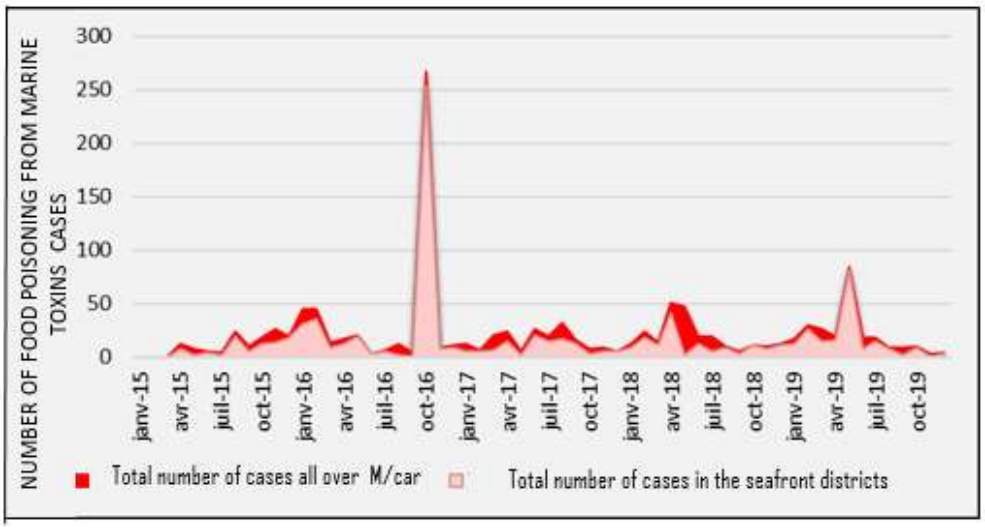
[5] https://www.banquemondiale.org/fr/news/feature/2021/07/07/reducing-child-stunting-in-madagascar#:~:text=Avec%20un%20taux%20de%20retard,mesures%20pour%20inverser%20la%20tendance

[6] CPI classification of Acute Food Insecurity: 1 – Minimal ; 2 – Stress ; 3 – Crisis ; 4 – Emergency ; 5 - Famine

3.3.1.2. *Marine food Poisoning (ICAM)*

Despite fishing bans during periods favorable to the development of phytotoxic marine species, marine food poisoning, more particularly by ingestion of sardinella (clupeotoxism) as well as sea turtle meat (chelonitoxism) and toxic shark meat (carchatoxism), affects the majority of Madagascar's maritime districts each year. Poisoning by sharks, sardines, turtles and reef fish affects the southwestern part of Madagascar. The extreme south and the south-eastern part of the island seem to be the most affected by carchatoxism. Poisoning by turtles, sharks and reef fish affects rather the North-East part of the island. The isolated cases of ICAM recorded in the highland districts can be explained by the conservation of the suspect meal or the delay in the appearance of the first symptoms of intoxication.

Figure 19: Evolution of the number of ICAM cases



Source: Health Statistics Service/Ministry of Public Health (Data processing: Health and Environment Service)

From the outset, the evolution of ICAM cases in coastal areas generally remains stationary between 2015 and 2018, except in 2016 when a peak occurred in October. That same year, 249 cases were recorded in the district of Fenoarivo Atsinanana alone.

The species most often implicated are the hawksbill turtle (*Eretmochelys imbricata*) and the green turtle (*Chelonia mydas*), animals prohibited for consumption by the Washington Convention (J. Turquet et al., 1999). In October 2020, in Mahambo, still in the district of Fenoarivo Atsinanana, some 40 people fell ill and three young children died after eating turtle meat[7]. The habits and dietary needs lead the population of coastal areas to consume the flesh of these prohibited species, thinking that they can eliminate the toxins by passing through a cold chain or with a good cooking. However, the marine toxins ingested by animals are for the most part fat-soluble thermostable toxins that are not altered by heat or freezing (Source: Pierre A. et al, 2020). Symptoms occur a few hours to 4 days after ingestion and are manifested by digestive signs (diarrhea, nausea, vomiting), oral signs (ulceration of the oral cavity) and neuro-sensory disorders (headache, motor disorders).

[7] https: //lexpress.mg/07/10/2020/

Currently, with the effects of climate change and marine pollution, the access of the population in coastal areas to healthy, safe and nutritious food is under increasing threat, placing foodborne infections such as ICAM among the main public health concerns.

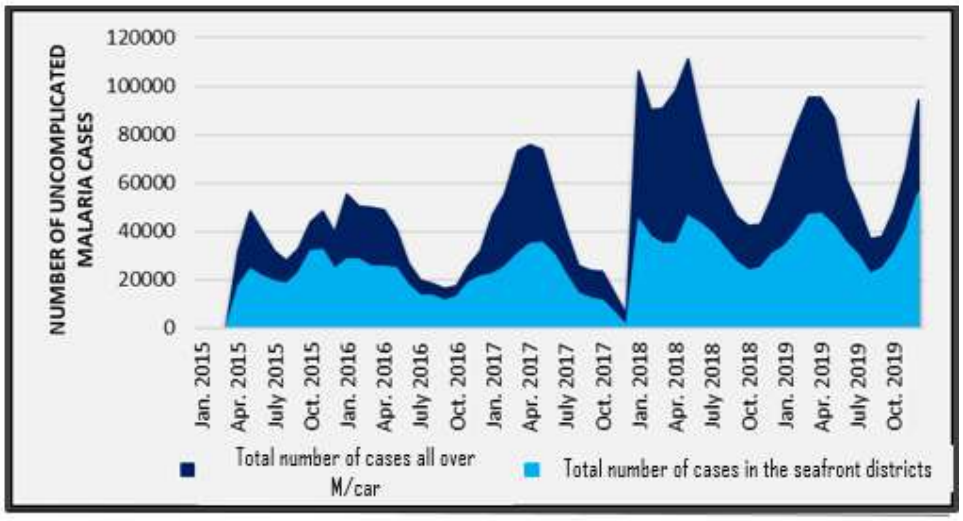
Being aware of the different issues and the multisectoral dimension of food security, Madagascar has committed itself to implementing the National Strategic Plan for Food Safety in Madagascar for 2020 to 2024 so as to strengthen enforcement of Act No. 2017-048 governing food and animal feed safety as well as the Standard Operating Procedures for the prevention and response to food foodborne infections.

3.3.1.3. Malaria

In Madagascar, malaria is a major public health problem. In 2016, it was the fourth leading cause of morbidity in primary health facilities and the fourth leading cause of hospital mortality. At the national level, the trend in incidence remains irregular. It was marked by a reduction in incidence from 97.7 ‰ in 2013 to 79.9 ‰ in 2014; followed by a very significant increase to 130.7 ‰ in incidence in 2015 which was probably due to lack of funding and implementation issues. A gradual increase was observed over the three consecutive years 2016, 2017 and 2018, ranging respectively from, 19.53 ‰, 32.04 ‰ to 37.83. During these three years, malaria deaths compared to all-cause deaths in hospital settings increased by 7%, 10% and 13%.

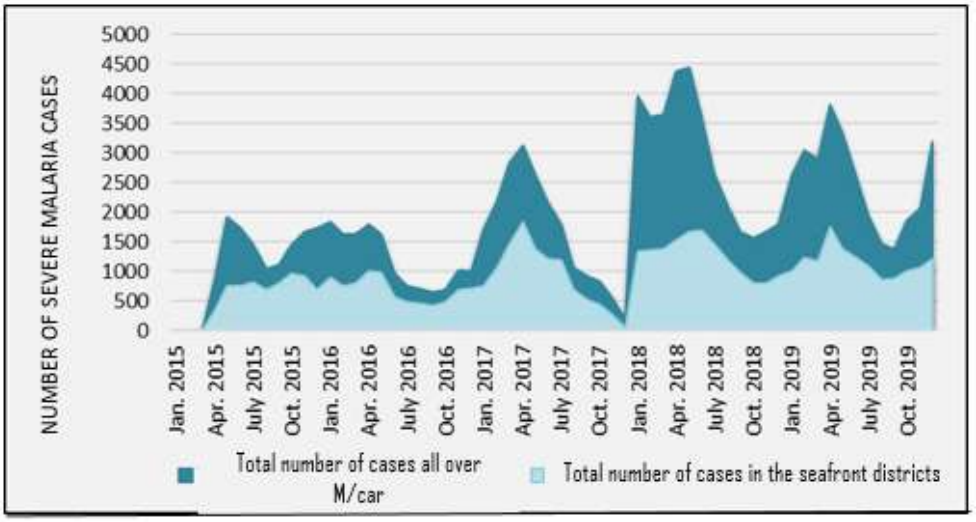
The districts which bear most of the burden of this pathology are those located in the Southwestern part and East coast of the island. Uncomplicated malaria is most prevalent in the districts of Vangaindrano (38,863 cases per month between 2015 and 2019), Farafangana, Taolagnaro, Toliara II and Mahanoro, whereas the districts of Nosy Varika (1,043 cases per month on average between 2015 and 201 9), Vangaindrano, Mitsinjo, Manakara Atsimo and Analalava record severe forms of malaria.

Figure 20: Evolution of the number of uncomplicated malaria cases



Source: Health Statistics Service/Ministry of Public Health (Data processing: Health and Environment Service)

Figure 21: Evolution of the number of severe malaria cases



Source: Health Statistics Service/Ministry of Public Health (Data processing: Health and Environment Service)

By observing the evolution curves of simple malaria and severe malaria, two epidemiological profiles can be distinguished in Madagascar. There is first stable malaria, with perennial transmission along the coasts where more than half of the population lives. It explains the parallelism of the curves of evolution of the number of cases in the coastal districts and the other districts of Madagascar. The differences are smallest during the hottest period of the year, between July and November, when climatic conditions are most favorable for mosquito development. On the other hand, the significant differences in malaria cases observed in the coastal districts and the other districts of Madagascar, from December to May, can be explained by the development of unstable malaria characterized by a seasonal transmission in the highlands and in the sub-desert South and whose incidence reaches its peak in April.

Four epidemiological facies are derived from these two profiles: (i) the equatorial facies on the east coast (strong and perennial transmission), (ii) the tropical facies on the west coast (seasonal transmission lasting more than 6 months), (iii) the sub-desert facies in the south (short episodic transmission taking on epidemic proportions), as well as (iv) the facies of the High Plateaux (epidemic malaria) (Mathilde Suc, 2014).

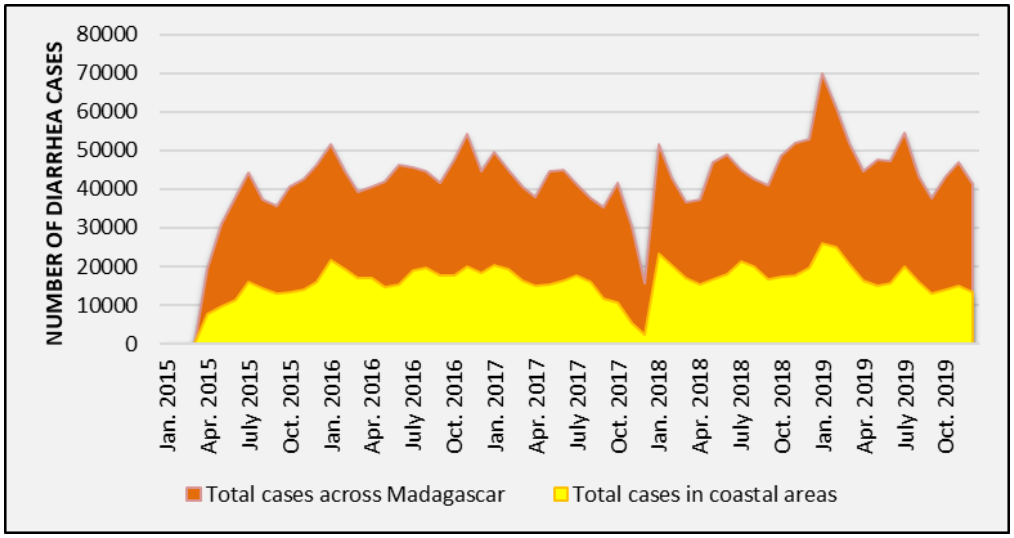
Madagascar's coastal areas are particularly at high risk from climate change. Yet, vector development depends on climatic conditions, mainly heat and humidity.

If the global objective of malaria control is to reduce the incidence of malaria by at least 75% in 2030, Madagascar, through the National Malaria Control Program, in its National Strategic Plan for Malaria Control 2018-2022, has set the objective of reducing the incidence of malaria by 40% in districts with high endemicity and 30% in other districts, with the technical support of technical and financial partners and the increase of the State's financial participation.

3.3.1.4. Diarrhea

The growth of waterborne diseases, among others diarrhea seen in outpatient clinics in seafront districts health facilities is 334,937 cases in 2015 to 589,452 cases at the end of December 2019, although the number of cases decreased in 2017 with 464,326 cases.

Figure 22: Evolution of the number of diarrhea cases



Source: Health Statistics Service/Ministry of Public Health (Data processing: Health and Environment Service)

The resurgence of diarrheal diseases is closely linked to the access of institutions and households to safe drinking water and sanitation. However, only half of the health facilities currently have improved water sources and 60% have hygienic latrines. At the household level, a MICS survey conducted in 2018 showed that access rates to safe drinking water and sanitation remain low, respectively at 44.9% and 39.8%.

Despite State efforts to improve household access to safe drinking water and basic sanitation, especially in large cities, the districts of Mahajanga I, Toamasina I, Taolagnaro, Toliara I and Manakara Atsimo remain the most affected by diarrhea.

3.3.1.5. STI/HIV - AIDS

The health facility activity package includes the provision of Sexually Transmitted Infections (STIs) and Human Immunodeficiency Virus - Acquired Immunodeficiency Syndrome (HIV-AIDS) services, which has improved due to the proximity of the services offered. Health centers are adopting the syndromic approach to screen classic STIs, whereas staff are trained on screening, and first-line antiretrovirals are prescribed at treatment centers.

In 2018, there were 192 or 0.3% new HIV cases without immunosuppression seen in outpatient referral at the hospital level. From 2015 to 2018, the number of newly screened HIV-positive individuals increased linearly and the proportion of people living with HIV receiving antiretroviral treatment rose from 67.05% to 77.7%. The stigma and discrimination associated with HIV infection by society, the lack of awareness, the perception of misconceptions about the disease, and the inadequate targeting of testing explain in part the low proportion of HIV-positive people tested compared to the estimated 15.5% in 2019.

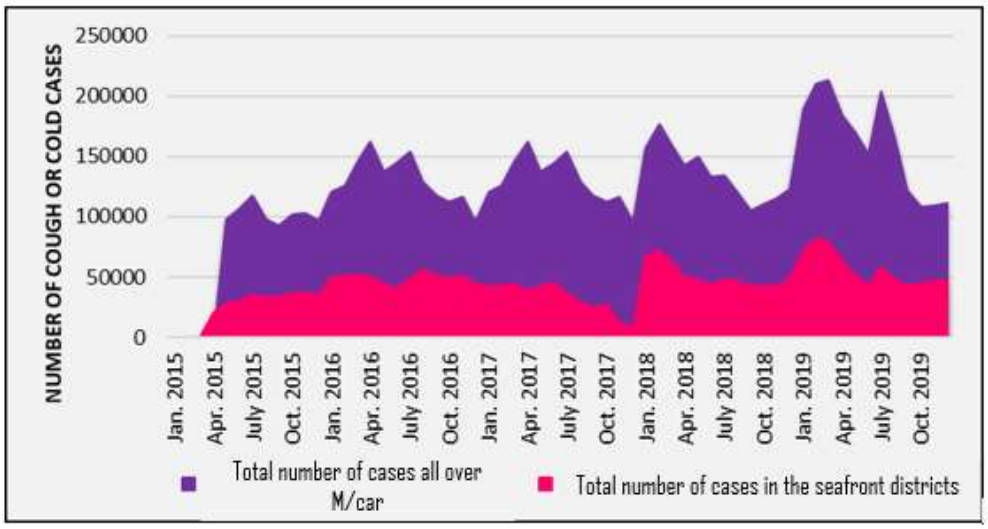
DIANA, Boeny, Atsinanana, Atsimo Andrefana and Analanjirofo are at risk coastal regions.

3.3.1.6. *Acute Respiratory Infections*

Acute Respiratory Infections (ARI) are the main reason for consultation at the Basic Health Centers (CSB) and are among the most frequent causes of mortality in children in Madagascar.

The number of cases of cough or cold seen in outpatient clinics in health facilities has been constantly increasing in recent years. From 1,346,923 cases in 2017, the number of cough or cold cases in the seafront districts reaches 1,939,712 in 2019. The districts of Mahajanga I, Toamasina I and Taolagnaro are particularly affected.

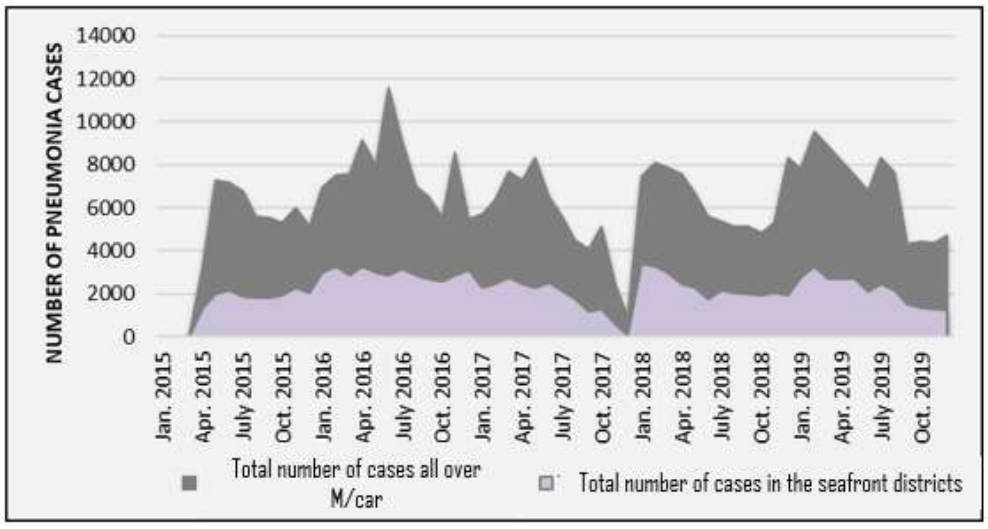
Figure 23: Trends in the number of cases of coughs and colds



Source: Health Statistics Service/Ministry of Public Health (Data processing: Health and Environment Service)

In addition, there is a constant increase in the number of new cases of pneumonia in the districts of the coastal zones, from 64,569 cases recorded in 2017 to 82,514 in 2019, representing an increase of 28%. The districts of Farafangana, Taolagnaro and Manakara Atsimo are the most affected.

Figure 24: Evolution of the number of pneumonia cases



Source: Health Statistics Service/Ministry of Public Health (Data processing: Health and Environment Service)

Data from health facilities reveal that the morbidity share of Other ARIs in coastal areas increased from 193,708 in 2015 to 561,865 cases in 2016. The districts of Toamasina I, Mahajanga I and Manakara are the first three seafront districts most affected.

3.3.2. Access to health services

The structure of public health facilities in coastal areas is based on four levels of service provision, including the national level with 08 out of 22 University Hospital Centers (CHU), the intermediate level with 09 out of 16 Regional Reference Hospital Centers (CHRR), the peripheral level with 30 out of 100 public District Reference Hospital Centers (CHRD) as well as 1,151 out of 2,719 Basic Health Centers (CSB), and the community-based level which offers promotional services and integrated management of illnesses in children under 5 years of age (Ministry of Public Health, 2021).

The latest human resources census estimates the health staff at 16,421 ; 23% of this figure belong to the medical staff, 41% are paramedical staff and 36% are administrative and support staff. The ratio of health facilities to the population is 1/9,400, i.e. one health facility for every 9,400 people. Regarding the geographical accessibility of the population to the Basic Health Centers, approximately 45.22% of the population live less than 5 km from the nearest Basic Health Center, and 25.75% live more than 10 km away, with an outpatient rate of 38.9% (Annuaire des Statistiques du secteur santé de Madagascar, 2018). Right now, 51% of the CSBs are run by only one worker on-site while 50.3% of the CSBs2 do not have general practitioners. As for the CHRRs, the average number of staff is 60, all categories combined, whereas the standards are set at 156 staff, and for the CHRDs with operating theatres, the average number of staff is 26, compared to the 84 required by the standards (PDSS, 2021). The ratio of doctors per capita is estimated at 0.181/1,000 in Madagascar (World Bank, 2014).

Generally, two major problems contribute to the occurrence of illness and death. The first is the low use of services with its various determinants which are linked to the providers, the individual, the Community and the environment where the interventions are implemented. The second is related to the failure in services provision, including limited geographical coverage, lack of resources, lack of a clear framework and lack of demand stimulation. There is also the problem of geographical and financial accessibility which is a barrier for people to access information and quality healthcare.



Lean period (Analamary, Ambovombe District Ambovombe- Androy Region, 2020)

Table 17: Evolution of the rate of use of outpatient clinics (OC)

Region	Rate of use of OC for CSB (%)		Rate of use of OC referral at CHRD level (%)		Rate of use of OC referral at CHR/CHU/ES level (%)	
	2015	2018	2015	2018	2015	2018
DIANA	37.5	48.6	1	2.8	0.2	0.4
SAVA	25.8	25.7	1.3	1.2	0.1	0
Atsimo Atsinanana	31.5	45	1.3	1.8	0.2	0.1
Vatovavy Fitovinany	29.7	29	1.7	2.1	0	0
Boeny	60.1	67.5	0.3	1.4	0.1	0.5
Melaky	17.1	27.8	0.5	0.4		
Sofia	10.4	29	2.1	3.1	0.5	0.3
Atsinanana	43.5	51.2	0.8	1.3	0.1	0.2
Analanjirofo	19.4	35.8	0.5	0.6	0	0
Atsimo Andrefana	36.4	35.9	1.7	3	0.4	0.4
Androy	18.1	27.1	0.2	1.4	0.4	0.4
Anosy	21.5	65.3	0.4	0.8	0.2	0.1
Menabe	29.2	67.3	1.2	1.3	0.7	0.4
TOTAL	**29.6**	**43.7**	**0.9**	**1.5**	**0.3**	**0.3**

Source: Health Statistics Department/Ministry of Public Health, 2020

3.4. Access to safe drinking water and sanitation

3.4.1. Access to safe drinking water

The drinking water sector challenges in Madagascar remain significant. An update/review of the Water, Sanitation and Hygiene Sector Plan dated July 2021[8] reported that the rate of access to drinking water in Madagascar is 24%.

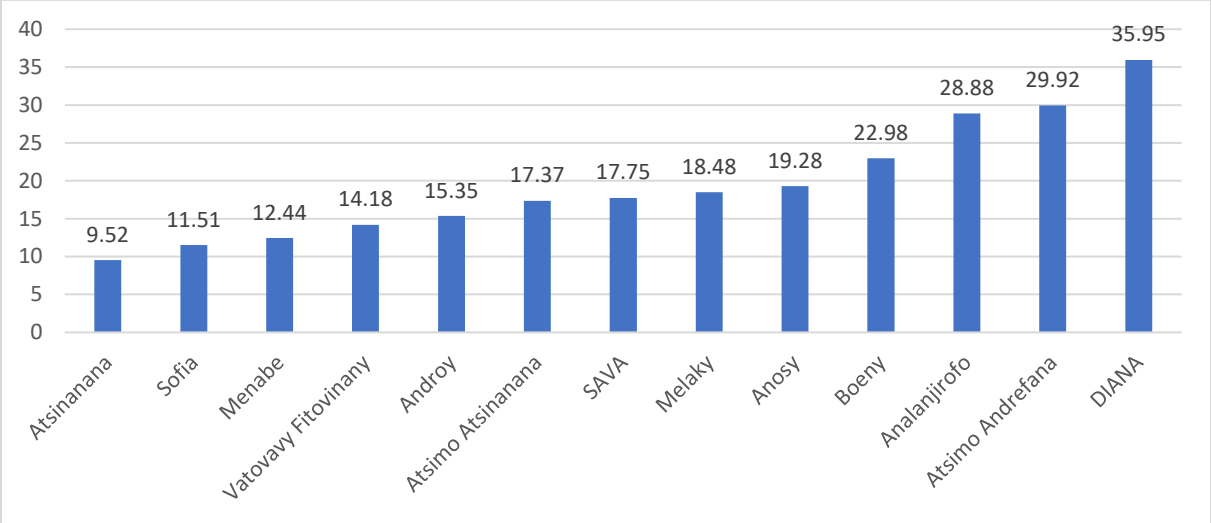
Despite the strong climatic pressures that the southern part of Madagascar is undergoing, it does not suffer from the lowest rate of access to drinking water. The data presented in the following figure show

[8] https: /www.linfo.re/ocean-indien/madagascar/un-faible-taux-d-acces-a-l-eau-potable-a-madagascar

that among the seafront regions, the Atsinanana Region is the most disadvantaged region in terms of access to drinking water, which seems paradoxical for a region that has great water wealth. In 2020, only 9.52% of its population had access to safe drinking water. This situation is due to the fact that the partners focused their actions in the arid and semi-arid regions. However, it is the Analanjirofo, Atsimo Andrefana and DIANA regions that have relatively high service rates, with a variation between 28,88% and 35.95%.

However important the efforts of the Malagasy Government were, the access rate of the population to improved drinking water supply sources is even lower in coastal districts. This could be explained by the fact that most of the population in coastal areas still use unimproved and unprotected water sources such as lakes, wells and streams. As a result, their population cannot enjoy good water quality, and would suffer from water-related diseases.

Figure 25: Access rate to safe drinking water in the seafront Regions



Source: Ministry of Water, Sanitation and Hygiene, 2020

3.4.2. Access to sanitation

At the national level, the access rate to latrines by the population is estimated at 37.34% in 2020. This rate is 34.25% in rural areas and 49.34% in urban areas. However, 11.6% of the population uses improved latrines[9], including 9.31% in rural areas and 20.46% in urban areas.

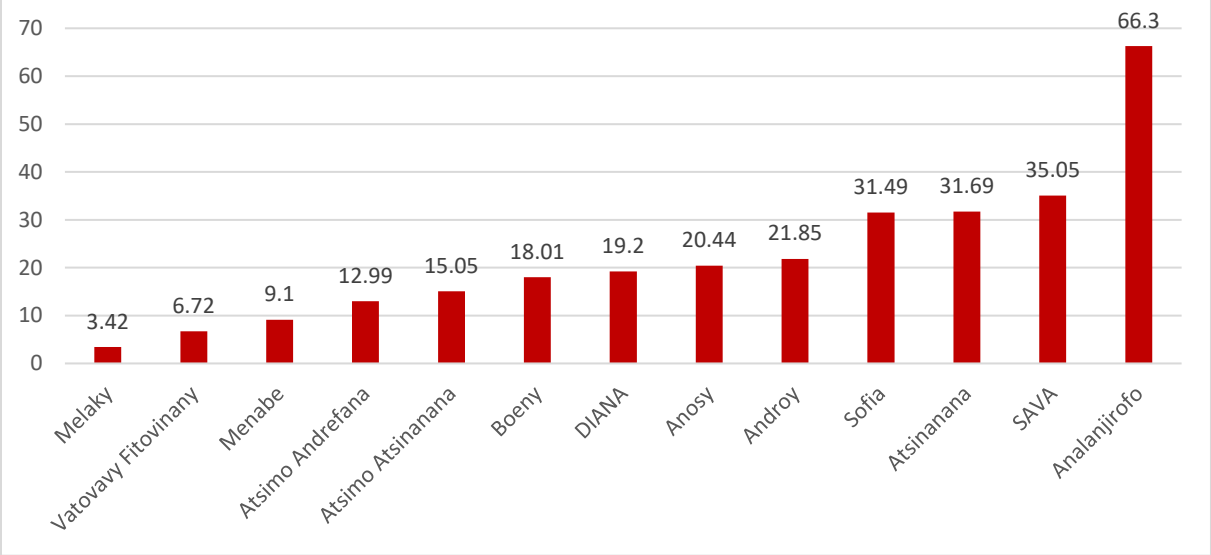
Melaky, Vatovavy Fitovinany and Menabe are the coastal regions where latrines are least used with respective rates of 3.42%, 6.72%, and 9.1%. Next are the Atsimo Andrefana and Atsimo Atsinanana regions with a rate of 12.99% and 15.05%. These figures could be explained by the failure of the population to adapt to the use of latrines. In addition, for some coastal regions, storing faeces within a four-wall structure is a taboo. Therefore, open defecation is more common and prevails as a common practice.

[9] Improved latrines: A latrine is improved when it provides enough separation between human faeces and its users and ensures at the same time that there is no contact with its users. This infrastructure therefore must have a strong platform (a slab) that can be washed and cleaned. It is completely hygienic and prevents any propagation of illnesses.

While, for the Analanjirofo Region, the number of population using toilets is higher, the rate is respectively 66.3% and 24.21% for latrines and improved latrines. These figures show that the region is most convinced of the importance of using toilets.

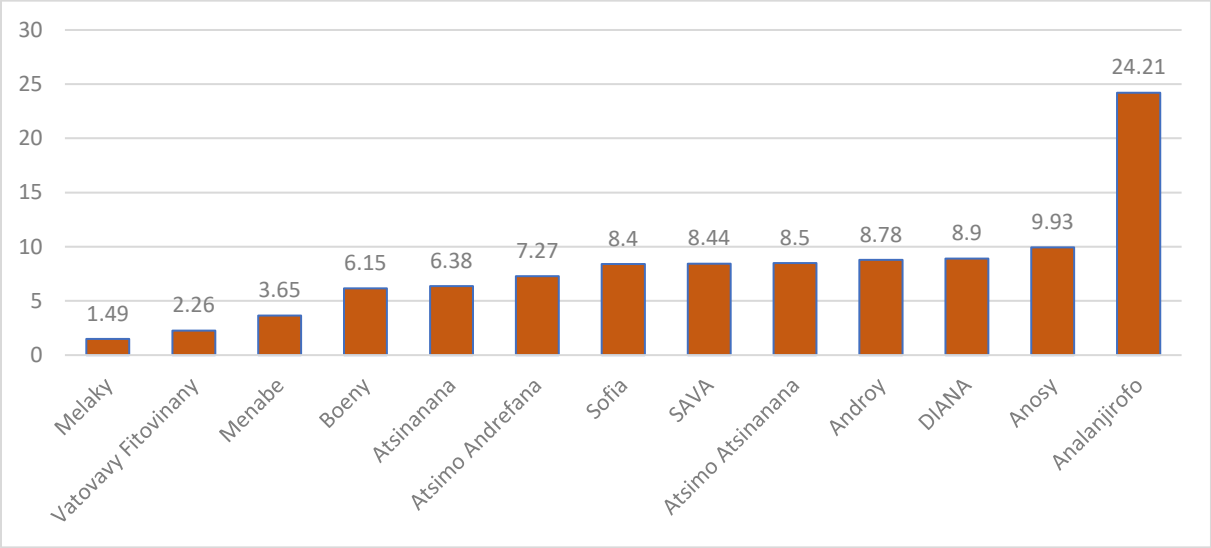
Given that the two regions "Vatovavy" and "Fitovinany" are recently separated administratively in 2021, their data are still combined.

Figure 26: Rate of use of latrines in seafront regions



Source: Ministry of Water, Sanitation and Hygiene, 2020

Figure 27: Access rate to improved latrines for seafront regions



Source: Ministry of Water, Sanitation and Hygiene, 2020

3.5. Education

Education plays a central and primary role in the 2030[10] Agenda. Indeed, 7 of the 17 other Sustainable Development Goals (SDGs) include the educational dimension. However, particular emphasis is placed on SDG 4, which aims to "Ensure equal access to quality education for all and promote lifelong learning opportunities" by 2030.

3.5.1. Overall context of the education sector

The overall structure of the Malagasy educational system, both public and private, is organized as follows[11]:

- Pre-school, which lasts three years and is educational in nature, focusing on early learning and socialization activities, is not compulsory and is intended for children aged 3 to 5;
- Fundamental 1 or primary school, at the end of which, a certificate called the CEPE or “Certificat d’Etudes Primaires Elémentaires”, is delivered, is officially intended for children aged 6 to 10;
- Fundamental 2 or general secondary school lasts four years. The BEPC or Brevet d'Etudes du Premier Cycle de l'enseignement secondaire is then issued ;
- Secondary education or general secondary education, leading to the “Baccalauréat de l'enseignement secondaire general”.

Several indicators enable us to establish the overall situation of the educational system in terms of supply and demand. Thanks to their analysis, improvements resulting from the efforts made are demonstrated, and challenges to guide future interventions can be identified.

3.5.1.1. Coverage Indicators



Coverage indicators provide information on the aspects of education, with regards to infrastructure, and thus on the relationship between supply and demand for education. One such indicator, which provides information on the general level of access to primary education and the capacity of the

[10] UNESCO statistics institute, 2018. A Quick guide to the education indicators for SDG4

[11] Education Sector Plan (PSE), 2018 to 2022

education system to ensure access to the first grade for the population of official school entry age, is the access rate.

The table below shows the raw values of the access rate by level of education in Madagascar.

Table 18: Access rate per level

Pre-school		Primary		Middle school		High school	
Public	**Private**	**Public**	**Private**	**Public**	**Private**	**Public**	**Private**
15.0%	8.3%	144.8%	26.9%	31.4%	17.5%	12.2%	8.5%

Source: Statistical Yearbooks, Education Statistics Service/Education Planning Department/Ministry of National Education (SSE/DPE/MEN)

For the 2020-2021 school year, the primary school access rate is the highest in the education system. However, this gross access rate of well over 100% also shows that children who are too old and/or too young are entering elementary school for the first time.

a. Preparation for elementary school

Early childhood education is generally designed with a holistic approach to support children's early cognitive, physical, social, and emotional development and to introduce young children to organized learning outside the family context. This indicator measures the proportion of children exposed to organized learning activities in the year before starting elementary school, and also contributes to measuring the achievement of target 4.2 of the MDG.

In the case of Madagascar, the coverage rate of the indicator is still low with a national value of 29.6%, the highest value of 46% for DIANA and the lowest value of 12.8% for SAVA.

Table 19: Percentage of children in the first grade of primary school who attended pre-school the previous year

Percentage of children in the first grade of primary school who attended pre-school the previous year	
Total	29.6
Sex	
Male	29.1
Female	30.0
Home	
Urban	49.2
Rural	25.3
Vatovavy Fitovinany	28.8
Atsimo Atsinanana	22.2
Atsinanana	23.7

Percentage of children in the first grade of primary school who attended pre-school the previous year	
Analanjirofo	36.1
Boeny	35.9
Sofia	28.0
Melaky	20.8
Atsimo Andrefana	21.1
Androy	22.8
Anosy	41.0
Menabe	20.7
DIANA	46.0
SAVA	12.8

Source: Multiple Indicator Cluster Survey (MICS), 2018

b. Participation in Education

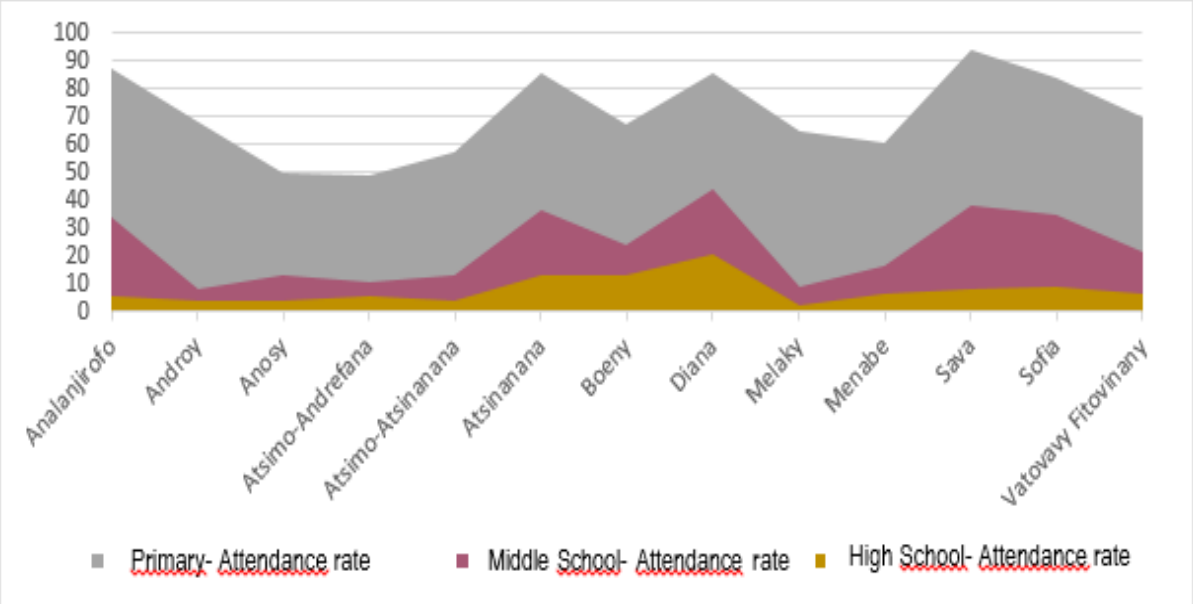
Madagascar, compulsory schooling lasts for 5 years, from age 6 to age 10. The official school ages by level of education are 3 to 5 years for preschool, 5 to 10 years for primary, 11 to 17 years for middle school and high school[12].

The net attendance rate provides a more accurate measure of the extent of participation in a given level of children[13] education in the official school age group for that level.

[12] Htttp: /uis.unesco.org/fr/country /mg

[13] UNESCO statistics institute, 2018. A Quick guide to the education indicators for SDG4

Figure 28: Net attendance rates for elementary, middle, and high school, school year 2017-2018



Source: Multiple Indicator Cluster Survey (MICS), 2018

The figure above provides an overview of the formal education system by Regional Directorate of National Education (DREN) with maritime facades in terms of attendance rate. This rate contributes to the achievement of target 4.2 of the MDG stipulating: "by 2030, ensure that all girls and boys have access to quality early childhood care and development and to quality pre-school education that prepares them for primary school ».

Overall, the figure shows that the primary level is the most attended, followed by middle school and finally high school. The highest attendance rate is recorded in SAVA with rates of 85.6%, 43.7% and 21% for primary, middle and high school respectively. The Atsimo Andrefana Region has the lowest rate with 48.7%, 12.8% and 3.6% for primary, middle and high school respectively.

Disparities in school attendance persist between regions, ranging from 49 to 95% for primary school. For middle school and high school, attendance rates are lower in almost all the southern regions (Atsimo Andrefana, Androy, Anosy and Atsimo Atsinanana)[14].

[14] Multiple Indicator Cluster Survey (MICS), 2018

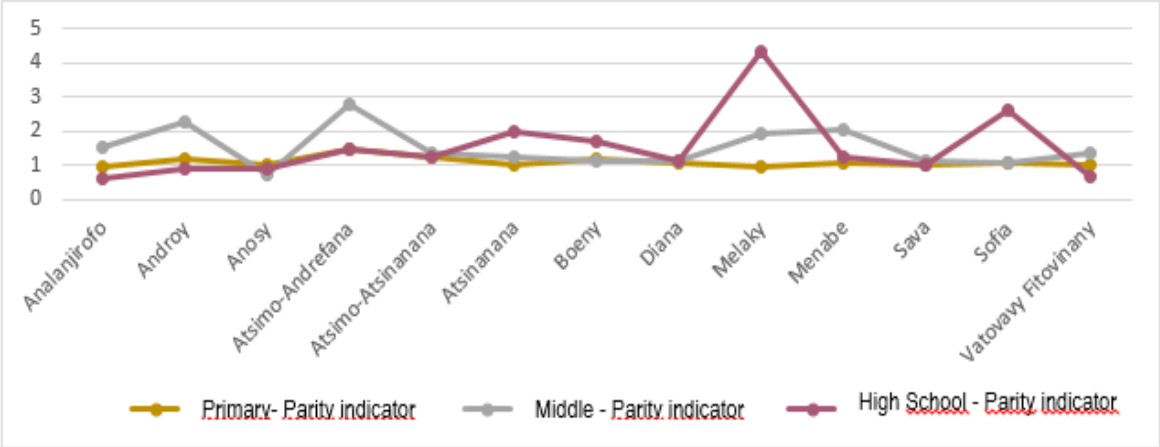


c. *Ratio of girls and boys attending school*

The gender parity index provides a measure of the progress made towards gender parity in terms of enrollment and/or learning opportunities available to female individuals compared to male individuals[15]. It is also indicative of the degree to which women's status in society has been enhanced.

In terms of parity between boys and girls, there is a slight imbalance in favor of girls in elementary school and an overall greater advantage in favor of girls in middle and high school.

Figure 29: Net Attendance Rates



Source: Multiple Indicator Cluster Survey (MICS), 2018

d. *Literacy rates*

While the "international standard" sets that the illiteracy rate should not exceed 40% of the total population, in Madagascar the literacy rate of people aged 15 and over was 74.8% in 2018 (Source:

[15] UNESCO statistics institute, 2018. A Quick guide to the education indicators for SDG4

UNESCO[16]). Almost 75% of the population (especially in rural areas) cannot read or write. This high rate is a factor of poverty. *Thanks to the efforts made by the Ministry of Education and supported by several partners, this rate has significantly changed. The National Literacy Strategy (SNA) has been updated* and UNESCO has supported its development through its CAP ED Pilot program. As part of the Education Sector Plan (PSE), the challenge is to reduce the illiteracy rate among young Malagasy people aged 15 and over to 25% by 2030 (Source: MEN[17]).

3.5.1.2. Internal efficiency indicators

a. School exclusion

According to the results of the studies conducted by UNESCO on "Analysis of data on out-of-school children and the impact of the Covid-19 pandemic in Madagascar",[18] the percentage of out-of-school children by level amounts to:

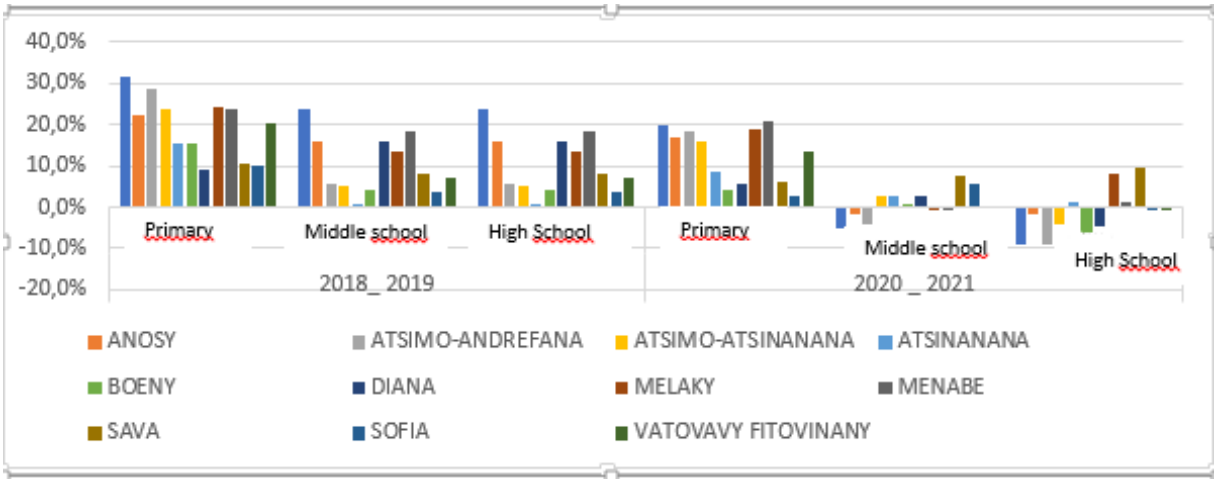
- 40% for preschool, representing between 285,000 and 316,000 children under 5 years of age.
- 22 to 27% for primary school, representing between 751,000 and 921,000 children.
- 30 to 40 percent for middle school, representing between 741,000 and 1 million children.

In addition, according to this study, the most important problems in the system are late entry, high repetition rates, and dropouts at the primary level, which is of particular interest to us.

The dropout rate makes it possible to evaluate the phenomenon of school dropout before graduation in an age group and its impact on the internal efficiency of the education systems. In addition, it is a key indicator for analyzing and predicting the school career of students during the education cycle.

The figure below gives us the details of the dropout rate by level of education and by region of the education system during the school years 2018 to 2021.

Figure 30: Net attendance rates



[16] https: //donnees.banquemondiale.org/indicateurs/SE.ADT.LITR.ZS ?locations=MG

[17] https: //www.education.gov.mg/journee-internationale-de-lalphabetisation-2018-strategie-nationale-de-lalphabetisation-sna-a-madagascar-actualisee/

[18] https: //www.unesco.org/fr/articles/lexclusion-scolaire-madagascar-pendant-la-covid-19#text=pourcentagedesenfantsnonscolarisesetmillionsd'enfants

Source: Statistical Yearbooks, Service de la Statistique de l'Education/Direction de la Planification de l'Education/Ministry of National Education (SSE/DPE/MEN)

On the whole, a regression of the indicator at all levels of education between 2018 and 2021 is recorded. If the trend of school dropout is decreasing, it is however necessary to note the importance of this phenomenon in the regions that are most exposed to the effects of climate change such as Androy, Anosy, Atsimo Andrefana and Atsimo Atsinanana.

According to UNESCO[19], the dropout phenomenon in Madagascar is such that primary school children have only a 33% chance of reaching the last year of the cycle. However, once in middle school, they have a 73% chance of reaching the last grade, and those who reach high school have an 87% chance of reaching the last grade.

b. School Completion

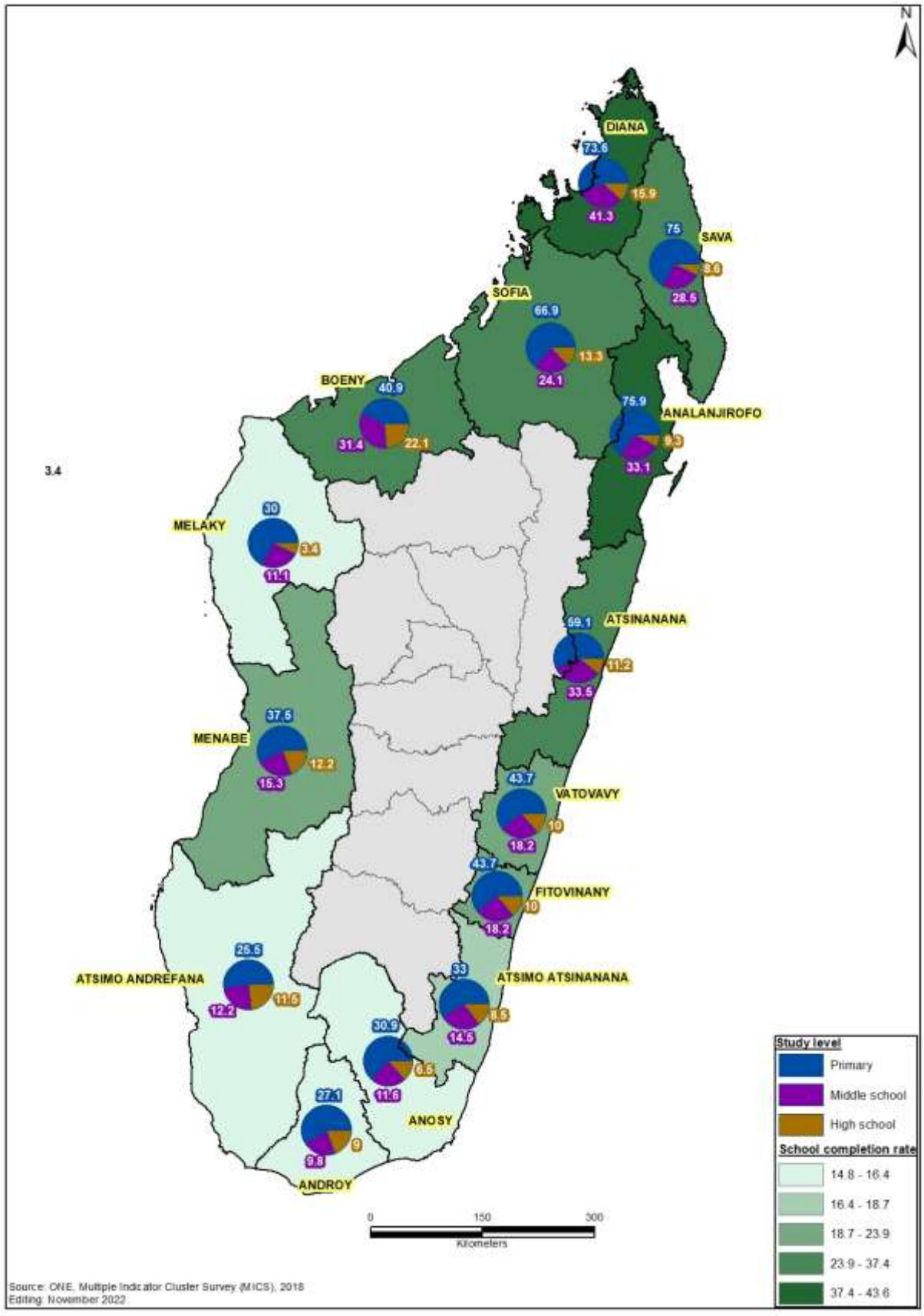
School completion is defined as the percentage rate of a group of children or youth aged 3 to 5 years above the expected age for the last grade of each level of education who completed that grade.

The completion rate contributes to the achievement of MDG Target 4.1: "Ensure that by 2030 all girls and boys complete a full course of free, quality primary and secondary education that leads to meaningful learning. »

In the case of Madagascar, the issue of school completion remains a major concern for the education system. Indeed, less than three out of five children complete primary school, one quarter complete middle school, and one in six completes high school.

[19]Https://www.unesco.org/fr/articles/lexclusion-scolaire-madagascar-pendant-la-covid-19#text=pourcentagedesenfantsnonscolarisesetmillionsd'enfants

Map 24: School completion rate



Source: Multiple Indicator Cluster Survey (MICS), 2018

3.5.1.3. *Regional disparity in resources*

For a school to function properly, a variety of resources such as well-equipped, attractive and electrified classrooms, separate latrines for boys and girls, a library, etc must be available.

In addition, pedagogical conditions such as qualified teachers and relevant textbooks are required to ensure the quality of school results.

The indicators below provide information on the situation of the education sector in this area, particularly the disparities that underlie the system, broken down by area of residence, state of the schools and level of education.

Table 20: Some key indicators on resources

Indicators on the teachers according to their location and status Indicator on the equipments, furniture and educational infrastructures									
Indicators	HOME	PRESCHOOL		PRIMARY		MIDDLE SCHOOL		HIGH SCHOOL	
		PUBLIC	PRIVATE	PUBLIC	PRIVATE	PUBLIC	PRIVATE	PUBLIC	PRIVATE
Ratio pupils / seats	RURAL	5.5	1.2	2.0	0.9	1.3	0.9	1.2	0.8
	URBAN	2.8	1.1	1.9	0.9	1.5	0.9	1.3	0.8
	TOTAL	**5.0**	**1.1**	**2.0**	**0.9**	**1.4**	**0.9**	**1.2**	**0.8**
Ratio pupils / teachers	RURAL	22.7	24.9	42.0	32.8	19.7	16.5	19.3	13.5
	URBAN	21.3	25.3	46.5	31.4	27.6	18.6	25.1	15.2
	TOTAL	**22.5**	**25.1**	**42.4**	**32.3**	**21.2**	**17.5**	**21.5**	**14.5**
Ratio pupils / manuals	RURAL			0.5	1.1	1.0	5.0	1.2	8.3
	URBAN			0.5	1.2	0.6	5.8	0.6	7.8
	TOTAL			**0.5**	**1.2**	**0.8**	**5.4**	**0.8**	**8.0**
Percentage of teachers	RURAL	88.3%	46.1%	90.4%	63.4%	80.8%	53.0%	60.8%	41.9%
	URBAN	11.7%	53.9%	9.6%	36.6%	19.2%	47.0%	39.2%	58.1%
	TOTAL	75.6%	24.4%	77.3%	22.7%	57.6%	42.4%	46.1%	53.9%
Percentage of teachers who are not civil servants	RURAL	91.7%		65.5%		51.4%		45.5%	
	URBAN	76.1%		39.5%		22.6%		24.2%	
	TOTAL	**89.9%**		**63.0%**		**45.9%**		**37.2%**	
Percentage of teachers paid by the government	RURAL	15.6%		65.0%		53.1%		54.8%	
	URBAN	38.0%		77.4%		79.8%		76.3%	
	TOTAL	**18.2%**		**66.2%**		**58.2%**		**63.3%**	

Indicators on the teachers according to their location and status Indicator on the equipments, furniture and educational infrastructures									
Percentage of qualified teachers	RURAL	57.5%	51.4%	14.8%	7.9%	25.9%	9.5%	28.1%	14.0%
	URBAN	72.2%	47.3%	35.1%	13.5%	52.1%	15.3%	39.2%	18.9%
	TOTAL	**59.2%**	**49.2%**	**16.8%**	**10.0%**	**31.0%**	**12.2%**	**32.4%**	**16.8%**

Source: Statistical Yearbooks, Education Statistics Service/Directorate of Education Planning/Ministry of National Education (SSE/DPE/MEN)





3.5.2. Negative impact of climate change on access, retention and quality of educational services

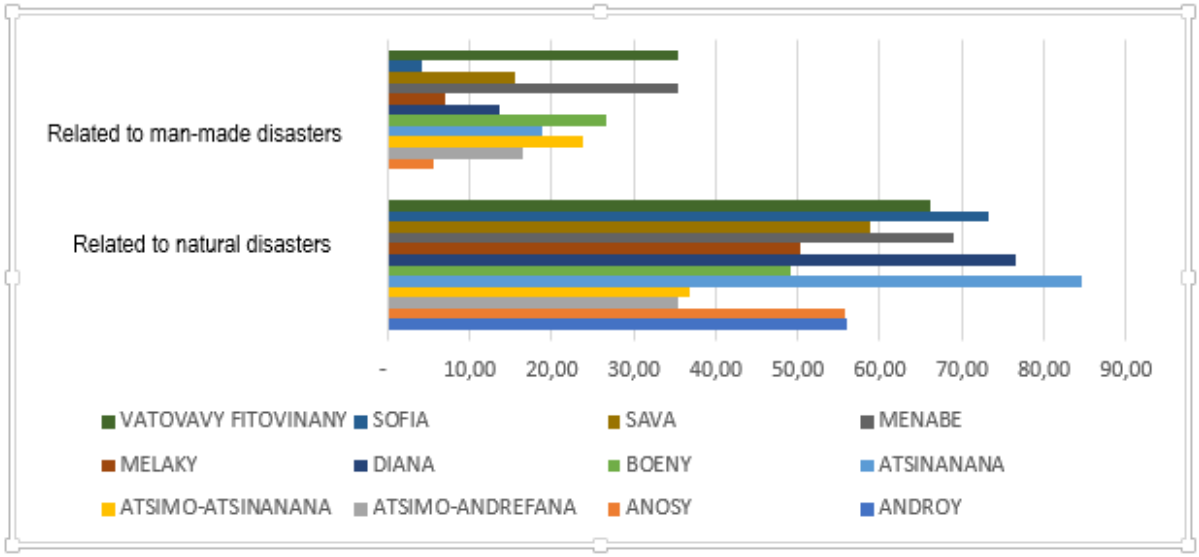
Being in the intertropical convergence zone, Madagascar is exposed to the threat of strong winds and heavy rains brought by the string of tropical depressions that form over the Indian Ocean between December and April each year. The large island is also regularly hit by periods of intense drought. With climate change, these weather disturbances tend to become more frequent and intense. However, these major natural events, destined to intensify, combined with the difficult socio-economic conditions of the population, constitute a permanent and even increasing state of risk. The impacts on the education sector (destruction of schools, high dropout rate in the districts of the Grand Sud compared to the national rate) place the education system in a state of repeated and increasing vulnerability.

For example, at the beginning of 2022, following the passage of cyclones Batsiraï, Dumako and Emnati,

- 6,954 classrooms in 2,498 schools completely destroyed (all levels of education combined);
- 2,706 classrooms in 1,189 schools and 25 administrative buildings (Direction Régionale de l'Education Nationale (DREN), Circonscriptions Scolaires (CISCO), Centres Régionaux de l'Institut National de Formation Pédagogique) partially destroyed ;
- 2,913 classrooms in 1,287 schools completely destroyed;
- 423,866 students in 20 regions affected.[20]

[20] Source: Disaster Risk Management, General secretary, Department of National education, data regarding damages to the educational system, year 2022 (SGRC/SG/MEN)

Figure 31: Net school attendance rates



Source: Multiple Indicator Cluster Survey (MICS), 2018

To deal with this situation, various strategic orientations have been initiated and adopted by the Ministry of National Education.

3.5.2.1. Education sector policy in terms of risk and disaster management integrating climate change [21]

In alignment with the Sendaï framework and the 2015 National Risk and Disaster Management Policy, the Education Sector Plan integrates in its strategic point number 6 the strengthening of the resilience of the education system to risks and disasters by aiming to control the negative repercussions of the crises through the strengthening of the education system. In this sense and in close collaboration with partners of the Education Sector Group and other ministries, the different parties agreed to:

i. **Reduce the risks arising from natural or man-made hazards through actions to:**
   - Refurbish all damaged rooms;
   - Provide capacity building of committee members in Disaster Risk Management (DRM).

ii. **Strengthen the resilience of the education system through actions of:**
   - Expanding the implementation of disaster resistant school infrastructure standards in at-risk areas;
   - Providing capacity building in DRM/ Disaster Risk Reduction (DRR) for supervisors and trainers at the level of DREN, CISCO and Heads of Administrative and Pedagogical Zones (ZAP);
   - Training of directors and teachers of basic schools in DRR.

3.5.2.2. Program to integrate SD and ESD in the educational system

[21] Education Sector Program (PSE), from 2018 to 2022

In parallel to the integration of Risk and Disaster Management in the Education Sector Plan, the Ministry also implements at all management levels the concept of Sustainable Development (SD) and Education for Sustainable Development (ESD) by:

- Setting up at the level of the Ministry of National Education the Education for Sustainable Development Committee (MEN ESD Committee) in which each directorate is represented, and whose technical representatives have the role of sensitizing the staff of the directorates they come from on SD and ESD and its eco-citizen practices.
- Integrating SD and ESD themes, including climate change, into the curriculum in a progressive manner since 2016.

3.5.2.3. Globe Program

This is about implementing the GLOBE Program which is a scientific, educational and environmental program. It deals with the themes of larvae control against mosquitoes, the vectors of malaria, contribution to the protection of world heritage, research project on climate change and environmental degradation. Through the use of high-tech equipment, the Globe program contributes to the alignment of the quality of education with international standards, getting students used to scientific analysis through mini-projects and raises awareness of climate and environmental issues.

At the time being, there are 25 GLOBE high schools, 3 CEGs and 2 EPPs in Madagascar.

a. Since 2006: at the primary and secondary levels

Most actors working in the education sector, such as WWF (World Wide Fund for Nature), MFG (Madagascar Fauna and Flora Group), GIZ (The Deutsche Gesellschaft für Internationale Zusammenarbeit), etc. target primary school students, aged 6 to 14. This is because they are more likely to change their behavior and develop new attitudes. In addition, children are vehicles for environmental messages in their respective homes and in the society.

Manual production:

The WWF organization was one of the pioneers of Environmental Education in Madagascar. Various educational kits and manuals are produced, such as:

i. Ny Voaary, in collaboration with the Ministry in charge of National Education, the Ministry in charge of the Environment and the Secretariat of State in charge of Technical Education and Vocational Training;
ii. Textbooks for students on the protection of marine and coastal ecosystems for primary and secondary school students living around Andavadoaka, in collaboration with other NGOs and the Centre Culturel et Educatif à l'Environnement (CCEE) Toliary.
iii. Cahier Maitso/ or Green copybooks, in collaboration with the Soakapila Association and the CCEE Toliary.

Introduction of the eco-pedagogical approach in about fifty school districts.

Production of modules or guides including the practical guide for teachers by other organizations such as the Madagascar Fauna Group, Ivoloina Tamatave.

Design and production of an environmental education teaching material kit « KIT MAD‟ERE » by the GIZ program, in collaboration with the Ministry in charge of the environment, aiming to develop environmental reflexes from a young age.

b. Since 2008: at the preschool level

Design and creation of activities for the learning process in early childhood, song and story books in collaboration with technical and financial partners including UNICEF (United Nations Children's Fund).

The implementation of the national strategy for early childhood has allowed the integration of Environmental Education at the early childhood level. It is a starting point for the transmission of basic notions about Environment.

It is expressed through songs, poems, mimics, playful and artistic games (drawing, graphics and coloring) of fauna and flora, while mentioning their names. Thus, early childhood is a stage of life where values and behaviors can already be instilled in children, without the influence of their family or society.

c. **Since 2017: Curricula and training**

Progressive integration of climate change themes in the Curricula and accompanying documents, in partnership with the Ministry in charge of the environment and with the German cooperation through GIZ.

i. Basic education: T1, T4, T7
ii. Secondary education: Seconde, Première, Terminale.

d. **2016: Availability of educational manuals in DRR**

DRR manuals for students and teachers "Arovako amin'ny loza ny Fireneko" including 11 themes of risks to be managed in Madagascar including cyclone, flood, fire, climate change, tsunami, food insecurity, erosion, drought, locust invasion, pollution and epidemic.[22].

e. ***2021: At the school level***

Implementation of the "one student, one tree" program through an agreement between the Ministry of National Education and the Ministry of Ecology and Sustainable Development.

3.6. Infrastructures

3.6.1. Road Infrastructure

The Ministry of Public Works manages roads that fall under national roads classification. Communal roads generally fall under the responsibility of the decentralized authorities, i.e. the governorate and the communes.

Among the 50,000 km of Madagascar's existing road network, only 29,100 km are officially classified as National Roads (RN) and Roads of Provincial Interest (RIP) according to Decree No. 99-776 in 1999:

- RNs are classified into three categories:
  - Les The Primary National Roads (RNP). These are the RN2, RN4, RN6 and RN7. They are all currently tarred with a total length of 2,564 km
  - The Secondary National Roads (RNS) with a total length of 4,654 km, 47% of which are tarred
  - The Temporary National Roads (RNT) with a total length of 4,600 km, 20% of which are tarred.
- The total length of RIPs is 17,352 km, 97.8% of which are dirt roads. The majority of these RIPs are in poor condition.

[22] DRR Notebook and manuals « Arovako amin'ny loza ny fireneko », Ministere de l'Education nationale

According to the estimate[23] in 2019, more than 20,000 km of rural Communal Roads (RC) exist in Madagascar, but the decree which allows to proceed with the official classification of RCs has not yet been drwan up since the release of the Madagascar Road Charter in 1998. These infrastructures are in poor condition.

The total length of roads in coastal areas is approximately 5,245 km meaning 44.3% of the existing road infrastructure (RN and RIP). The state of the road network, which is not unusual, leads to a very contrasting and marked situation of accessibility and remoteness for seafront Communes. Thousands of kilometers of roads are in poor condition throughout the coastal regions. The degradation of road infrastructure is mainly due to the direct or indirect impacts of climate change (recurring floods, landslides, etc.), difficult topography (type of soil, slope, etc.), lack of maintenance and lack of budget allocated to the maintenance of existing infrastructure (roads and bridges).

Road repairs and rehabilitation to ensure that all Communes, Districts and Regions are directly connected and that none of them is isolated, were carried out by the Malagasy State. Examples include the rehabilitation work of the RNS5 between Mananara Nord and Maroantsetra, the routine maintenance of the RNS30 between Ambalavelona and Ankify (DIANA Region), the maintenance work to improve existing infrastrucutre (concrete pavement construction) on the RNT17A (Androy Region), additional rehabilitation work of the RN5 between Ambodiatafana and Foupointe (Atsinanana Region), ...

The Ministry of Transport has to supervise the bodies which are under its responsibility and which are in charge of the management of the transport infrastructure (road transport infrastructure, maritime and river transport infrastructure, and air transport infrastructure).

This ministry is responsible for promoting the road transport system, particularly through the development of standard transport infrastructure, namely passenger bus stations and rest areas. Once the public transport infrastructure has been built, the Land Transport Agency, the body attached to the Ministry, is responsible for awarding the concession to companies or other public or private entities, through a competitive bidding process. In addition, there are also private transport infrastructures (built by private transport operators) whose construction and operating conditions are governed by Ministerial Decree of the Ministry in charge of Transport.

There are currently throughout Madagascar (Source MTM)

- 13 public bus stations, 4 of which are not in use
- 29 private bus stations
- 91 parking lots (not standardized)
- 2 functional safety, service and rest areas and 5 under construction.

It should be noted that transport infrastructure is different from road infrastructure, where we talk about national or secondary roads.

3.6.2. Port, river and maritime infrastructure

Madagascar is served by 17 ports classified as Ports of National Interest (PIN) and Ports of Regional Interest (PIR).[24]

[23] ONG Lalana – March 2019

[24] https: //www.apmf.mg /

- Ports of National Interest include Antalaha, Antsiranana, Ehoala, Mahajanga, Nosy Be, Toamasina, Toliara and Vohémar ports
- Ports of Regional Interest include Maintirano, Manakara, Manajary, Maroantsetra, Morombe, Morondava, Saint Louis, Sainte Marie and Taolagnaro ports.

The ports of Toamasina, Mahajanga, Antsiranana, Nosy Be, Toliara, Ehoala (Taolagnaro) and Vohémar (by way of derogation) are international ports.

Madagascar does not have any inland waterway designed to allow the navigation of large-scale waterway transport units.

River navigation is currently limited to traditional units (canoes) as well as to a few small artisanal units that are mainly on the rivers of the West coast (Tsiribihina downstream from Miandrivazo, Betsiboka downstream from Marovoay, Sofia).

The only exception is the Pangalanes Canal which stretches over nearly 650 km in length between Mahavelona (Foulpointe) in Atsinanana Region as the north edge and Farafangana in Atsimo Atsinanana Region as the south edge.

Before 2002, almost the entire Pangalanes Canal was not navigable. There were some navigable portions for some villagers but they were in unsafe conditions. Currently, studies are ongoing to carry out major construction work projects (rehabilitating and widening the canal, enlarging mooring areas, constructing port infrastructures and jetties).

The Law No. 2003-025 of September 05, 2003 on the statute of ports and governing the management of ports in Madagascar.

Ports of National Interest are subject to two (02) specific management modes, namely:

- Autonomous management mode, hence the name "Ports with Autonomous Management" (PGA)
- And non-autonomous management mode with global concession, hence the term "Ports with Global Concession" (PCG)

The PIR are managed by the Maritime and River Port Agency (APMF).

Below is the statute of ports in Madagascar:

Table 21: Status of ports in Madagascar

PORTS	PIN	PIR	PGA	PCG
Antalaha	●			●
Antsiranana	●			
Ehoala	●			●
Mahajanga	●			
Maintirano		●		
Manakara		●		
Mananjary		●		

Maorantsetra		●		
Morombe		●		
Morondava		●		
Nosy Be	●			
Saint Louis		●		
Sainte Marie		●		
Taolagnaro		●		
Toamasina	●		●	
Toliary	●			
Vohémar	●			●

Source: Maritime and River Port Agency (APMF)

3.6.3. Airport infrastructure

The ADEMA SA company (Aéroport de Madagascar) was founded in 1989, by interministerial order of February 26, 1991 which granted a 15-year concession. By Decree No. 2017- 007 of January 3, 2017, the Malagasy State also delegated to Aéroport de Madagascar the power to build, manage and operate the 44 civil aerodromes. Thus, ADEMA SA operates 6 international airports, 4 major airports and 44 civil airfields which are open to public air traffic. In total, 54 platforms are under ADEMA SA supervision.

The main airports in Madagascar are:

- Antsiranana International Airport, located 7.4 km south of the downtown area
- Sambava airport is located in the eastern part of the city
- Mahajanga International Airport is located 7.7 km northeast of the downtown area
- Sainte-Marie International Airport, is located near the southern tip of the island
- Toamasina international airport is located 5 km northwest of Toamasina city (Toamasina has the largest port in Madagascar)
- Morondava airport is located 4.5 km east of the downtown area
- Fianarantsoa airport is located less than 3 km from the downtown area
- Mananjary airport is located 3.8 km north of the downtown area
- Toliara airport is located 7 km south-east of Toliara downtown area. With a terminal of 3,022 m², Toliara Airport is the third largest airport in Madagascar, after those of Ivato and Mahajanga. It can accommodate two 737 Boeing aircrafts at the same time
- Taolagnaro international airport is located 3 km southwest of the downtown area
- Nosy Be Fascene international airport is located in the east of Nosy Be island

Ravinala Airports currently manage the Nosy Be and the Ivato airports (Antananarivo).

3.6.4. Railway infrastructure

Madagascar's total railway network stretches over 835.92 km. The railway networks in the coastal areas are made up of two lines of 540.54 km (Tananarive- Côte Est or TCE: 377.54 km and Fianarantsoa-Manakara or Fianarantsoa Côte-Est (FCE): 163 km), 56 railway stations, 77 tunnels and 111 bridges.

With the two ports (Toamasina and Manakara), the TCE and FCE lines which respectively connect Antsinanana region to the capital of Madagascar and Vatovavy Vitovinany region to Haute Matsiatra region represent the main economic drivers of the country.

These two lines provide transport for goods (dangerous goods, construction materials, quarry products, agricultural and food products, containerized products, etc.) and people who live in remote areas which are not accessible other than by rail.

The Southern network (Fianarantsoa Côte-Est) is managed by FCE and the Northern network (Antananarivo-Côte Est) by MADARAIL company.

The Southern network: the market potential of the FCE line can reach 250,000 passengers per year. In 1995, freight traffic amounted to over 35,000 tons, including 12,000 tons of hydrocarbons. The fact is that this traffic no longer exists, in fact it stopped long before the closure of the port of Manakara in 2005, but fruit traffic has taken its place.

Table 22: FCE cargo tonnage results (in tons) from 2015 to 2021

Year	2015	2016	2017	2018	2019	2020	2021
Goods	13,300	18,563	10,805	15,571	13,828	5,099	14,017

Source: FCE, 2021

The national road linking Fianarantsoa to Manakara is operational and represents an advantage for the Districts of the East Coast, which can choose the means of transport to use for their goods and commodities. However, the particularity of rail transport lies in its ability to pull large tonnage. The FCE Line has not yet experienced special transports, such as refrigerated cars. On the other hand, the Malagasy Ministry of Transport and Meteorology is currently dealing with the paperwork to acquire this equipment for the FCE.

Indeed, the potential demand on the areas served and the areas of influence of the FCE line confirms the profitability of this kind of transport from Manakara. The market for seafood products is still large, even if we refer only to demand in areas where FCE has a monopoly and the District of Fianarantsoa I.

The areas of impact of the FCE are made of:

- The Betsileo Highlands Zone: Communes of Fianarantsoa, Vohimasina, Sahambavy, Alakamisy Ialamarina;
- The Tanala Zone: Communes of Ranomena, Tolongoina, Manampatrana, Ikongo, Ionilahy, Mahabako, Fenomby;
- The coastal zone: Communes of Sahasinaka, Mizilo, Ambila and Manakara.
- The northern network: the transport of goods by rail in 2021 is as follows
    - Transport of hydrocarbons: 94,814 tons
    - Transport of food products: 6,870 tons
    - Transport of construction materials: 17,800 tons
    - Transport of chrome: none, stopped in 2016 due to failure of the Kraoma to pay their invoices
    - Transport of containers: none, due to lack of traction



Andrambovato Railway station – FCE
(Photo: ONE)

Map 25: Road, port and aeroport Infrastructures



3.6.5. Telecommunications infrastructure

The government's policy on telecommunications and ICT is to promote socio-economic development throughout Madagascar by improving the performance of the telecommunications and ICT sector in terms of national coverage. In the country, the Communication Technologies Regulatory Authority (ARTEC) is responsible for regulating this sector.

In the country, four operators in the telecommunications sector operate networks corresponding to different technological generations: 2G, 3G, 4G:

- Telma Madagascar, a cell phone operator, and at the same time Internet service provider
- Airtel and Orange Madagascar offer mobile and internet networks
- Blueline Madagascar focuses its market only on internet subscriptions

Thanks to the existence of various applications (SMS, voice and video calls, multimedia, internet...), these are the most efficient means to communicate, manage, and transmit data and information from one region to another. In general, all the monitoring and observation systems set up in the Big Island use telecommunications networks to transmit data and information. These networks are mainly used as warning and mitigation systems in case of disasters. On the one hand, to prevent by conducting awareness campaigns on the fragility of ecosystems and environmental impacts in general. On the other hand, to manage risks and natural disasters by using meteorological data (atmospheric pressure, temperature, wind direction and speed, ...), to anticipate as well as to assist in the management of various crises (rescue or rapid interventions on sites).

3.6.5.1. Mobile coverage

Among the 14 coastal regions of Madagascar, 3G and 4G broadband coverage varies by location. The statistics presented on Map No. 23, concerning mobile coverage in the coastal regions in 2020, show that the regions with the largest cities and high potential for economic development (tourism, fishing, agriculture, exports, etc.) are the most affluent in terms of broadband coverage.

In 2020, the coverage rate for broadband was higher in the DIANA, SAVA, and Boeny regions, including 83% to 89% for 3G technology, and 30% to 64% for 4G. These three regions are renowned tourist areas (ecotourism, seaside), producing cash crops (cocoa, vanilla, pepper, cloves). One has a national seaport and an international airport, while the other is a potential area with favorable conditions for fishing. Moreover, Boeny is classified as the second rice granary of Madagascar and the first shrimp town.

Next come the regions of Atsinanana, Fitovinany and Analanjirofo with a variation between 58 and 76% for 3G; between 19 and 28% for 4G. This may be explained by the reputation of these regions in terms of tourism and economic potential. Atsinanana the second economic lung of the island, whose activities are mainly related to the existence of the sea and river port. Fitovinany one of the regions accessible by sea, river and rail transport. Above all, the Analanjirofo Region is known for the production of cash crops (cloves and coffee). This region, more precisely the island of Sainte Marie, hosts the whale festival[25] every year.

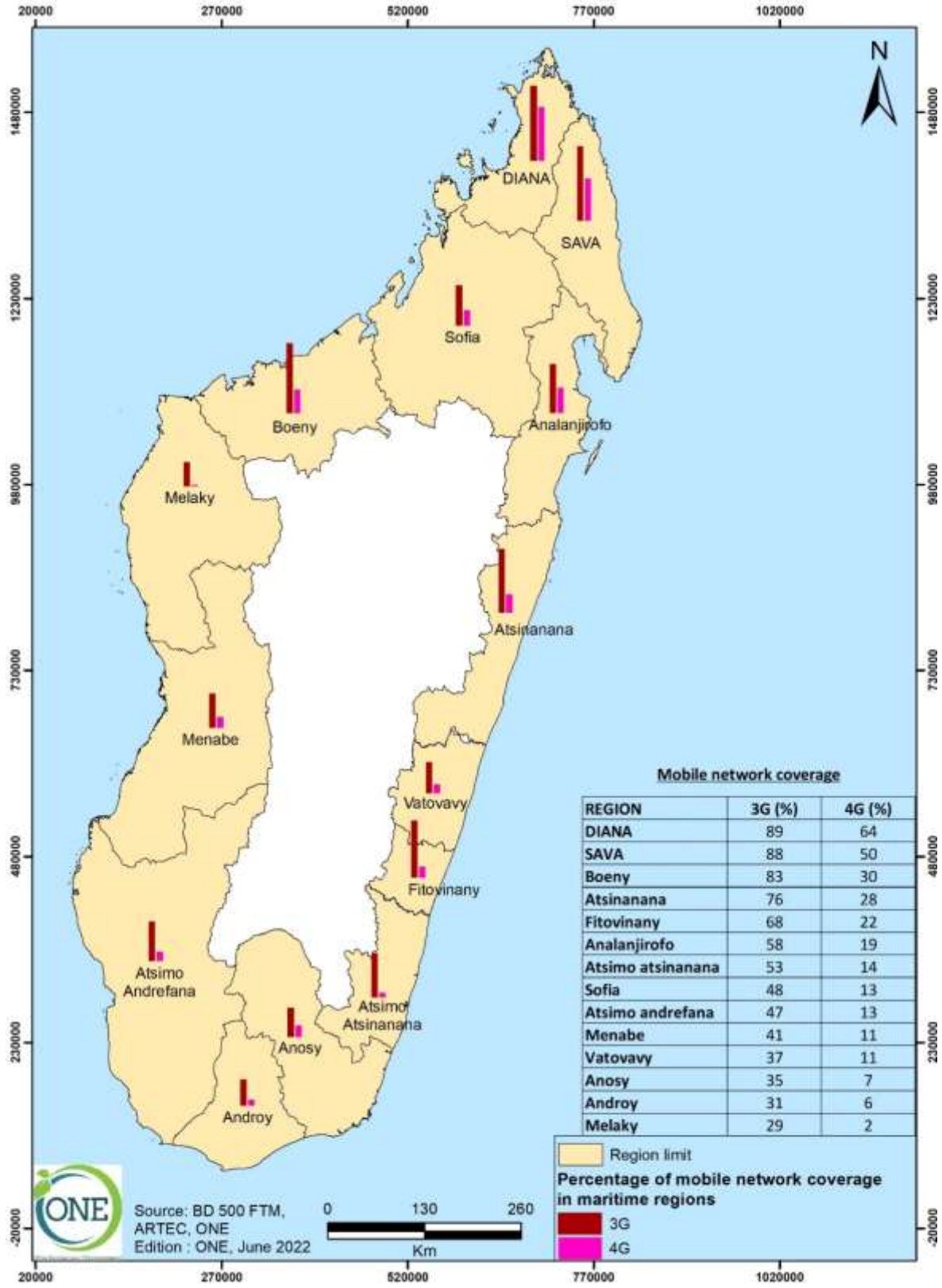
On the other hand, broadband coverage is low or almost non-existent in areas far from the capital such as Melaky, Androy, Atsimo Atsinanana, Atsimo Andrefana, Menabe, Anosy, Vatovavy whose rate varies from 29 to 41% for 3G and 2 to 14% for 4G.

[25] Celebrating marine mammals that choose every year to reproduce themselves and to breed their babies in the warm water of the Indian Ocean.

According to the calculations, we can deduce that in relation to the overall national coverage with a total number of 1,693 communes, 608 communes belonging to the seafront Regions are equipped with 3G, while 221 communes with 4G, that is to say a respective rate of 35.91% and 13%. Despite the effort made by the State in terms of performance of its sector, this rate is still low.

The map below shows the percentage of mobile network coverage in the maritime regions in 2020:

Map 26: Mobile coverage



3.6.5.2. *Fixed telephony services, DATA and active SIM cards*

At national level, the number of subscriptions for fixed-line telephone services has fallen by 32.61%, from 73,673 to 49,645 lines for the years 2019 and 2020. For its part, the operator Telma continues to clean up its fixed-line network by removing obsolete lines. However, the number of active SIM cards in the telephony market is increasing year by year. If the number of cards was 9,964,752 in 2017, it reached 12,608,132 in 2020.

In relation to the fixed internet, the figure remains almost constant for four successive years. It can be said that Internet users choose more mobile internet because accessing a website through a smartphone and "mobile internet" packages is much easier for the general public. According to ARTEC, nearly 99% of total internet subscribers use mobile internet.

As for mobile internet users, the number has not stopped increasing from 2017 to 2020, as it ran from 2,288,635 to 3,393,354.

Table 23: Evolution of the number of subscribers in telephony service, DATA, active SIM cards

Number	2017	2018	2019	2020
Phone service				
Landline subscribers	68,792	69,046	73,673	49,645
Active SIM cards	9,964,752	9,595,884	11,708,083	12,608,132
DATA Service				
Fixed DATA subscribers	27,092	27,150	29,113	29,738
Mobile internet subscribers	2,288,635	2,735,165	2,946,637	3,393,354

Source: ARTEC Report activities, 2017-2020

3.6.5.3. *Optical fiber*

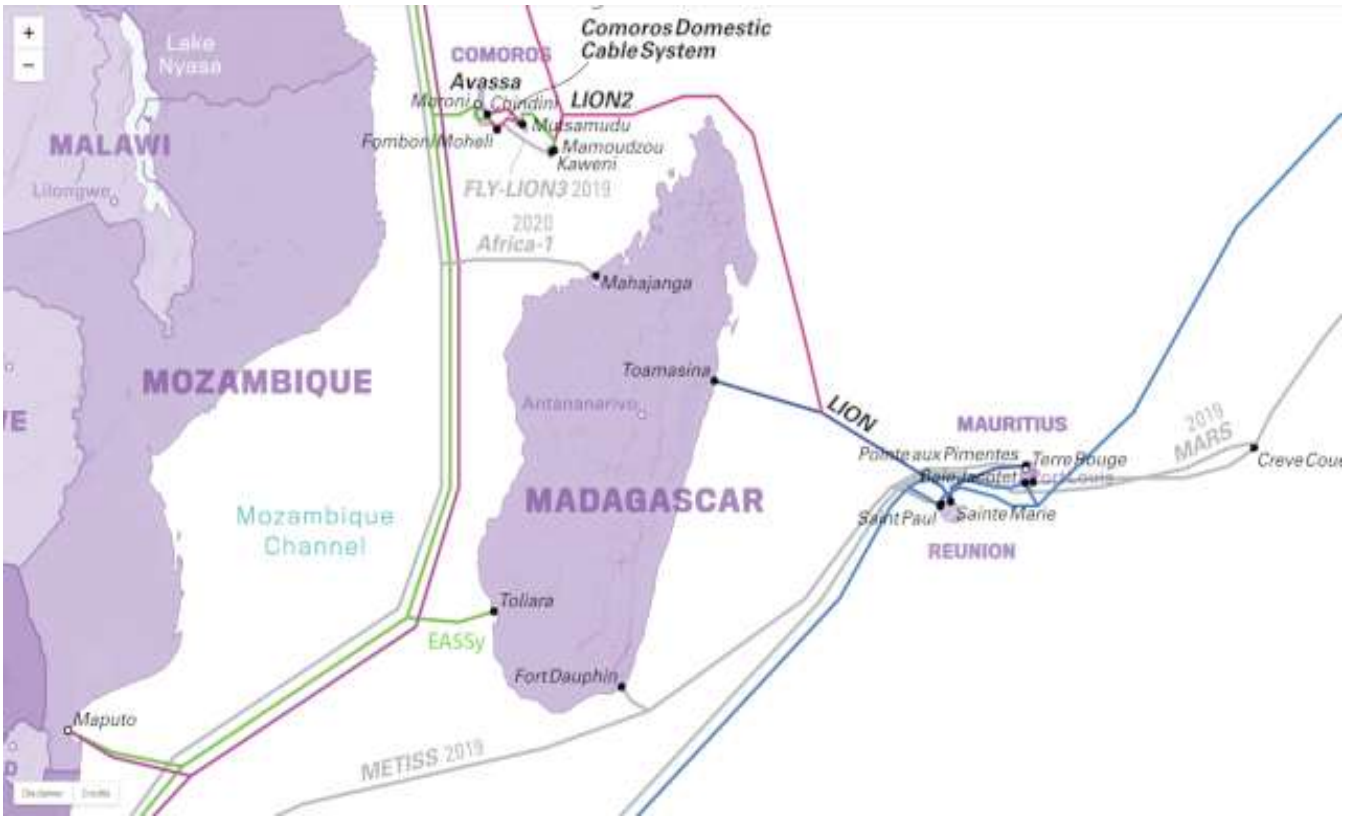
Madagascar is connected by submarine optical fiber cables. In 2009, the operator Orange began installing the 1,060 km long LION cable, which has an optical transmission capacity of more than 1.3 Terabits/second. In 2010, Telma's EASSY cable with a distance of 10,500 km, with a capacity of 1.4 Terabits/second landed in Toliary, Atsimo Andrefana Region. Then, the LION 2 cable with a length of 2,700 km has been in operation since 2012.

In 2017, Telma increased its performance in terms of very high speed. Therefore, it signed an agreement for the construction and management of the next-generation MeLTINGPOt Indianoceanic Submarine System (METISS) optical fiber submarine cable with the 06 operators (CEB FibreNet Mauritius, Emtel Mauritius, Canal+ Telecom La Réunion, SFR Réunion, Zeop La Réunion). This very high speed cable with a length of 3,200 km and a capacity of 24 Terabits/second effectively connects Mauritius, Reunion and Madagascar to the international bandwidth of South Africa.

On the other hand, the number of subscribers to Optical fibers increased by 79.13% in 2018, while those of ADSL[26] or Asymmetric Digital Subscriber Line decreased by 41.19%. According to ARTEC, users are gradually abandoning ADSL and using Optical Fiber, which offers a high-speed connection.

The two maps below illustrate the connection of all optical fiber optic cables (map No. 27), as well as the map of optical fiber coverage in Madagascar (map No. 28). With the exception of the Melaky Region, we can see that all the Regions with a maritime coastline are served by the optical fiber connection.

Map 27: Connection of optical fiber cables



Source: [Optical Fiber - OkZone Madagascar]

[26] https://www.linternaute.fr/dictionnaire/fr/definition/adsl/
Simple Definition: Top technology of high debit

Map 28: Coverage in optical fibers



Source: http://www.artec.mg/dses/couverture.php







4. Chapter 4. Coastal Livelihood Assessment

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Historical background of the blue economy concept

This chapter talks about the blue economy concept given that it is absolutely essential if we want to look at livelihoods, coastal economy and especially Madagascar's place within the international communities in relation to the various major global commitments on sea and oceans preservation and sustainable development.

Indeed, 50 years ago, the United Nations Conference on the Law of Sea held in Geneva in 1958 enabled several countries to appropriate and exploit marine resources and develop economic activities related to the maritime sector. However in 2012, the Rio+20 United Nations conference formalized the concept of sustainable use of the sea as a means of progressive implementation of the Agenda 21. In 2014, the Samoa conference enabled small Islands to unite their voices to emphasize the importance of the concept of sustainable use of the sea so as to improve their livelihoods and well-being.

In January 2014, during the high-level conference on the blue economy which was held in Abu Dhabi, participants acknowledged:

- The fundamental importance of the marine environment and its resources for the future and for the sustainable development:
    - The role of fisheries in food security and well-being
    - Decent employment created by the tourism sector and its contribution to the fight against poverty
    - The development of renewable energy from wind, waves, tides, biomass ...
    - The sea as a source of hydrocarbon and mining resources
    - The development of international trade through ports and maritime transport.
- The health of the seas and oceans has seriously been degraded by irrational exploitation, pollution, habitat destruction and acidification and therefore deserves to be taken into account.

In 2015, the international community adopted the 2030 Agenda with the 17 Sustainable Development Goals, with Goal 14 specifically addressing conservation and sustainable use of the sea, oceans and marine resources.

The "blue economy", "blue growth", "ocean economy" concepts have then become the main key words when discussing the importance of the blue economy in achieving the objectives of the sustainable development agendas.

(Source: Professeur Alistair Mcllgorm, University of Wollongong en Australie 2019 & University of Seychelles: Commonwealth of learning 2017)

Background of the Blue Economy in Madagascar:

In terms of Environment and Sustainable Development, Madagascar has been ahead of other African countries, because already in 1991, before the Earth Summit in Rio in 1992, the National Office for the Environment was created within the framework of the National Environmental Action Plan.

Furthermore, the Law n ° 90-033 of December 21, 1990 amended by the laws n ° 97-012 of June 06, 1997 and n ° 2004-015 of August 19, 2004, on the Malagasy Environment Charter, has already incorporated the concept of sustainable development and the management of the environmental impacts of investments through environmental impact assessments of public and private investment projects operating in Madagascar.

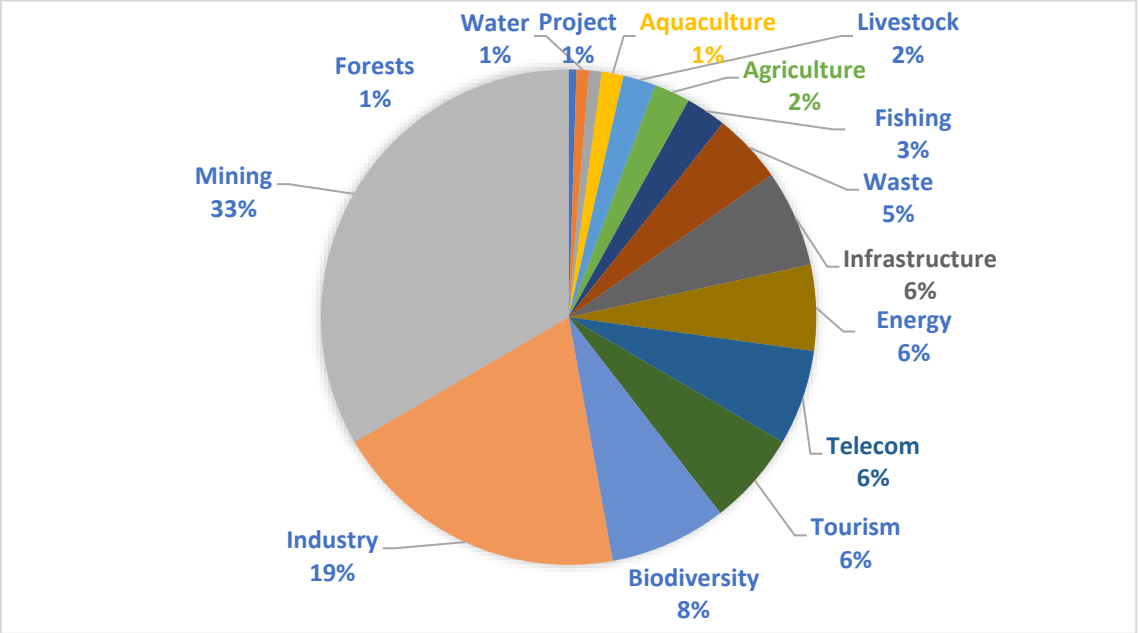
As a result of this charter, the MECIE Decree which aims at making sure investments are compatible with the environment, was established in 1999 and then revised in 2004 for environmental assessments in Madagascar. This text is the general framework governing the EIA (Environmental Impact Assessment) evaluation process of public and private investment projects which are

implemented in the country. Economic activities within the maritime and coastal field are therefore part of the activities that are subject to the MECIE procedures.

These legal and institutional provisions already express the "green aspect" and more recently the "blue aspect" of economic investments in Madagascar, particularly those concerning the maritime and coastal field.

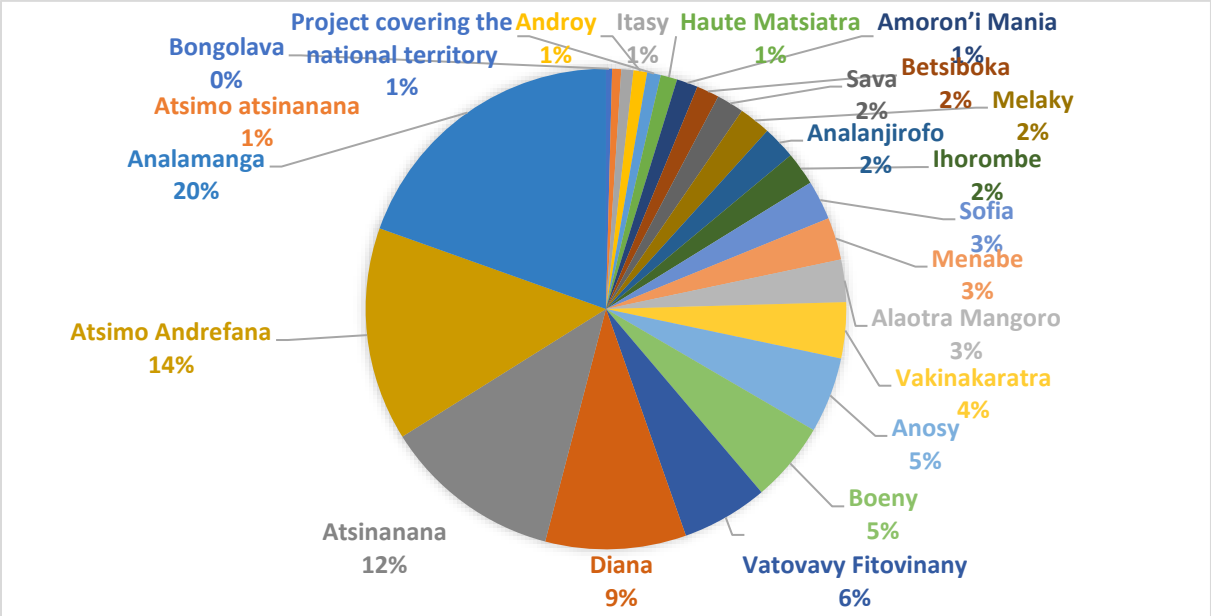
To illustrate the achievements related to environmental program of the country, about 1,000 environmental permits have been issued since the year of implementation of the MECIE Decree.

Figure 32: Distribution of environmental permits by sector



Source: ONE 2022

Figure 33: Distribution of environmental permits by region



Source: ONE, 2022

These two figures show the distribution by sector and by region of the environmental permits issued by ONE. They also indicate that mining operations (35%), followed by industries (18%), are the two most dominant activity sectors. In terms of spatial distribution, apart from the Analamanga Region with 20%, it is the coastal Regions of Atsimo Andrefana (14%), the East (Atsinanana 12%) and the North (DIANA 9%) and in the South East (5% Anosy) where most of these activities which have environmental permits are located. In the case of the Anosy Region, the large Ilmenite exploitation project operating in this region constitutes a major issue for the marine and coastal environment.

In addition, we can notice that the main activities which are included in the blue economy in Madagascar are timidly represented in these statistics. They include the following: fisheries sector (3%), tourism (6%), aquaculture (1%), biodiversity management which includes Protected Areas (8%), waste management (5%) … However, these statistics do not consider the informal sectors that actually predominate economic activities in coastal areas.

It should be noted that between 2004 and 2019, around 580 medium and/or small-scale projects located in the coastal regions of Madagascar were notified to carry out an Environmental Commitment Program or ECP, which is a more simplified form of Environmental Impact Assessment, the responsibility of which lies with the sectoral ministry that is involved in this activity.

As an island country, promoting the blue economy at the institutional level is part of the spearhead of Madagascar's State to generate its sustained and sustainable growth. This explains the existence of several departments at all levels within the different Ministries that are in charge of the promotion of the Blue Economy. They are the Blue economy Service entity within the Presidential Projects Department, the Ocean Governance Department within the Ministry of Fisheries and blue economy, the Blue Economy Department within the Ministry of the Environment and Sustainable Development.

At the international level, Madagascar made a statement during the first IORA conference on the Blue Economy which was held in Mauritius on September 02 - 03, 2015. The following recommendations were reiterated at that conference:

- Technological innovations should support economic development.
- National blue economy initiatives should be based on regional initiatives such as the Nairobi Convention and the 2050 Integrated African Maritime Strategy.
- Local community development should be at the heart of the blue economy.

- Knowledge should be built so as to better manage and exploit opportunities in the blue economy.
- Protection, conservation and sound management of marine and aquatic biodiversity should be set in place.
- Climate change mitigation and adaptation measures should be taken into account and prioritized in the legal frameworks governing the blue economy.
- Economic sectors should be harmonized to resolve cross-sectoral conflicts.

Mixed economic results (2018 National Strategy for the Blue Economy)

According to the national blue economy strategy document established by the Presidential Projects Department, Madagascar's economy is still lagging behind despite all the institutional and legal provisions that have been put in place. Speaking specifically of the maritime sector, according to the National Blue Economy Strategy Document, established by the Blue Economy Service entity within the Presidential Projects Department, the following issues affect the maritime sector:

1) Maritime insecurity

Coastal areas which are the main tourist attractions suffer from insecurity problems that affect tourism and international trade. The looting of our marine resources by pirates of foreign nationality represents a shortfall of about 500 million Dollars each year.

2) Irrational management of marine resources

For Madagascar, the depletion of its resources is particularly due to the overexploitation and the impacts of global warming and pollution. This situation seriously affects the already fragile economic situation of the country and increases in a more direct way poverty and food insecurity of the population who depend on it daily. The South-West, the South and South East Regions are particularly the most vulnerable.

According to the World Bank, in 2009, only 45% of the world's seafood consumption came from aquaculture. It would reach 62% in 2030.

3) Marine pollution

Marine pollution is generally caused by human activities, including industrial activities, or by maritime accidents or disasters (accidental pollution) or other polluting activities on the high seas (deep-sea pollution). Even land-based pollution ends up at sea.

The majority of waste comes from the hinterland, carried by rivers or dumped directly on beaches. However, in the case of Sainte Marie, other foreign products from Asian countries located in the Indian Ocean were taken by the ocean current.

In addition, several regions of the island still practice open defecation on the beaches. Actions have been taken to eradicate this practice but much remains to be done.

In the Eastern Region, in the hinterland, there are frequent pollution problems of the Pangalanes Canal. This is due to the establishment of several industries, some of which have been established since the 2nd Republic. To illustrate this, an old oil refinery continues to spill oil into the canal, which is a threat to this aquatic system along the East coast of Madagascar.

4) The degradation of the marine and coastal ecosystem

The coral reefs which are very fragile ecosystems cover an area of more than 2,000 km². They are along the coast of approximately 1,400 km from Toliara to Antsiranana and from Cap d'Ambre to Toamasina. The coral reefs are populated by various classes of marine animals (madrepora, cnidarians, molluscs, echinoderms, marine mammals, etc.) and plants.

These reefs are not immune from the bleaching phenomenon due to global warming.

With an area of more than 300,000 ha, the mangroves form dense forests of several hectares in the northern and western coastal part of the Big Island. Indeed, mangrove wood is often considered as a local wood which does not cost much for the natives. Mangroves, which have lost 10% of their surface area in 40 years, also protect corals from siltation by retaining river alluvium, while the reef moderates the power of the ocean. These complementary ecosystems are essential for the survival of many marine species by fulfilling the role of spawning ground and nursery for shrimp and fish.

The stock of exploitable products is depleting and the impoverished local fishing population may turn to other species and ecosystems, further exacerbating the extent of degraded areas.

Several actions are under way as part of the implementation of Integrated Coastal Zone Management (ICZM). The coastal and marine resources management plan has enabled the creation of marine and coastal protected areas and the establishment of the "Reefs" network. Mangrove areas are preserved for conservation and sustained use. Reforestation has started in order to regenerate ecosystems …

5) The impacts of climate change

Madagascar is not one of the GHG emitting countries, with a rate of only 0.2% in the world. Yet it is one of the countries which is most threatened by global warming. Madagascar was even ranked third country most exposed to extreme climate risks in the world during the Climate Summit that prepared the Paris Agreement in 2014. Madagascar is also among the first countries to ratify this Agreement. Since 2017, our country would be the seventh most threatened country by global warming.

Avian diseases spread more easily. Cyclones are increasing in intensity, becoming more and more frequent and destroying all vulnerable infrastructure on their way. While there were 18 cyclones of category 4 and 5 between 1975 and 1989, they increased to 50 between 1990 and 2004.

6) Aging infrastructure (ports and security equipment)

Madagascar Madagascar has 17 ports, 6 of which are open to international traffic (the two deep-water ports of Toamasina and Ehoala, the ports of Antsiranana, Toliara, Mahajanga and Nosy-Be). Other ports are used for cabotage or costal navigation (secondary ports).

4.1. Coastal fishing

According to the FAO report [27] on the world situation of fisheries and aquaculture, world fish production reached 179 million tons in 2018, 156 million tons of which were for human consumption which is equivalent to an annual consumption of 20.5 kg per capita. Aquaculture occupies 46% of the total production and 52% of the volume for human consumption. Specifically, for marine fisheries, production reached 84.4 Mt in 2018, and 82.1 MT for aquaculture.

Human consumption is the main use of these fishery products at 156.4 MT and 22.2 for non-food use. Exports reached 67.1 Mt for a value of 164 billion USD.

At the level of fishermen and aquaculturists, 59.51 million people were employed in the capture fisheries and aquaculture sector. For Africa, there are about 5,407 (in thousands) number of jobs in the fisheries and aquaculture sectors.

Regarding the state of the fishing fleet, the total number of fishing vessels, from small open and unpowered vessels to large industrial vessels, is estimated at 4.5 million in 2018.

Regarding the state of marine fish stocks, the share of fish stocks exploited at a biologically sustainable level on a global scale has decreased from 90% in 1974 to 65.8% in 2017.

Sustainably exploited stocks accounted for 59.6% in 2017, and 6.2% for under-exploited stocks which reflects better implementation of management measures.

Also, in 2018, of the 179 Mt of fish produced, 88% is used for direct human consumption and 12% is used for non-food purposes.

The processing of fish products into fish meal and fish oil constitutes a significant proportion.

For fish consumption: the average annual growth rate of total fish consumption was 3.1%. The increase in consumption is explained by the increase in production, technological progress, the increase in income, the reduction of losses and waste and the awareness of consumers of the health benefits of fish.

On the other hand, at the regional level, it is in Africa that per capita consumption is the lowest at 9.9 kg/inhabitant in 2017.

The fishing sector is one of the key sectors of the Malagasy economy. It is one of the providers of foreign currency and state revenue through exports of fish products and fishing licenses issued to foreign vessels.

4.1.1. Labor force in the fisheries sector

Fishing is practiced by about 18.1%[28] of agricultural households in Madagascar. Two types of fishing are practiced in Madagascar: continental fishing in continental water bodies, such as lakes and rivers, and maritime fishing along the entire length of the 5,600 linear kilometers of coast. Traditional maritime fishing using small rudimentary equipment is the most common, accounting for the vast majority of fishermen. The number of traditional fishermen in the marine fisheries sub-sector is presently estimated at more than 100,000. Productions of the traditional fisheries are essentially destined for the local market, except for some specific products such as lobsters and trepang whereas

[27] Extract of the summary on global situation on fisheries and aquaculture, FAO 2020

[28] Extract of the summary on global situation on fisheries and aquaculture, FAO 2020

the productions of the large fishing companies operating on the high seas are essentially destined for export.

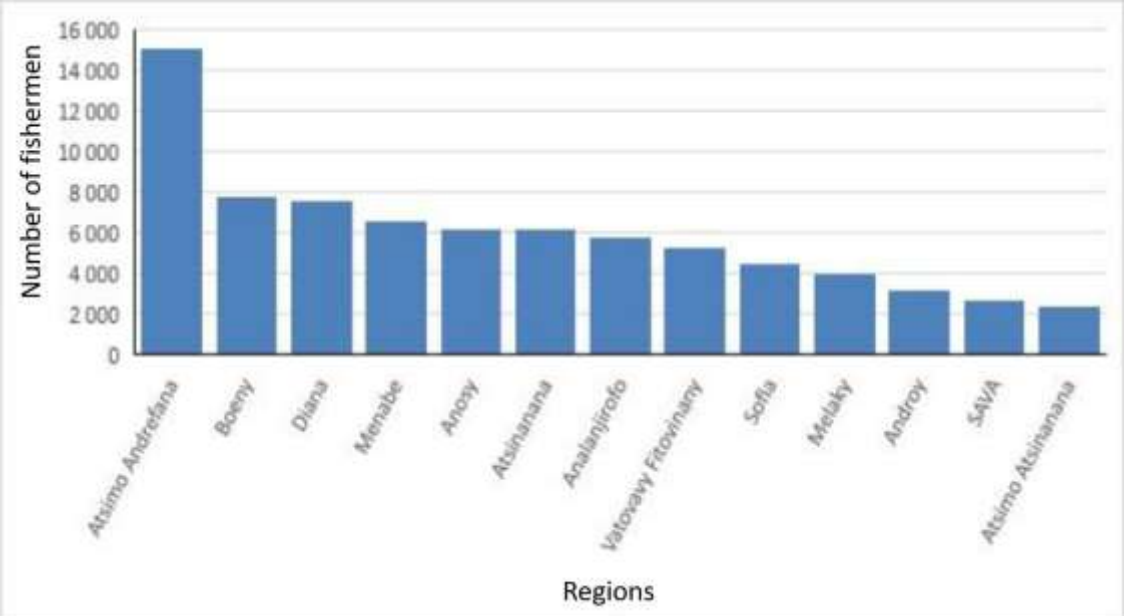
Fishery and coastal resources are important to Madagascar both in terms of economy and livelihood. The fishing sector contributes up to 5.5% of the GDP in 2018. Due to overexploitation, habitat destruction and pollution, a decline in production of several fisheries has been observed which implies a decline in stocks (WAVES, 2013). However, fishing also plays an important role in terms of employment and in meeting the food needs of Malagasy people. It generates around 500,000 direct and indirect jobs (ANDRIANTSOA and RANDRIAMIARISOA, 2013).

The fishing and aquaculture sector plays an important social and economic role for the country. It is a sector that provides employment for the populations of the coastal areas, which are still not very favorable to agriculture. Likewise, the export of fishery products is an important source of foreign exchange for the country, although it is only practiced by a minority of the population, less than 5% of agricultural households. Fishing and aquaculture products represent on average almost half of the total value of exports from the agriculture, livestock and fishing sub-sectors. The shrimp industry is the most important, providing nearly 1% of the total value of exports each year, bringing in SDR 20.5 million of the total value of SDR 1,890.8 million in exports. And more than half of the total volume and sometimes up to almost 80% of the export values of fishery products. For some years now, the SWIOFISH project has been implemented to improve the fishing sector by supporting traditional fishermen through the formalization of the activity, the provision of fishing equipment and gear and, above all, by building the capacity of fishermen. This initiative has raised awareness among fishermen of the importance of rational exploitation of natural resources and has led to an improvement in the quantity and quality of production through the use of efficient and appropriate equipment in the project intervention areas in the northern and northwestern parts of the island.

4.1.2. Number of fishermen in the coastal regions of Madagascar

84,536 people were involved in small-scale fishing in 2012 against 40,000 in 1988. 92% of them were in coastal regions, one third of which were close to mangrove areas. The below figure gives their distribution by coastal region (RAKOTOVAO JM, RAZAFIARISON JC, AND RABEFALY P., National Framework Survey 2012-2013).

Figure 34: Number of fishermen in the coastal regions of Madagascar



Fisheries and coastal resources are important to Madagascar both in terms of the economy and livelihood. During the last decade, the fisheries and aquaculture sector is one of the three main growth sectors (with the mining sector and tourism) on which the Malagasy government intends to base the country's economic development.

The fishing sector contributes up to 5.5% of the GDP in 2018. Due to overexploitation, habitat destruction and pollution, a decline in production of several fisheries has been observed which implies a decline in stocks (WAVES, 2013).

Table 24: Contribution of the fisheries sector to the current GDP (as a percentage of GDP)

	2014	2015	2016	2017	2018
% of GDP of the livestock and fisheries sector	5.9	5.8	5.6	5.6	5.5

Source: REF 2017-2018

Table 25: Growth rate (annual variation in %)

	2014	2015	2016	2017	2018
Growth rate of Livestock and fisheries sector	2.8	0.8	1.9	4.5	1.9

Source: REF 2017-2018

At the primary sector level, GDP growth in 2017 was mainly driven by the performance of the fisheries sector (+ 11.2%) and this by contributing to 4.5% the growth of the "Livestock and Fisheries" division. This was due to the different initiatives and actions to boost traditional fishing (fish, shrimp, octopus) within the second SWIOFISH Project framework.

4.1.3. Fish stock

4.1.3.1. Fishery production by type of fishing (industrial, artisanal fishing, ...)

The total fish production in 2019 was 122,561.01 tons/year.

Table 26: Evolution of fishery production from 2013-2019

Spicies/field/Activity	2013	2014	2015	2016	2017	2018	2019
Maritime production	**107,220.83**	**98,690.50**	**78,528.54**	**104,598.39**	**132,546.53**	**107,539.11**	**109,237.67**
Industrial fishing	8,310	9,497	9,968	11723	12743	13858.4	14,980
Artisanal fishing	1	107.88	22	621.84	844.85	372.88	382.66
Traditional fishing	89,972.87	78,857.62	49,689.60	70,226.36	96,014.12	83,023.29	81,484.53
Marine aquaculture	8,936.96	10,228	18,848.94	22,027.19	22,944.56	10,284.54	12,390.48
Freshwater production	**38,151.92**	**25,346.11**	**29,570.85**	**35,384.60**	**30,945.99**	**15,955.84**	**13,323.34**
Continental fishing	37,155.96	22,460.39	26,025.78	30,940.66	25,554.19	14,790.39	12,335.49
Freshwater aquaculture	995.96	2,885.72	3,545.07	4,443.94	5,391.80	1,165.45	987.85
Total production	**145,372.75**	**124,036.61**	**108,099.39**	**139,982.99**	**163,492.52**	**123,494.95**	**122,561.01**
Tunas caught by foreign flagged vessel (in the EEZ Madagascar)	7,261.74	6,772.69	11,385.91	9,635.14	9,470.81	8,048.90	9,083.83

Source: Directorate General of Fisheries

For the year 2019, DIANA Region was the main fishery producing region.

Since then, the production trend has continued to decrease for this region from 40,678.52t to 3,487.47t in 2018 despite a significant increase in 2019.

Table 27: Maritime production and freshwater production by Region (in tons)

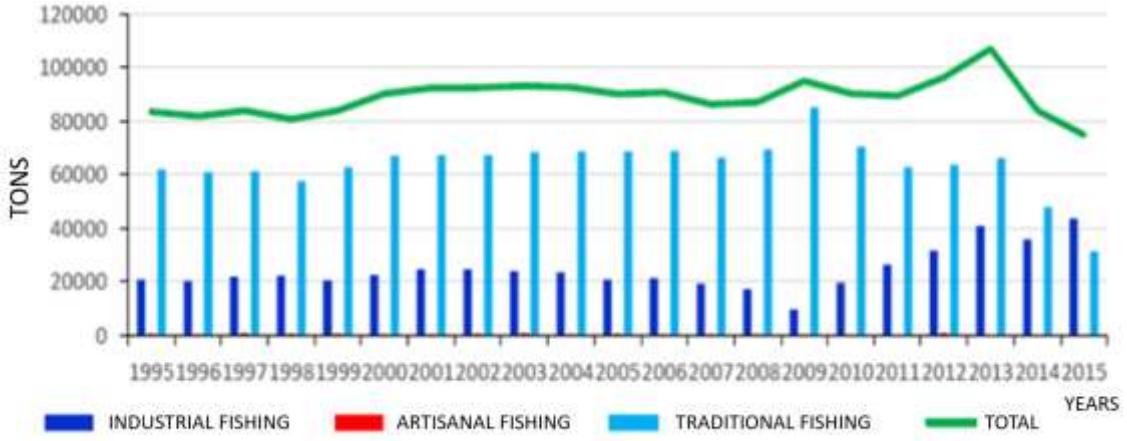
	2013	2014	2015	2016	2017	2018	2019
Analanjirofo				132.16	1,649.14	2,547.32	4,220.86
Androy	147.65	281.59	11.53	54.58	70.098	9.89	62.69
Anosy	2,522.05	1,132.13		3,336.07	3,323.39	5,857.09	9,421.06
Atsimo Andrefana	15,933.35	11,378.59		7,778.26	5,210.989	153,333.38	20,400.76
Atsimo Atsinanana	875.9	64.65			415.393	303.38	357.88
Atsinanana	2,981.05	6.93	1,811.89	537.138	1,721.08	2,535.3	1,493.18
Boeny	27,598.32	15,668.23		43,027.58	40,116	49,792.1	1,953.09
Diana	40,678.52	22,695.63	32,051.31	23,887.23	66,364	3,487.41	23,399.42
Melaky	1,480.05	2,422.12		2,987.3	1,369	1,958.42	2,472.09
Menabe	14,232.36	10,707.47	70.4	1,768.82	5,247.662	15,675.7	9,072.03
Sava	353.17	125.18	1,287.946		4,090	1,498.4	4,655.86
Vatovavy fitovinany	634.47		1,922.43	2,156.22	3,204.14	5,124.47	2,685.02

Source: Directorate General of Fisheries, 2020

4.1.3.2. Catches by type of fishing

Traditional fishery products largely dominate catches as shown in the following figure:

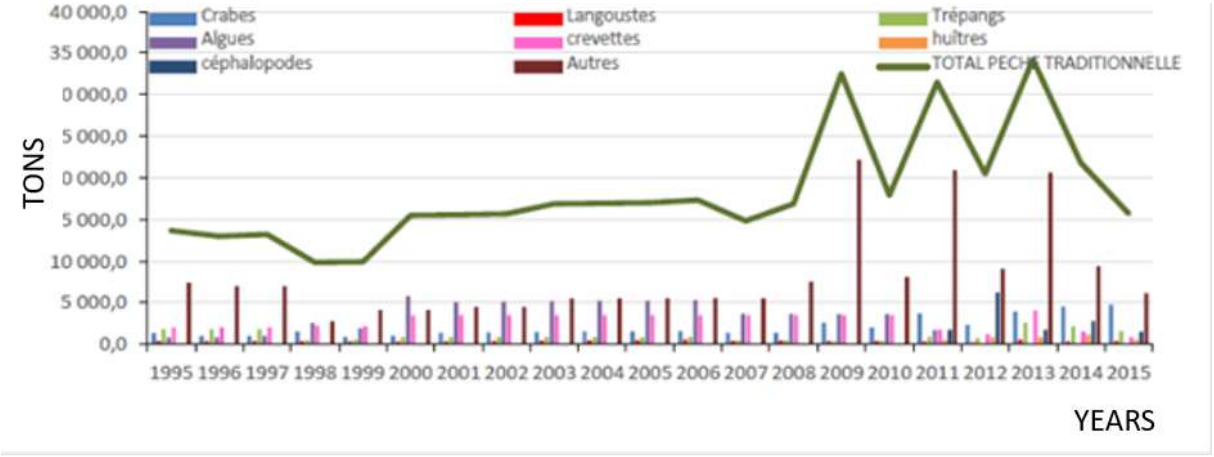
Figure 35: Evolution of catches from industrial fishing, artisanal fishing and traditional fishing from 1995 to 2015



Source: Ministry of Marine Resources and fisheries, 2016

The following graph shows the breakdown of these catches according to the group of species in each fishery :

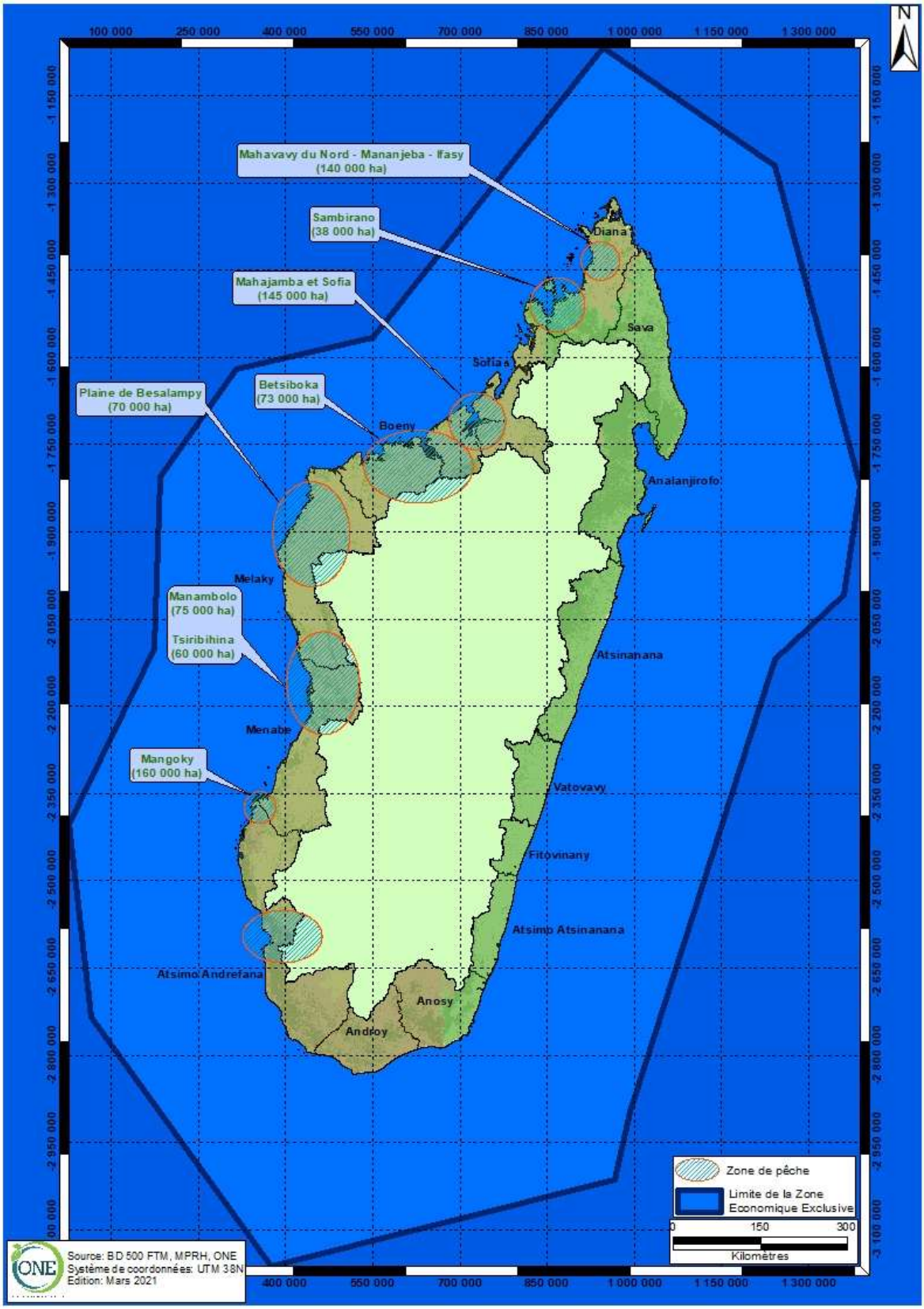
Figure 36: Evolution of the composition of catches from traditional fishing from 1995 to 2015



	crabs		lobsters		Trepangs
	algae		shrimps		oysters
	cephalopods		others		Total from traditional fishing

Source: Ministry of Marine Resources and fisheries, 2016

Map 29: Maps showing the location of the main fishing areas



4.1.3.3. Impact of marine ecosystem degradation on income and quantity

The degradation of marine and coastal environment is a crucial problem for Madagascar. It can be seen through the degradation of water quality, the modification of habitats and communities (reefs, mangroves, coastal forests, coastal ecosystems, etc.) and the decrease in the numbers of living marine resources (marine mammals, turtles, cetaceans, sea cucumbers, crabs, reef fishes…).

4.1.3.4. Fisheries sector and climate change

Most coastal communities depend on natural resources for their livelihoods, especially when under the stress of climate change. However, the resilience of ecosystems and the services they provide decline as biodiversity falls.

The signs of climate change are essentially the increase in water temperature, the rise in sea level, the eco-toxicological effects (lengthening of the periods of toxic algal blooms), the frequency and strength of storms, coastal erosion, flooding, drought etc.

The rise in sea level whose trend is 2.7 mm / year, leads to flooding of low-lying coastal areas, thus causing shoreline decline, and consequently, the decrease and / or displacement of coastal ecosystems. It also threatens mangroves which serve as nurseries or habitats for many species, provide timber and firewood for communities, serve as pasture for livestock and protect against storms.

Increasing temperature leads to potential changes regarding animal population, with species migrating to more mild temperature areas. It is also predictable that high temperature will have impacts on highly migratory species such as cetaceans, sea turtles and tunas (Anon, 2008). It leads to coral bleaching episodes which makes these ecosystems not very conducive to the development of reef biodiversity. This phenomenon affects fishing communities which heavily depend on their resources, with toxic algal blooms appearing mostly in hot season.

4.1.3.5. Illegal exploitation

Strong demand from Asian and European countries for high value species has led to overfishing and committing infringements. If we take crabs, for example, Madagascar is today a niche of living crabs for China. Its export quantity increased from 800 tons in 2009 to nearly 2,000 tons in 2013.

Many texts are simply bypassed (use of prohibited materials, non-compliance with closed periods, etc.), fishing licenses have been issued to an Asian fleet of 6 boats. Furthermore, the lack of information on a large number of exploitable marine stocks does not facilitate decision-making in the face of demands.

In 2015, many boats were caught red-handed depleting the seabed of Sainte-Marie and that of the Malagasy East Coast in general. According to testimonies, a boat managed to fish up to 250 kgs of sea cucumbers on its own in a day though this type of fishing was officially closed during that period of time. There are also hundreds of illegal fishermen practicing illegal fishing during this period. This leads to the rapid eradication of all forms of life on coral reefs. In addition to the degradation of marine resources, fishermen who are often drunk and have no identification identity do not hesitate to squat and vandalize the surrounding houses in the fishing areas and cause a degradation of these places. In addition to this, officials are corrupt and insecurity can also become a serious problem on the island, etc. (source: www.midi-madagasikara.mg/economie/2015/12/23)

In 2016, the Ministry of Fisheries and fisheries resources took a measure to temporarily suspend all forms of sea cucumber exploitation in the face of the proliferation of illegal exploitation of fishery resources in the Great Island including sea cucumbers. Thus, all fishing, collecting and other related activities are suspended until further notice.

Lovasoa Dresy, Senior fisheries officer at WWF Madagascar, declared during the celebration of World Tuna Day that *"Tuna is a wealth whose potential is still needed to be developed for Madagascar. This*

means that efforts must be made to assess and sustainably manage this potential in order to enable the country and its people to fully benefit from the positive economic impact of exploiting this wealth."

Recently, overexploitation of the three tuna species, namely skipjack, yellowfin and bigeye tuna, representing 15% of the total tuna fisheries, has occurred. But even before the COVID-19 pandemic, the health of some tuna stocks was at risk. Skipjack, the most used type of tuna for the canned market, is widely considered to be at a healthy level of abundance. However, a recent increase in skipjack catches in the Indian Ocean resulted in a 30% excess above of the catch limit for 2018-2020. It is very likely that this tuna species has already been classified as "overfished" species.

In addition, a significant increase in yellowfin catches has been observed. A stock which is already under considerable pressure and also considered overfished by experts. The fate of yellowfin and skipjack is linked, as yellowfin juveniles are mainly caught with skipjack through purse seine fisheries. The increase in skipjack catch, along with the corresponding bycatch of yellowfin, will significantly delay the ability of the yellowfin stock to recover after years of overfishing in the Indian Ocean. Scientists believe that yellowfin stocks could collapse by 2027.

Over the last few years, black oysters have also been illegally exploited through underground traffic. In 2014, the Fisheries ministries published the decree No. 21216/2014 on June 05th to forbid the exploitation of black oysters (antiparthia sp.) on the whole territory of Madagascar. The dispositions stated on article 1 specifically forbids any form of exploitation, from its extraction to its collect, conservation, transport, purchase or sale. In addition, the same traffic is also prosecuted by the law related on the CITES (Law No. 2005 018 on October 17th, 2005), because the article No. 29 (7) contains the same ban as the above mentioned one.

In September 2021, Madagascar joined the FiTI (Initiative for the Transparence of Fishing), which is a global partnership that aims to increase transparency and participation for more sustainable management of marine fishing. It is a complementary tool to fight against illegal fishing by improving the availability of information on fishing management while at the same time making sure that the information is accurate, timely and reliable.

4.1.3.6. Exports of fishery products

Exports, f.o.b. (Value in millions of SDRs, volume in thousands of tons, unit value in SDR/kg unless otherwise indicated)

Table 28: Evolution of crustaceans export

	2014	2015	2016	2017	2018
Value in millions of SDRs	20,4	19	22,8	24,2	25,6
Volume in thousands of tons	4,5	4,5	4,9	5,2	5,8
Unit value in SDR/kg	4,5	4,3	4,7	4,7	4,4

Source: Economic and Financial Report, 2018

4.1.3.7. Lack of coordination and management effectiveness

The problem of sectoral activities coordination (fishing, tourism, aquaculture, mining and petroleum industries which are under development…) results in conflicts of use of space which sometimes become acute. It also generates issues on the management of fisheries, mining, conservation and strategic resources and these issues have led to a moratorium on trepang and crab. Other conflicts between modern and customary law are also common in the north-west of Madagascar in terms of natural resource management.

In traditional maritime fishing, due to lack of resources, small-scale fishermen operate in their comfort zone. They cannot go any further. It is normal for the resource to be depleted in this area (e.g.: North-West axis from Mahajanga to Antsiranana and South-West from Morondava to Belo sur Tsiribihina). In addition, traditional fishermen use fishing nets with too small meshes and destroy in their passage all the progeny of the fishery resources.

On the other hand, some industrial fishers, especially for large companies, enter areas which are prohibited to them. Instead of fishing offshore, they sail along the coast. With inadequate controls, they exploit other resources which are not included in the list of authorized products in their fishing license.

4.1.3.8. Economic potential of the fishing sector

Madagascar has a huge potential in fishery resources but unfortunately there is no system for monitoring or evaluating the evolution of the total stock of resources. No reliable data are therefore available for reporting so as to discuss the wealth related to these resources.

Table 29: Madagascar's potential in fishery resources

Resources	Indicative potential (ton/year)	
	(Ralison, 1990)	(MPRH, 2012)
Penaeid shrimps from the continental shelf	7,000	12,000
Deep-water shrimps	1,000	
Deep demersal resources (Shrimps, Crabs, ...)		7,000
Mangrove crabs (Scylla serrata)	7,500	7,500
Lobster from the continental shelf	200	1,000
Demersal fish, West Coast	30,000	
Demersal fish, Est Coast	13,000	45,000
Cephalopods (including octopus and squid)		>1,500
Small coastal and neritic pelagics	50,000 to 110,000	+/- 100,000
Major tunas	1,600	
Minor tunas and associated species	50,000	52,000
Red algae	750	3,600
Trepang	140	>1,000
Sensitive species (sharks/fin, congers/swim bladder)		
Total	200,000	230,600

Source: Ralison, 1990 ; MPRH, 2012

4.1.3.9. Illegal Unreported Unregulated fishing

The Ministry of Fisheries has a Fisheries Surveillance Center (CSP), responsible for monitoring this activity in Madagascar's Maritime Territory. The main infringements recorded by this service can be summarized as follows: Activity during an unauthorized period (during the moratorium period); Use and possession of prohibited or non-regulatory fishing gear; Activity without authorization; Holding of species under minimum size/weight; activity in unauthorized areas such as Protected areas or conservation areas.

Table 30: Number of infringements in coastal areas

Year	Number of infringements
2015	42
2016	41
2017	31
2018	25
2019	69
2020	124
2021	16

Source: MPEB

4.1.3.10. Outcome of the maritime surveillance

In relation to the activities of foreign and Malagasy vessels, the watch carried out in 2018 has revealed the following types of infringements: non-functional beacon, non-declaration of entry/exit into Malagasy EEZ, 12-mile zone violation, capture and conservation of unauthorized species, on board fishing without adequate permission, unauthorized support vessel. In addition, the Exclusive Economic Zone of Madagascar has a huge potential for Madagascar's economic development. It arouses the envy of foreign countries hence the diplomatic conflicts with other countries such as France, which continues to claim sovereignty over the scattered islands despite the United Nations resolution in 1979 to return these islands to Madagascar.

In 2019, the Fisheries Monitoring Center (FMC) carried out 180 days of land inspection, 80 days of maritime inspection and 15 hours of aerial inspection. 895 satellites and 160 vessels in 802 locations were monitored to fight trafficking and irrational exploitation of natural resources. 16 community monitoring units have been installed and operational for the fishing communities (Swiofish 2 funding).

4.1.3.11. Number and type of fishing vessels, fishing gear, method of catch

4.1.4. Industrial fishing

The type of vessel authorized for industrial fishing is a motorized watercraft > 50 HP. For fishing gear, the Trawl and / or longline are the most used. Shrimps, tuna or pelagic fish and demersal fish are the focus of industrial fisheries.

Table 31: Industrial Fishing effort

Average days/vessel	242
Average fishing hours/vessel	4,700
Number of hours per fishing day	19

Source: MPEB, 2020

4.1.5. Artisanal fishing

Artisanal fishing in Madagascar is of average size and requires the holding of a fishing permit provided the vessel is a motorized watercraft between 15 HP and 50 HP. The present Ministry of Fisheries focused its policy on developing the artisanal sector. Therefore, since 2021, fishing permits for artisanal ships weighing less than 5 GT are free of charge while fees for much larger boats are highly affordable. For the next coming years, the country is looking forward to reaching the expected outcome which is the increase of the number of artisanal fishermen.

Table 32: Artisanal Fishing effort

Average Number of hours of fishing	15-19
Motorized and unmotorized vessel <15HP	Canoe
Average time for fishing	6

Source: MPEB, 2020

4.2. Tourism and leisure activities

Madagascar is the largest island in the Indian Ocean. It is home to thousands of endemic animal species such as lemurs as well as rainforests, beaches and reefs. For the development of tourism, Madagascar has very important advantages and potentials thanks to the diversity of its natural resources.

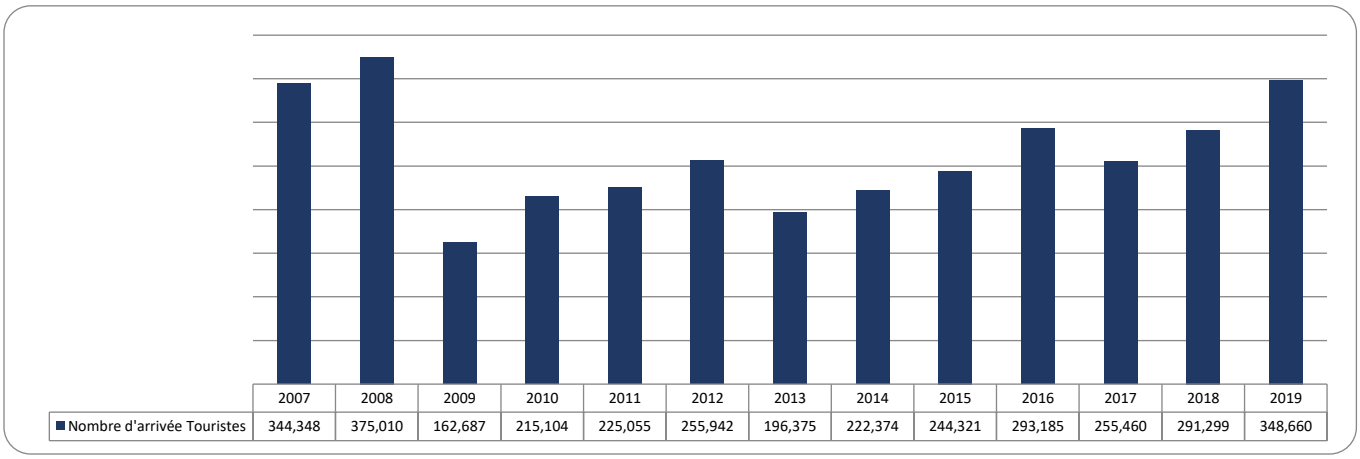
With its abundant natural resources and its 5,600 km of coastline, Madagascar has major assets.

4.2.1. Types of tourism

Depending on the purpose of the trip or the area of travel, or the activities to be undertaken, there are several types of tourism:

- Relaxation and leisure tourism (beaches, sun)
- Tourism of culture, knowledge and tradition (palaces, museums)
- Discovery tourism (endemic flora and fauna)
- Entertainment and fun tourism (adventure and sport)

Figure 37: Number of tourist arrivals per year



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Nombre d'arrivée Touristes	344,348	375,010	162,687	215,104	225,055	255,942	196,375	222,374	244,321	293,185	255,460	291,299	348,660

Source: Tourism Statistics, MTTM 2019

The year 2020 could have been an excellent year for Malagasy tourism if the efforts and results of 2019 during which the statistics of tourist arrivals greatly exceeded the record ever reached in 2008 were carried on. For its part, the Ministry of Transport, Tourism and Meteorology has established a clear increase in the number of non-resident tourists who visited Madagascar during the tourist year 2019. Also, according to official statistics, 350,000 non-resident tourists have been registered the previous year. An increase of more than 20% is thus noted, between 2018 and 2019. This is even better as this is a historic level which was reached over the last 10 years. On average, between 2009 and 2019, the arrivals of non-residents in Madagascar grew by more than 11.5% per year.

Being on the right track since 2019, Malagasy tourism, like everywhere else in the world, has also been affected by the spread of the pandemic. The sector has been the most seriously affected by the COVID 19 pandemic. All flights and cruises had to be canceled. Tourism, which occupies a more than important place in the national economy, has been brought to a halt since March 2020.

4.2.2. Tourist preferences in Madagascar

Renowned for its biodiversity, its beautiful beaches, its culture, as well as the richness of marine fauna and flora, Madagascar is very popular among those who love seaside tourism, ethnography and ecotourism and has countless assets to attract any visitor.

Ecotourism is the kind of tourism that focuses on the discovery of nature. It holds the record for visits and represents 55% of tourism activities in Madagascar. Currently, ecotourism remains the main reason for tourist visits.

Table 33: Evolution of the number of people visiting the protected areas managed by Madagascar National Parks (2010 – 2015)

Year	2010	2011	2012	2013	2014	2015
Number of visitors in PA	129,376	159,129	158,339	147,987	150,839	150,233

Source: Madagascar National Parks - 2016

In the Protected Areas networks of Madagascar National Parks, there has been a marked change in the number of visitors since 2010.

Isalo, Andasibe, Nosy Tanikely, Montagne d'Ambre, Ankarana and Bemaraha are the most visited sites out of the 32 existing ones.

4.2.3. Tourism and environment

In general, tourists are motivated to visit a particular destination for its environment, as well as its safety. The majority or even the totality of tourists need to enjoy their stays in a healthy environment with a beauty of natural riches such as fauna and flora.

Since the main motivation for tourists' choices for Madagascar is the discovery of its biodiversity, ecotourism (measured here by tourism in the PA) greatly contributes to the national economy. The idea is to capture the tremendous willingness of foreign tourists to pay to see the biodiversity of Madagascar.

4.2.4. The Economic Impact of Tourism

Tourism generates significant economic activities in other production and service sectors. The building sector is obviously involved during the building of hotels and tourism- related facilities including infrastructure. Hotels and other types of accommodation generate economic activity through upstream and downstream links with agriculture, fishing and industry. The provision of tourist services and the tourists themselves, through their personal expenses in and outside their tourist accommodation create a demand for transport, banking and insurance services, telecommunications, medical services, security and retail, and more particularly, handicrafts and other souvenirs.

4.2.4.1. Foreign exchange earnings

In Madagascar, according to the Central Bank, tourism is one of the top three sectors in terms of foreign exchange earnings, fluctuating in line with free zone enterprises and fishing.

According to the Ministry of Tourism, tourism revenues brought in the equivalent of SDR 511,691 million in 2019. This represents a significant contribution in foreign exchange.

4.2.4.2. Tourism-related activities

Tourism cannot happen without the following sectors: visitors' accommodation, catering, travel agencies, passengers' transport, cultural activities and retail trade of goods which characterizes tourism.

Currently, tourism generates 33,778 jobs in the hosting and catering industry and 7,329 in tourist activities and travel companies as shown in the Table below:

Table 34: Evolution of direct employment generated by the tourism sector (cumulation)

Types of activities	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Hotel and/or restaurants	17,805	19,395	20,623	21,998	23,845	25,412	28,325	30,413	31,515	32,693	33,778
Travel and tourist services companies (EVPT)	4,527	4,852	5,039	5,301	5,544	5,795	6,003	6,303	6,517	6,691	7,329
TOTAL	**22,332**	**24,247**	**25,662**	**27,299**	**29,389**	**31,207**	**34,328**	**36,716**	**38,032**	**39,384**	**41,107**

Source: Ministry of Tourism

The average length of stay in Madagascar is exceptionally long—22 days according to official statistics, but more likely a few days less.

Table 35: Average length of stay for non-resident visitors

	2007	2008	2009	2010	2011
Days	17	17	21	21	21

Source: Survey held with non-resident visitors

Today, tourism is included in the GDP by sector of Madagascar under the heading "Commerce, Hotels and Restaurants". The estimates of jobs created (some 41,107) are limited to those of hotels and restaurants and travel agencies and TOs without taking into account the jobs generated by tourism in agriculture, fishing and agro-industrial activities and in industries which supply the products needed for the accommodation of tourists, their transport and other related services to tourism (such as diving activities, guides, etc.) and through handicrafts sold to tourists.

4.2.5. Economic potential of the tourism sector

Madagascar's extraordinary natural capital, both marine and terrestrial, makes it a target destination for a diverse range of tourists.

As the world's fourth largest island, with nearly 5,600 km of coastline and a continental shelf equal to 20% of the land areas, Madagascar has a world-class seaside capital. It benefits from the biological diversity of seas and coasts, which is more important than that of any island in the Indian Ocean, and particularly of its spectacular underwater mega-fauna.

Madagascar's sun, sea and sand are a remarkable asset but has to face competition from the other more famous and developed Indian Ocean seaside destinations. Madagascar also has potential as a destination for cruise ships and is already part of several cruise line programs, placing itself between three prime cruise destinations namely Cape Town, Durban and Mombasa.

Tourism is not developed enough in Madagascar despite its undeniable advantages. The Big island is not a favorite destination for tourists yet and investors in the sector do not flock as is the case in other countries with similar opportunities. The ecotourism attraction due to the presence of exceptional flora and fauna has not been enough to attract as many tourists as in the neighboring islands. Apart from the distance from Europe, the United States and Asia, the reasons for this are the relatively high air fares, the lack of transport and reception infrastructure and the absence of a proactive policy.

The economic potential related to tourism in the Big Island remains untapped. One just needs to refer to Mauritius to get a clear idea. This small neighboring island, with 1,250,000 tourists, achieves 1,450 billion dollars in tourist revenues.

The figures speak for themselves. Madagascar is 300 times larger than Mauritius in terms of surface area, on a land area of 587,041 km² compared to 1,865 km². « Is it acceptable that with its 5,000 km of coastline, its natural biodiversity, and its endemic fauna and flora, Madagascar has only recorded 280,000 tourists per year, while Mauritius has 1,250,000 tourists? »

By 2023, however, the Ministry of Tourism in Madagascar has set a fairly ambitious goal of hosting 500,000 visitors taking into account the guidelines of the General State Policy.

4.2.5.1. Barriers to tourism growth

From January to March, the rainy season brings heavy rains. Rivers are flooded and roads are impassable making some land travel impossible. Rough seas can delay or make inter-island trips dangerous.

Group travel is a feature of today's international tourism, and many hotels outside Antananarivo cannot even provide accommodation for small groups of 16 people and less who travel to Madagascar.

The average stay in Madagascar lasts two weeks rather than the one-week standard of the other islands of the Indian Ocean. Most of these seaside destinations have few attractions besides the sun,

the sea and the sand, which limit the time during which tourists can stay in a resort without getting bored.

The seaside market is the most competitive demand segment in the world and Madagascar faces competition from destinations in the Caribbean, the South Pacific and other "paradise islands", as well as the rest of the Indian Ocean. Indeed, Madagascar destination is far for tourists from the American and European Continents or even from Oceania such as Australia and New Zealand. However, these countries are the countries of departure for wealthy tourists in search of a destination which is rich in biodiversity such as Madagascar.

In addition, the dahalo phenomenon or rural banditry, causing insecurity issues and happening on tourist routes such as the Tsingy de Bemaraha destination in the West, largely discredits Madagascar destination. Indeed, in 2018 and 2019, many tourists suffered from armed attacks on the roads. This really discouraged tour operators and tourist guides.

4.2.5.2. Cruise Tourism

Madagascar is on the programs of different cruise ship lines due to different contexts and combinations of ports of call: cruise ship around Africa, the Islands of Southern Africa and the Seychelles, the Indian Ocean and one German cruise line travel…

A major obstacle is the lack of possible destinations in Africa that have the necessary port and reception infrastructure for cruise ships, as well as exceptional tourist capital nearby (due to the short stays in each port) and a peaceful and secure environment for cruise passengers.

Madagascar is among the route choices for cruise ships between two major cruise destinations: Mombasa and Durban/Cape Town. The ports which are visited by the cruise ships are: Fort Dauphin, Antsiranana, Maroantsetra, Toamasina, Tuléar and the islands of Nosy Be. One of the smallest cruise lines (200 passengers) goes to Nosy Be (12 hours), Antsiranana (7 hours) and Maroantsetra (5 hours) during the same 12-day cruise. The lemurs and/or the beaches and/or the adventure tourism of Madagascar is/are a perfect capital to entertain the cruise passengers during a long cruise or to be combined with a safari in southern or eastern Africa. Madagascar has the most secure ports of call for passengers cruising around Africa. However, cruise ships in the surrounding areas often pass off the coast of Madagascar.

Most cruise lines do not have regular travel schedules. At present, the frequency of cruise ship movements is not known even though the Government should be able to gather the information related to them. However, Madagascar could facilitate a decision to include one of its ports in the itinerary by improving first of all port facilities as well as access to the tourist capital which is located near Antsiranana, Maroantsetra, Toamasina and the islands of Nosy Be.

Cruises could develop tourism to areas in Madagascar which are not accessible to land tourists.

The main obstacles to the development of cruise movements are:

- The lack of adequate port infrastructure to accommodate cruise ships and their special requests for disembarking and embarking passengers.
- The lack of adequate vehicles which are available to transport passengers from the port to an inland tourist destination where reception facilities are often lacking, and
- The poor quality of the roads between the port of call and the tourist capital.
- The costs incurred in creating a port infrastructure are high therefore the financial and economic benefits from cruise revenues are a matter of debate.

4.3. Industries

Like many other cities in Madagascar, coastal cities are experiencing real urban growth as is the case of Toamasina, the country's main port city which is conducive to the development of trade on the one hand, and also because of the presence of numerous industries on the other.

Table 36: Industry sector's contribution to the current GDP (as a percentage of GDP)

	2014	2015	2016	2017	2018
GDP % of secondary sector	15,7	15,9	16,7	18,0	18,6

Source: MEF

Table 37: Growth rate (annual variation in %)

	2014	2015	2016	2017	2018
Industry sector Growth Rate	8,5	7,3	5,5	9,0	6,7

Source: MEF

4.3.1. Factories

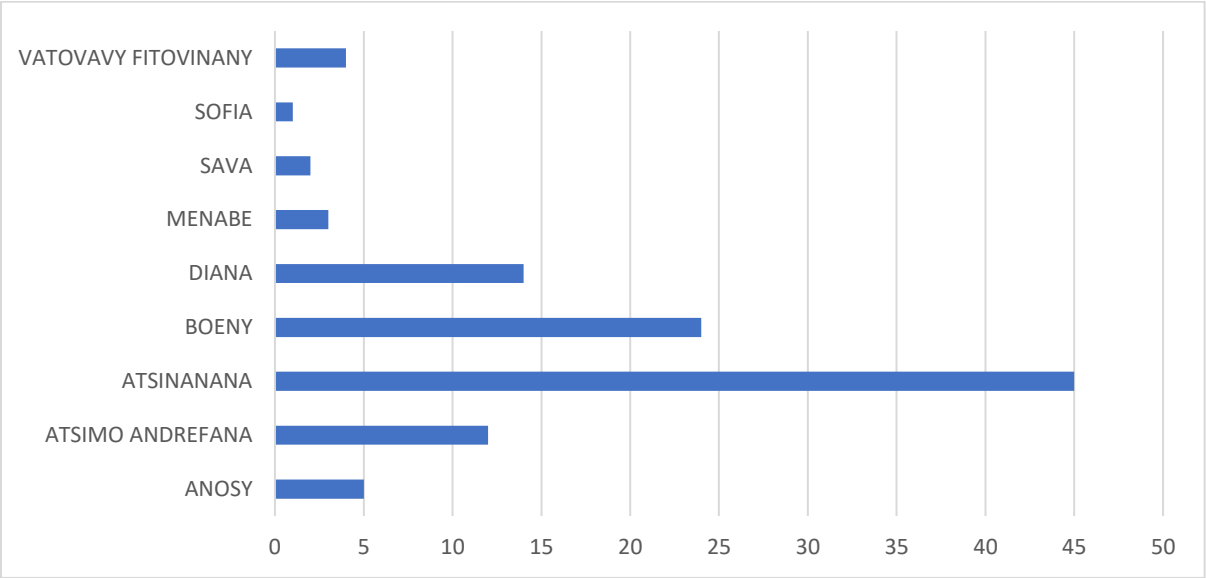
Regarding the environmental compliance of factories located in coastal regions, around one hundred and fifty factories have an environmental permit (ONE, 2020 Tracking System). Most of these factories are located in Atsinanana, Boeny, DIANA, Atsimo Andrefana, Anosy, Menabe, SAVA and Vatovavy Fitovinany Regions but a great number of the industrial units are located in Atsinanana Region in the city of Toamasina and Boeny Region in the City of Mahajanga, followed by Atsimo Andrefana and DIANA Regions.

In the Eastern region, the types of activities are generally as follows: soap factory, oil-mill factory, storage and silo, manufacturing of mattresses, steel industry, fishery product processing unit, ethanol micro distillery unit, feed mill factory, fruit processing, preparation of caustic soda, tannery, gas storage and filling, plastic bottle processing, production of pasta.

The Boeny Region in the western part of Madagascar is the second area where several factories are located. These factories comply with the environmental legislation. We note the same activities as those in the Eastern region but with a few textile industries. Other few units which are directly linked to maritime activities, such as boat manufacturing and shipyard (eg: SECREN, Tropical Boat, Seafood le Yard, etc.) are located in the northern part of DIANA region.

The Southwest region whose capital is the city of Toliara, is characterized by activities which have promoted the blue economy, such as seaweed and sea cucumbers farming as well as the processing of fishery products.

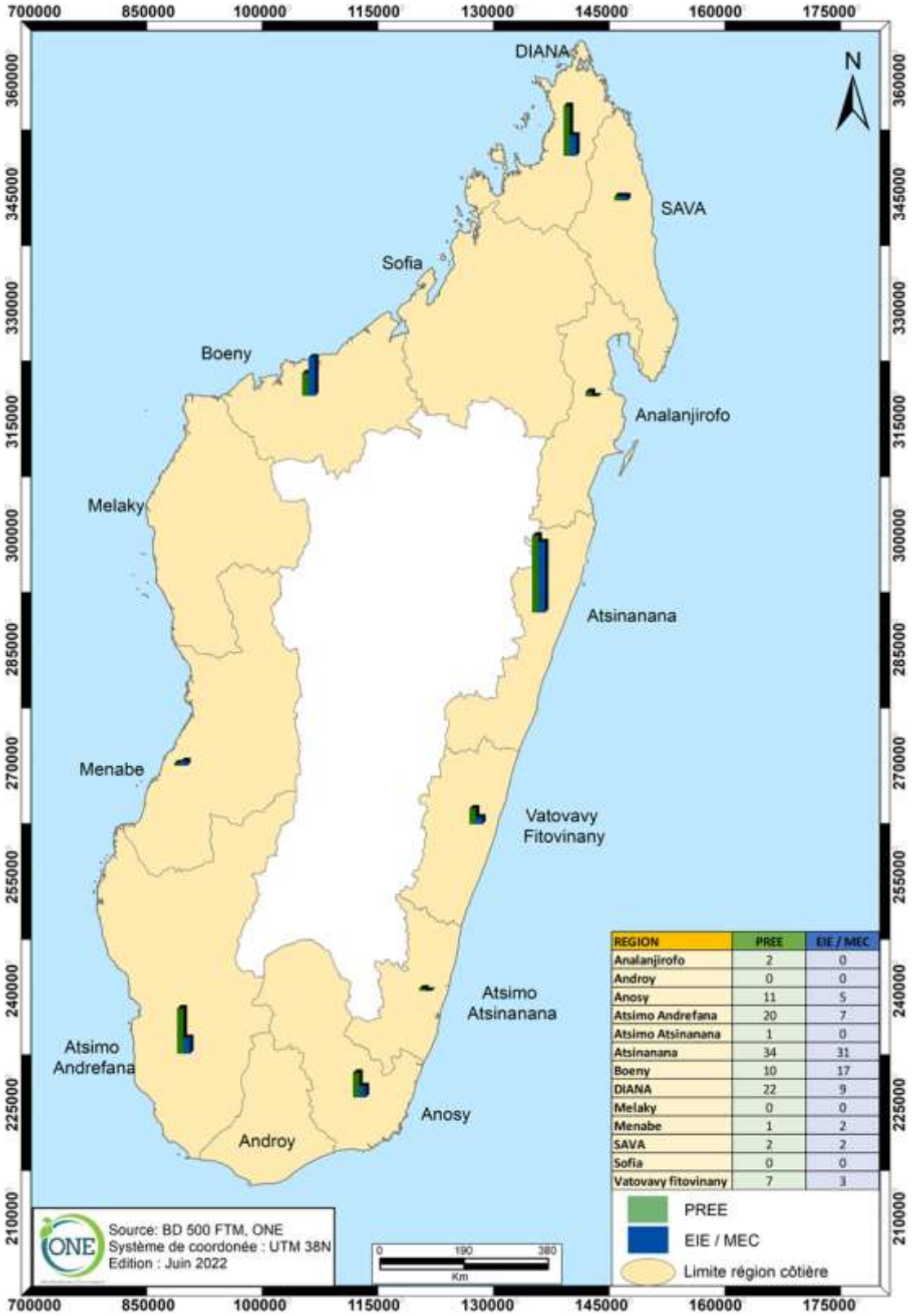
Figure 38: Number of factories with an Environmental Permit / Coastal Regions (2004-2019)



Source: ONE, 2020

Between 2004 and 2020, around 90 other small-scale factories were categorized as Environmental Commitment Program, i.e. those included in the Appendix 2 of the MECIE Decree, in those same coastal regions.

Map 30: Distribution map of factories which are subject to EIA and PREE in coastal areas



REGION	PREE	EIE / MEC
Analanjirofo	2	0
Androy	0	0
Anosy	11	5
Atsimo Andrefana	20	7
Atsimo Atsinanana	1	0
Atsinanana	34	31
Boeny	10	17
DIANA	22	9
Melaky	0	0
Menabe	1	2
SAVA	2	2
Sofia	0	0
Vatovavy fitovinany	7	3

4.3.2. Salt works

The salt works are installed on dried and saline tannes due to the lack of fresh water supply (rainfall) from the mangrove hinterland. The most important salt works exploited in Madagascar are on the North-West coast (in Antsahampano, installed since 1895, with an annual production of 70,000 tons), on the South-West coast (in Toliara which exploits 50 ha of tannes with 4 ha of crystallizers and in Ifaty), and on the west coast (in Belo-sur-mer). These salt marshes also produce "salt flower", "salt roses", gypsum; "sea oil", glasswort powder and *Artemia salina* (zooplancton).

4.4. Mariculture

In the field of marine aquaculture, several experiments such as shrimp farming, sea cucumber farming in Toliara (hatchery and grow-out), algaculture in the southwest and northeast, intensive eel farming in Mananjary, oyster farming in the Anosy Region have been carried out. These experiments are dependent on the sea water pumping. Marine aquaculture production has steadily declined since 2007, dropping from 9,687 tons to 4,874.4 tons in 2013. Most of the production comes from shrimp, which went from 8,354 tons in 2007 to 4,562 tons in 2013.

The productions of shrimp, seaweed, crab and lobster must also be considered. A respective increase of 123.8%, 333.5%, 107.0% and 158.8% was recorded.

Table 38: Evolution of the production from 2013 to 2019 in tons

Activity/Domain /Species	2013	2014	2015	2016	2017	2018	2019 (provisoire)
Shrimp farming	5,362.00	3,258.00	3,446.60	4,563.00	5,438.56	5,337.52	3,525.89
- Seaweed farming	3,574.96	6,970.00	15,377.00	17,423.24	17,407.20	4,947.05	8,864.59
- Sea Cucumber farming			25.34	40.95	98.80		
TOTAL	**8,936.96**	**10,228.00**	**18,848.94**	**22,027.19**	**22,944.56**	**10,284.57**	**12,390.48**

Source: General Directorate of Fishery

4.4.1. Seaweed (farm and trade)

Seaweed farming is now a well-known practice in Madagascar and has begun to develop. In Madagascar, it started in the 1980s by introducing species from the Philippines: *Euchema striatum* (red algae) or *cottonii*. The species was chosen because it is easy to cultivate compared to other species (resistance to parasites and temperature variations) such as *Eucheuma denticulatum* or *Eucheuma spinosum* known as spinosum and which is produced in smaller quantities in Madagascar (adapted from De San, 2012). Seaweed farming currently occupies 500 ha, and mainly focuses on brown alginate algae (*Euchema cottonii* and *Euchema spinosum*).

Madagascar is among the few countries in the sub-region that have been able to develop industrial production of at least 1,000 tons of dry seaweed over several years (adapted from DE SAN, 2012).

Seaweed is grown in lagoons and sheltered bays with a minimum of current for water renewal. The main production areas are in the northeast (Nosy Ankao) and southeast of Antsiranana province as well as near Toliara in the southwest of Madagascar.

Production is estimated at 1,600 dry tons by the MRHP (BANQUE MONDIALE, 2016) in 2014. The MRHP predicted stagnation at 2,000 tons in 2016-2018. Managing the use of coastal areas by different sectors to achieve these production levels will be crucial.

The tables below describe the export and production by different entities involved in the field of seaweed farming and exploitation.

Table 39: Production of cultivated seaweed from 2013 to 2019

Activity/Domain /Species	2013	2014	2015	2016	2017	2018	2019 (temporary)
Seaweed farming	3,574.96	6,970.00	15,377.00	17,423.24	17,407.20	4,947.05	8,864.59

Source: MPEB

Currently, algacultures which are carried out by Chinese companies are the subject of complaints in some parts of the island. Most of these complaints are usually due to the inconvenience caused to fishermen because of the installations which were set up in the water concerning seaweed farming. They take up a lot of space and often lead to conflicts with local fishermen.

4.4.2. Sea cucumber

Sea cucumber fishery plays an important role in the economy of Madagascar. In the region of Toliary (southwest of Madagascar), this fishery is a traditional activity widely practiced by communities in coastal areas. For the Vezo fishermen living in this region, the collect of sea cucumber has become an integral part of their subsistence activities and is the primary source of income for a significant portion of the population. The techniques used are simple, namely collect on foot or by snorkeling, and they require very little investment in equipment while ensuring equal participation of men, women and children.

The mastery of the larval development and the metamorphosis of Holothuria scabra (local strain) was a very important result obtained by the collaboration between the Malagasy (IHSM of the University of Toliary) and Belgian (Universities of Mons and Université libre de Bruxelles) universities. This stage was mastered in 2004 and encouraged both parties to move to the other stages (pre-growth and growth), that is, mastering the growth of post-metamorphic individuals. The studies of the latter stages were carried out in a pre-growth farm (external ponds) and in enclosures (fences located in the phanerogam areas) and led to very satisfactory results in 2007).

Two local NGOs, Blue Ventures and Trans'Mad-Development, worked in partnership with MH.SA and received funding from PROGECO (Regional Program for the Sustainable Management of Coastal Zones in Indian Ocean Countries) to develop holothuriculture into a sustainable income-generating activity for the fishing communities.

The NGOs selected villages in the vicinity of Toliary, notably Fiherenamasay and Andrevo-Bas in the north and Sarodrano in the south for the NGO Trans'Mad-Development while Blue Ventures intervened in the area (Velondriake) further north. In total, 24 villages were involved in these projects.

In 2011, after the end of PROGECO's funding, only the NGO Blue Ventures continued the activity in all the villages (including Sarodrano) by ensuring the operation of the farms with funding from NorgesVel. The sites of Andrevo and Fiherenamasay were abandoned due to socio-economic problems.

The complex nature of sea cucumber fisheries does not facilitate the implementation of fisheries management measures, due to the large number of links in the supply chain that need to be regulated. In Madagascar, the management of the sea cucumber fishery is particularly difficult due to inadequate regulations, lax enforcement and lack of statistical collect and management.

Figure 39: Drying of sea cucumbers caught in the wild in the village of Vezo



(Photo: B. Pascal, Trans'Mad-Développement)

4.4.3. Aquaculture

Aquaculture mainly involves fresh water fish in natural breeding in ponds or in rice fields. Fish intensive breeding is not fully developed yet at the level of traditional farm exploitations. More than 130000 farm households, ie 5.3% of the total number of farmers practiced fresh water fish breeding on a total surface area of 1695ha of pond area. There are however industrial aquaculture for shrimps in the regions of Boeny, Menabe and DIANA. Their productions are mainly for exports purpose.

Shrimp farming is done on live or herbaceous tannes. 37 sites were identified along the west coast, totaling an overall gross area of 15,554 ha or a net water area of 11,138 ha, and an area of 9,083 ha which can be used as basins. According to the SAAC (Schéma d'Aménagement Aquacole de Crevette), the mangrove area that can be used is limited to 5% of the total area of the facility. However, the mechanical pumping of water for the basins causes coastal erosion (ROGER, E., 2008). In 2007, the shrimp ponds occupied 2,267 ha of the area (OEFC, 2008).

Table 40: Evolution of shrimp production in tons

Activity/Domain /Species	2013	2014	2015	2016	2017	2018	2019 (temporary)
Shrimp farming	5,362.00	3,258.00	3,446.60	4,563.00	5,438.56	5,337.52	3,525.89

Source: MPEB

The shrimp aquaculture farms operating in Madagascar have all been subject to environmental assessment to mitigate their environmental impacts. Currently, companies like AQUALMA, and Les Gambas de l'Antakarana (LGA) continue to operate even if they were affected by the White Spot Virus, which has decimated all other farms operating in Madagascar.

Following are the impacts of the white spot virus:

- Closing of two aquaculture sites
- Loss in foreign currency and loss of employment (source: ASH)

For example, in the case of Malagasy aquaculture sites, the estimate loss according to the economic magazine "Marchés Tropicaux et Méditerranéens" is more than 3.5 million Euros and more than 600

people lost their jobs. With 3 billion Dollars in losses annually, White Spot disease is not the only disease likely to contaminate aquaculture farms but it is certainly one of the most costly in the world.

4.4.4. Crabs

4.4.4.1. The mangrove crabs

L'exploitation The exploitation of *Scylla serrata* mangrove crab in Madagascar is an exclusively traditional fishery. It is carried out on foot or with small non-motorized pirogues, using very simple and inexpensive fishing techniques. Mangrove crabs are harvested in the mangroves at the adult stage. Its trade on the international market has grown over the last decade. Catches have continued to increase.

The 2014 regulatory provisions set (i) the closing period for fishing and marketing from July 1 to October 31 ; (ii) the prohibition of crab aquaculture in mangroves ; (iii) the annual total catch (ATC) of 5,000 tons live weight with a possibility of review based on more reliable scientific data, (iv) and the minimum size of carapace width for fishing and marketing at 11 cm.

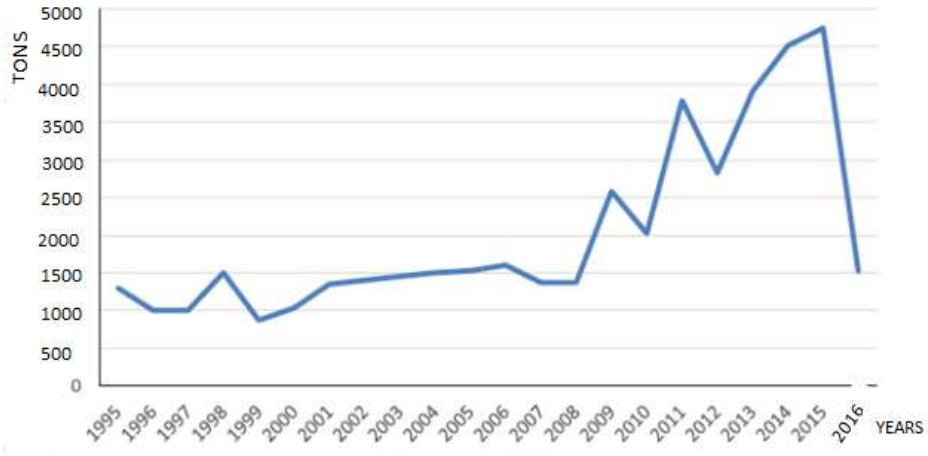
Production data are very likely underestimated whereas the potential of 7,500 tons is overestimated (World Bank, 2016).

Table 41: Crab production

	2016	2017	Variation en %
Crab (tons)	2,908.07	6,018.38	106.95

Source: REF 2018

Figure 40: Evolution of mangrove crab production in Madagascar from 1995 to 2016



Source: MRHP, 2016

4.5. Maritime transport

With a coastal zone representing 68% of its national territory (RAEM, 2017), the big island is among the countries which are most dependent on maritime transport.

Displaying a rich diversity from North to South and from East to West, Madagascar wants to show its willingness not only in the transition to a low emission of greenhouse gas, but also in the control of the sources of aggressions that ecosystems can suffer from.

Maritime transport poses a threat to the environment both on seas and oceans as well as on inland waterways although its importance in the economic life of the country (as in the rest of the world) is undeniable.

In fact, from the construction of ships and port infrastructures to their management and treatment of wrecks or the demolition of ship reception facilities, there is always a risk of air, water and noise pollution).

4.5.1. The schema of the Malagasy maritime transport

The port of Toamasina represents around 76% to 80% of the overall volume of national port traffic, excluding dhow traffic. The 7 other ports of national interest namely Antsiranana, Nosy Be, Vohemar, Antalaha, Mahajanga, Toliara and Tolagnaro ports account between 20% and 24% of the traffic, excluding dhow traffic (APMF statistics, 2019).

The other ports of regional interest perform a regional cabotage function representing 0.7% of total traffic (APMF statistics, 2019) and most of it is carried out by dhows. They play an essential role both in supplying the economy and in evacuating local production. This configuration, which puts Toamasina at the center of the country's international and cabotage flows, weakens the geography of national transport and its international openness.

The port of Toamasina is the only port with a significant program of rehabilitation, improvement and extension works. For the other ports, the ongoing work and the planned projects by the port authority mainly concern the rehabilitation or even reconstruction of severely degraded infrastructure.

Apart from that, most of the ports are located in urban areas. Traffic related to their activity amplifies road congestion. The roads which are often in poor condition worsen the flow of traffic. These same ports, with a medium to poor road network, do not have sufficient connectivity to their hinterlands to provide a high performing supply chain. The development of the port system should take into account

these congestion and connectivity matters and should be considered as part of a more global and multimodal supply chain (Master plan of the Malagasy ports APMF, 2020).

Although maritime transport, like other transport sub-sectors, poses risks to the environment and climate, it is also exposed to the impacts of climate change. Indeed, port infrastructures and waterways through their geographical positions in low-lying and coastal areas can suffer from environmental degradation as well as climate risks such as sea level rise, storms, silting and flooding.

And as mentioned by UNCTAD, given the importance of the role that maritime transport and especially ports play in the supply chain, but also taking into account the value and size of infrastructure, it is imperative to have an economic strategy showing the adaptation measures related to it UNCTAD, 2018).

4.5.1.1. Contribution of maritime transport to climate change

4.5.1.1.1. Importance

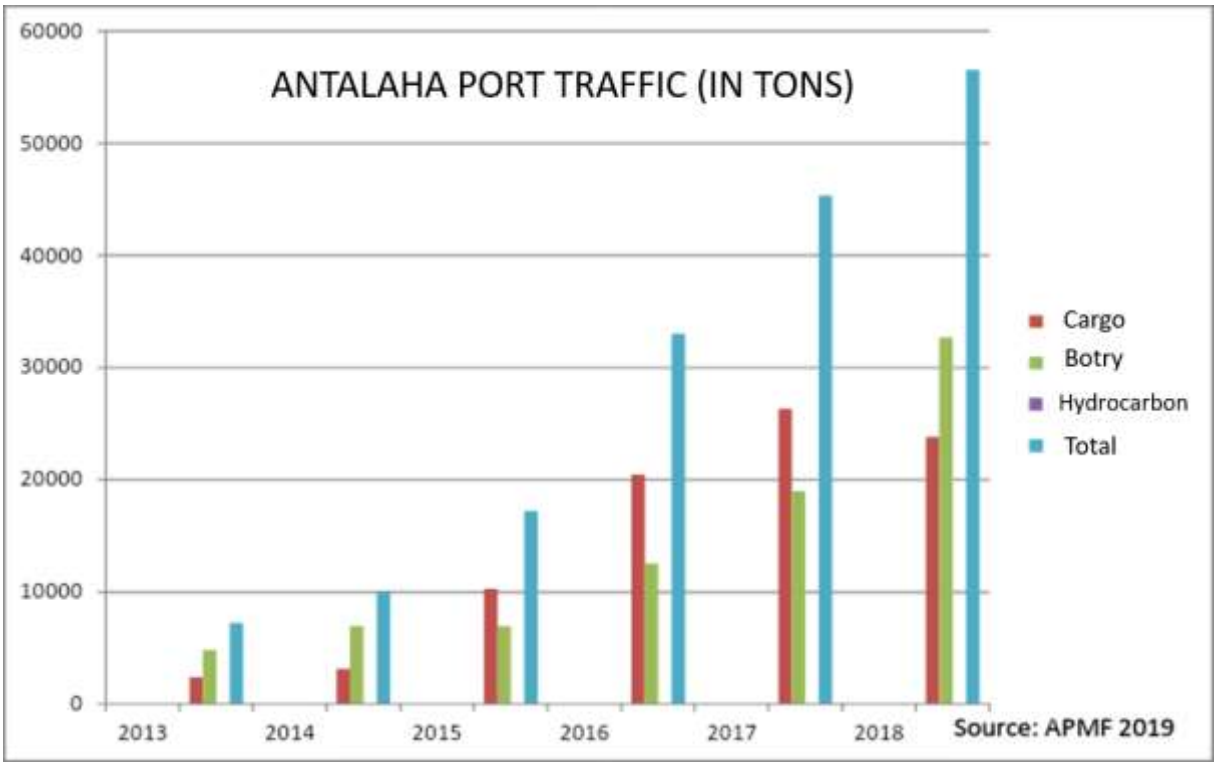
The contribution of maritime transport (Ports and ships) to environmental risks and climate change is due to gas emission, operational oil pollution, waste disposal, transport of invasive species by ballast water, accidents and their discharges, construction and maintenance of infrastructure.

Although the volume of Malagasy trade by sea and inland waters is not representative compared to other countries, it is worth noting the increase in these exchanges from year to year. The sub-sector's involvement in pollution thus remains considerable, particularly with regard to air and water. And its impacts are on climate, health and water acidification.

Sources of pollutants include transport vessels, port vessels, handling equipment as well as vehicles and wagons for multimodal transport.

The importance of the volume of goods transported by dhows is also to be considered given its increase over the last 5 years. In 2019, goods transported by dhow represented 60% of the traffic of some ports on the East-North route of the big island. Those types of ships require the cutting of trees.

Figure 41: Evolution of the port traffic in Antalaha



Source: Port statistics, APMF, 2019

4.5.1.2. Preventive measures

The Maritime and River Harbor Agency (APMF), within the framework of different international conventions such as MARPOL and in partnership with other entities such as the Anti-Pollution Events Body (OLEP) and the Maritime Information Fusion Center (CFIM), sets up the frameworks for the fight against the various risks of pollution which are previously mentioned.

Madagascar's ratification of the different conventions and their implementation demonstrate the country's willingness to slow down and reduce the impact of the maritime transport sub-sector on the environment and climate.

The monitoring and evaluation of port infrastructure projects (by the ONE and the APMF), the regulation of shipyards as well as the implementation of Inspections by the Flag State (by the APMF) remain to be the tools for preventing pollution risks related to maritime and port activities.

With respect to IMO 2020, the reduction of sulfur level to less than - 0.5% (Low Sulfur Fuel Oil) is the measure which was taken at the global level in relation to the sulfur emission level from ships using heavy fuel. In Madagascar, the heavy oils exploited by the Madagascar Oil Company fulfil these conditions.

4.5.1.3. Climate change and its impact on maritime transport

4.5.1.3.1. Climate change

The manifestation of climate change affecting maritime transport in the world and therefore in Madagascar can be summarized as follows:

- The increase of the average temperature
- The sea level rise whose trend is 2.7 mm / year (Report on the future of the environment of Madagascar 2017).

- The increase in the number of extreme weather events (storms, cyclones, etc.)
- Changes in maritime parameters such as swells, waves and rainfall
- Erosion and sedimentation

4.5.1.3.2. *Potential impacts*

Le Rerouting or change of route becomes more common and vessels of a certain power are no longer able to serve the said route because the water level continues to rise and bad weather increases due to global warming. Coastal erosion worsens and sedimentation patterns change. These significant changes have greatly affected the navigation channel.

Therefore, as existing routes are no longer safe or easy to navigate as before, new routes need to be planned. Itinerary changes can be very inconvenient and affect the productivity of both customers and shipping companies because instead of continuing their regular operations, shipping companies have to allocate time and financial resources to route planning. For customers, the increase in transit time will affect their deliveries. This was the case for some vessels that wanted to link Toamasina and Fort Dauphin and had to return halfway (Port of Ehoala, 2020).

The risk of damage to port infrastructure increases with the rise in seawater level. As a consequence, infrastructure whose investments are huge and which requires most of time aid from donors are left unused.

The indefinite shutdown of operations (vessels, ports and related activities) is seen as the direct impact of climate change on maritime transport. The need to relocate activities and even to inject new capital will therefore penalize the sub-sector stakeholders.

4.5.2. Vessels

With respect to maritime traffic and oil spills at sea, around 30% of the world's crude oil, i.e. more than 700 million tons, passes through the Mozambique Channel every year (FERNANDEZ and PHILIPPE, 2015) from the Middle East to serve Europe, America and Asia. For the Western Indian Ocean, recognized as one of the hotspots of global biodiversity, an accidental oil spill would have a disastrous effect on natural resources, on which major economic sectors such as tourism and fisheries depend. Due to its insular character, more than 90% of Madagascar's international trade is by sea. It has 17 ports which have been regulated by the Maritime and River Harbor Agency (APMF) since 2003. Four of them (Antsiranana, Toliara, Vohémar and Toamasina ports) have adequate port infrastructures allowing the loading and unloading of goods at the dock. In the other 6 ports, operations are carried out in the harbor by barge and access to the quayside port is by horse / the shallow depth of the river. The port of Toamasina, located on the East coast, is the country's largest economic port. Currently, 75% of Madagascar's cargo is loaded and unloaded in Toamasina.

Table 42: Conventional goods and hydrocarbon traffic in Toamasina port (in tons) from 2006 to 2015

Items	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Conventional goods	456,538	437,276	461,988	319,613	246,647	186,321	219,792	190,552	277,744	453,815
Hydrocarbon	575,853	621,923	631,830	616,294	681,505	758,661	805,931	785,559	775,649	9,369

Source: SPAT Management control

The coasts of Madagascar are exposed to accidental oil spills which are caused either by the dilapidated shore-based facilities or by maritime accidents. The last decade has been marked by several maritime accidents, some of which were sources or threats of an oil spill.

4.5.3. Dirtying

Depuis Since 2019, the Malagasy maritime sector has been considering to conduct a biological survey on the vessels. To cut down the risks, the Grofouling Project, which is the result of a partnership between the Global Environment Funds, the International Maritime organization and the United Nations Development Program will work on the transfer of aquatic species through the biological dirtying from the aquatic organisms that accumulate at the bottom part of the hull or the ships' structures.

Since biological dirtying is clearly associated with maritime transport and that threats as well as the impacts are of national concern that can affect different fields such as economy, environment, fishing, tourism and even health, APMF aims to coordinate the committee that has to make sure the Project takes place for the safety of our maritime border.

4.5.4. Employment [29]

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Code) sets the minimum training standards for all seafarers working on board ships operating in international waters without exception of nationality. Shipowners and manning/crew manager [30]agencies are actors in the maritime transport and the environment through their activities. Risks and anomalies in the maritime transport and the environment are largely due to the human factor.

Maritime transport is the act of moving goods from one point to another using a vehicle that can float and move at sea under the guidance of professional people called " Seafarers". The organization of maritime transport is governed by the international conventions namely SOLAS, ISM, MARPOL, STCW, CTM which were issued by the UN through its specialized agencies which are the IMO and the ILO. These international conventions are translated into maritime code and national regulations for each state.

In Madagascar, apart from the applicable laws relating to any individuals or legal entities of Malagasy nationality, Malagasy seafarers as well as manning/crew manager agencies in maritime employment are obliged to follow the international conventions, the Malagasy maritime code and the national regulations.

Indeed, there are quite a few blocking points namely the depreciation of the Ariary, the lack of some maritime training at the local level, the advanced age as well as the lack of a succession plan of maritime public officials specifically the ENEM.

Despite all of these, there are plenty of opportunities. Malagasy youth as well as the high unemployment rate are favorable to the activity of manning/crew manager agencies, given that the laws of French-speaking countries - the laws of the flag State - the international maritime laws do not in any way prohibit the hiring of foreign seafarers. In addition, the appreciation of the Euro and the USD is boosting the activity.

In 2015, there were 3,917 registered seafarers in activity, 2,976 of which embarked internationally, namely:

[29] Excerpt from a thesis, Risk analysis and handling of HR anomalies in transport M. Andrianombana, Lanja Achille

[30] A company that handles and boards a ship on behalf of a shipowner, the crew that is needed for its operations and its exploitation.

1. MSB: 24
2. MSC: 2,246
3. SCT: 373
4. EXTRAMAR: 48
5. MMS: 35
6. DSS: 123
7. Mauritian Fishing: 127

In addition, there are some freelancers not recorded at the level of the APMF.

Of the 3,917 active seafarers, 322 women, including 02 officers, and 3,595 men, including 271 officers, have been counted.

Table 43: Diagnostic analysis of sea-related employment (seafarers)

Opportunities	Threats
- Policy: National maritime transport policy encouraging investors to come to Madagascar - Economy: Appreciation in foreign currencies - Social: High unemployment rate and young population - Legal: Laws of French-speaking countries, laws of flag State and other international laws do not prohibit the hiring of foreign seafarers - Environment: There are enough manning agencies in Madagascar	- Economy: Depreciation of the Ariary currency - Technology: Maritime teaching equipment and logistics outpaced by the current technological and educational developments - Legal aspects: National laws do not reflect the reality and are unable to keep up with the changes in the various international maritime codes and texts as well as the customer needs, Inventory of solutions - Social and Health: Social insecurity and COVID 19, ageing officers [31] - Environment: ENEM maritime public service staff are starting to grow older, 85% of the permanent lecturers are in their seventies[32]. - Strong negotiating power of customers Within the APMF, the trends are as follows: - The applicable texts are outdated and cannot keep up with the changes, however, significant progress has been noted with the current APMF management staff since 2018 to catch up with the delay. At ENEM, the changes are:

[31] Data from a manning agency

[32] Minutes of ENEM board meeting, 2020

Opportunities	Threats
	- The lack of maritime lecturers to take over the transfer of competence. As an evidence, in 1991 the number of permanent lecturers with maritime competence to provide officer courses was six, in 2021 they are no more than five and are in their seventies. - Obsolete teaching materials - Lack of executive officer training. The most recent one was held in 1999
Inventory of solutions Based on the possibilities and proposed solutions for each of the above-mentioned root causes, the actions to be implemented that summarize all the solutions and enable each entity to be satisfied can be as follows: - Sensitizing the APMF and ENEM maritime public services regarding the importance of preparing other people to take over from them and by providing training for senior and junior Malagasy officers as well as for Malagasy non-management staff. - Setting up a training policy for officers and non-management staff within manning/crew manager agencies taking into account short-term and medium-term needs;	

4.6. Mining, Gas, Oil

Madagascar's coastal and marine areas are also rich in various mining resources (ilmenite, coal, gems and precious stones). The offshore area is home to large oil fields which are subject to several surveying.

The exploitation of marine and coastal oil and mining resources poses a significant danger to the ecological integrity of this environment due to the infrastructures that need to be set in place (storage silo for hazardous products, wastewater discharge etc.). This partly results from the lack of capacity of the state system to properly assess impact studies. These operations are seen only from a financial perspective. The following table gives the mining operations and exploitation prospects in the coastal areas of Madagascar.

The marine and coastal zones of Madagascar also contain a diverse range of mining resources that make up their wealth such as coal, ilmenite, gems and precious stones. The offshore part has important oil fields, which are currently under various prospections.

However, exploiting marine and coastal mining and oil resources can be potentially dangerous for the ecological integrity of the land because of the infrastructure it requires (silos to store dangerous products, used water disposal…). This is partly due to the fact that the government is not fully able to correctly assess the impact of the projects. These kinds of exploitations are only considered on their financial aspects.

4.6.1. Titanium

Two major mining projects have been implemented in Madagascar, one of which (Société Ambatovy SA) mines nickel and cobalt in the Eastern Region with an investment of $ 8 billions for an annual production estimated at 60,000 tons of refined nickel, 5,600 tons of refined cobalt and 200,000 tons of ammonium sulphate. Its operations are scheduled to continue until 2040. The other one (QMM SA) mines ilmenite in the South East Region of Madagascar, with an average annual production capacity of 720 KT of ilmenite and of 11,000 T of Monazite.

A third major project (Base Toliara) which has not started yet and is located in the South West Region of Madagascar also mines Ilmenite.

In Sambirano (meaning water tank), part of Ambanja and which is located in the northwestern part of Madagascar, there is a large mining deposit of rare earth. A company has been exploring this ore of the future since 2009. However, strong protest from the local population and civil society took place with regard to the possible extraction of this ore. This is due to the sensitivity of the environment which is marked by the presence of protected areas.

4.6.2. Oil and gas exploration

Quest for oil in Madagascar goes back as far as the 20th century when the first prospections took place. Geologists then discovered a land that is rich in sediments that are favorable to the formation of hydrocarbons.

Five sedimentary basins have been defined on a surface of 980,000 km². Today, local authorities want to promote 40 offshore blocks and about 100 onshore blocks.

Oil exists in large quantities in Madagascar, especially in the sedimentary basins throughout the western part, as evidenced by the signs of the presence of oil and gas which are both found onshore and offshore. Several exploration projects have been carried out and 20 oil blocks are under contracts with international oil companies, 17 of which are onshore and 3 offshore. For the moment, none of the oil and gas discoveries has been declared commercial except for Tsimiroro where heavy fuel oil is already being exploited. In terms of international standards set by the International Maritime Organization, the specifications of Tsimiroro Heavy Oil meet the requirements of IMO 2020 standards, Low Sulfur Oil (LSFO), i.e. -0.5% of sulphide rate in the heavy fuel oil.

The accessibility and importance of extraction costs are the most studied parameters, referred to as profitability (usability) from only a barrel price of at least US$120. However, it is important for Madagascar, before it begins to exploit these fields, to thoroughly examine not only the economic consequences but especially the social and environmental consequences that this could generate, given the overlapping of oil blocks with priority conservation areas on the one hand and the correlation between the existence of conflicts and the presence of oil exploitation on the other hand, not to mention the inequalities, tensions and social injustices that it would create if badly managed. The harmonization of land use through land use planning schemes as well as the strategic environmental and social assessment (SEA) of the sector are examples of tools that could be used for this purpose.

Madagascar has about 1,803,000 km² including the EEZ which is favorable for oil exploration. Until now, these oil projects have remained at the stage of exploration and were subject to EIA.

However, all these oil operations in general have not really had a significant impact on the marine environment given the fact that they comply with the provisions of the environmental management plans, such as the obligation to establish the communication structure which must at least include the following entities: Region and Communes concerned, Regional Technical Services (Environment, Fisheries and Fishery Resources, Hydrocarbons, Maritime Transport, APMF), Fishermen's Associations, the promoter and the team in charge of awareness raising.

- Operationalization of the team in charge of awareness raising

- Existence on board of Malagasy resource persons including fishing advisers, observer representing the Malagasy Administration
- Existence on board of marine mammal observers (MMOs) and PAM system managers
- Effective waste management according to international laws (SOLAS, MARPOL...)
- Respect of the soft start and the allowed power.
- Application of procedure in case of observation of marine mammals with respect to the safety zoning

In 2008, a major event occurred on the side of Antsohihy in the Northwest. A mass stranding of Electra's dolphins was observed. This event was attributed to offshore oil exploration by EXXON MOBIL. However, an independent expertise from an international institution called the ISRP made it possible to establish some recommendations and the following resolutions:

- The impact of subsequent use of MBES around the world and the behavior of these dolphins do not make it possible to assert the cause of the stranding.
- The report is not formal regarding the cause of dolphin stranding and the responsibility of EXXON MOBIL.

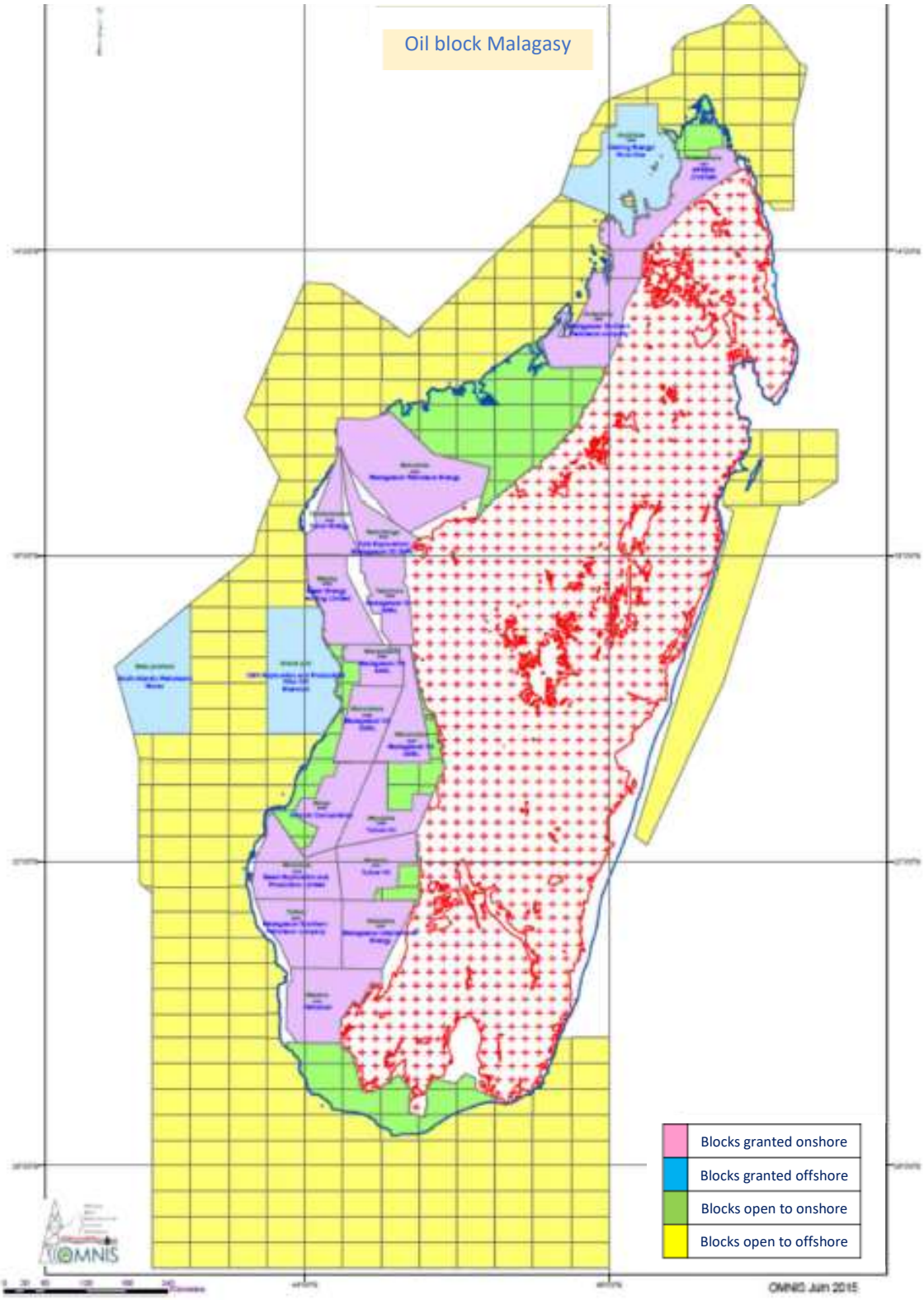
The use of MBES cannot be completely abandoned given the advantages it procures for seabed mapping compared to its disadvantages which are not proven.

Source: Exxon Mobil Closure Audit Assessment Report, ONE 2014

In addition, the Malagasy State, through the Malagasy Office for Mines and Strategic Industries or OMNIS, manages the onshore and offshore oil blocks. In general, the sedimentary basins which are geological formations favorable to the formation of oil reservoirs are located in the middle west and the Mozambique Channel, hence the concentration of oil blocks in this western part of the big island.

Map 31: Oil block distribution

ON-shore and off-shore oil block distribution granted and still to be granted in Madagascar



4.6.3. Coal

Madagascar Consolidated Mining company has conducted a research in the Sakoa reserve, estimating it at 65 millions tons. Pan African Mining and Lemurs companies are also carrying out significant exploration work there. (Monograph of the Malagasy mining sector, Chamber of Mines)

Table 44: Extractive industry's contribution to the current GDP (as a percentage of GDP)

	2014	2015	2016	2017	2018
GDP % from extractive industry	2,6	3,0	2,8	3,0	3,0

Source: MEF

Table 45: Growth rate (annual variation in %)

	2014	2015	2016	2017	2018
Extractive industry growth rate	25,9	19,5	-1,6	9,8	5,4

Source: MEF

4.7. Agriculture

Madagascar is a country where economic activities are based on agriculture and livestock. For several years, Madagascar has considered agriculture as one of the country's most important activities. The funding allocated by successive governments to this sector has evidenced this.

Economically, the three sectors namely agriculture, livestock and fishing account for about a quarter of the national economy. In 2018, the agricultural sector generated 11.4% of the GDP at acquisition prices (national accounts, base 2007) and occupied approximately 75% of the employment in Madagascar. Thus, the sector seems to be performing well in terms of creating added value and employment. However, in terms of employment productivity (GDP/employment), the sector is obviously lagging behind other sectors of the economy which create around 75% of GDP and occupy 25% of national employment. This means that the agricultural activities do not feed agricultural employment very much. The effect of this weakness of the agricultural sector is obviously poverty in general and that of the agricultural population in particular.

Table 46: Agricultural sector's contribution to the current GDP (in GDP percentage)

	2014	2015	2016	2017	2018
Agricultural sector's contribution to the GDP	13,8	13,1	12,7	11,4	11,4

Source: MEF

Table 47: Growth rate (annual variation in %)

	2014	2015	2016	2017	2018
Growth rate in agricultural sector	4,5	-2,4	1,4	-6,6	4,5

Source: MEF

4.7.1. Labor force in the agriculture sector

The deterioration of living conditions, especially those related to agriculture, encourages the exploitation of natural resources. Coastal areas are among the most popular migration areas. Migrants prefer to settle close to mangroves (case of Morombe, Marovoay, Mahajanga II) which are used for basic facilities (construction of huts, firewood) and provide livelihoods.

Migration, particularly from the hinterland to the coastal area, results from the decline in fertility and/or availability of agricultural land, the deterioration of the communities' purchasing power in general and the unemployment rate in the large urban areas. Migrations is also encouraged by the free access to most marine resources and the development of major sectors such as tourism, fishing and mining.

4.7.2. Export

Table 48: Volume of export in thousands of tons

	2014	2015	2016	2017	2018
Clove essence	2,0	1,1	1,5	1,8	2,0
Coffee	8,9	3,2	4,3	1,9	2,2
Vanilla	6,0	11,5	22,8	38,8	31,1
Cloves	12,6	20,0	18,4	27,2	30,1
Pepper	2,2	2,6	2,2	1,4	1,8

Source: MEF

4.7.3. Agricultural production in coastal areas

Madagascar can produce multiple product lines ranging from temperate-zone agricultural products (cereals: wheat, oats ; vegetable products: carrots, potatoes; fruit trees: peach trees, apple trees, pear trees) to tropical agricultural products (rice, bananas, mangoes, lychees…) There are also the industrial crops such as tobacco, cotton and sugar cane. Export crops (vanilla, coffee, cloves) account for more than a third of the export earnings. Despite a downward trend in volume, Madagascar still holds the world's top spot for vanilla. It ranks second in the world in terms of cloves export. Essential oils (including mainly ylang ylang, palma rosa and geranium) also have enormous potential (PNDR 2008)

Table 49: Evolution of coastal production from 2011 to 2015 – in tons

	2011	2012	2013	2014	2015
Lychees	190,994	198,729	198,469	199,129	ND
Coffee	37,630	38,849	42,806	47,386	46,309
Pepper	4,880	5,562	4,987	4,465	6,881
Cloves	25,000	25,990	19,724	20,697	21,864
Vanilla	3,760	3,529	3,104	3,139	2,922
Cocoa	9,081	9,640	10,234	10,865	11,535

Source: Agricultural Statistical Services

4.8. Forestry

Madagascar stands out for its status as a "sanctuary of nature": its 80% endemic biological diversity makes the Big Island a rich space of more than 9,700 plants and 770 vertebrates that are unique to it and most of which are found in forests. These forests which, during the mid-twentieth century, would have unfortunately been halved due to population growth and agricultural clearing, not to mention that until now, forests remain the main source of household energy.

4.8.1. Silviculture

Table 50: Silviculture's contribution to the current GDP (as a percentage of GDP)

	2014	2015	2016	2017	2018
Silviculture's contribution to the GDP	3.2	3.1	3.0	2.9	2.7

Source: MEF

Table 51: Growth rate (annual variation in %)

	2014	2015	2016	2017	2018
Silviculture growth rate	-1.0	1.0	1.0	1.0	-0.9

Source: MEF

4.8.1.1. Evolution of forest surface area by ecoregion (ha)

Madagascar has nearly 8.5 million ha of natural forests (ONE et al 2015). Overall, there are three main forest ecosystems: humid forests in the East, dry forests in the West and spiny forests in the South. In addition to these three major ecosystems, there are the coastal forest, the tapia forest, the mangroves and the plantation forests.

Table 52: Evolution of forest area by ecoregion (ha)

Forest 2005	Forest 2010	Forest 2013	Forest 2005
Humid	4,555,788	4,457,184	4,345,093
Dry	3,223,028	2,970,192	2,678,640
Spiny	1,681,527	1,558,533	1,466,765
Mangroves	173,564	171,220	169,877
TOTAL	**9,633,907**	**9,157,129**	**8,660,375**

Source: Office National pour l'Environnement - 2015

- The Eastern and Sambirano humid forest covers a surface area of 47,737 km², 39% of which are in protected areas. The surface area of degraded humid forest is 58,058 km², 2.45% of which are in protected areas.
- The Western sub-humid forest covers a surface area of 4,010 km², 6.88% of which are included in the Protected Areas networks.
- The Western humid forest covers 72 km².
- The Tapia forest covers a surface area of 1,319 km², 20.60% of which are protected.
- The Western dry forest covers a surface area of 31,970 km², 17.12% of which are included in protected areas.

Table 53: Evolution of standing timber stock in coastal areas (m^3)

2000	2005	2010	2015
2,749,633,965	2,719,405,702	2,625,099,739	2,420,253,671

Map 32: Wood volume per ha in coastal zones (m^3/ha)

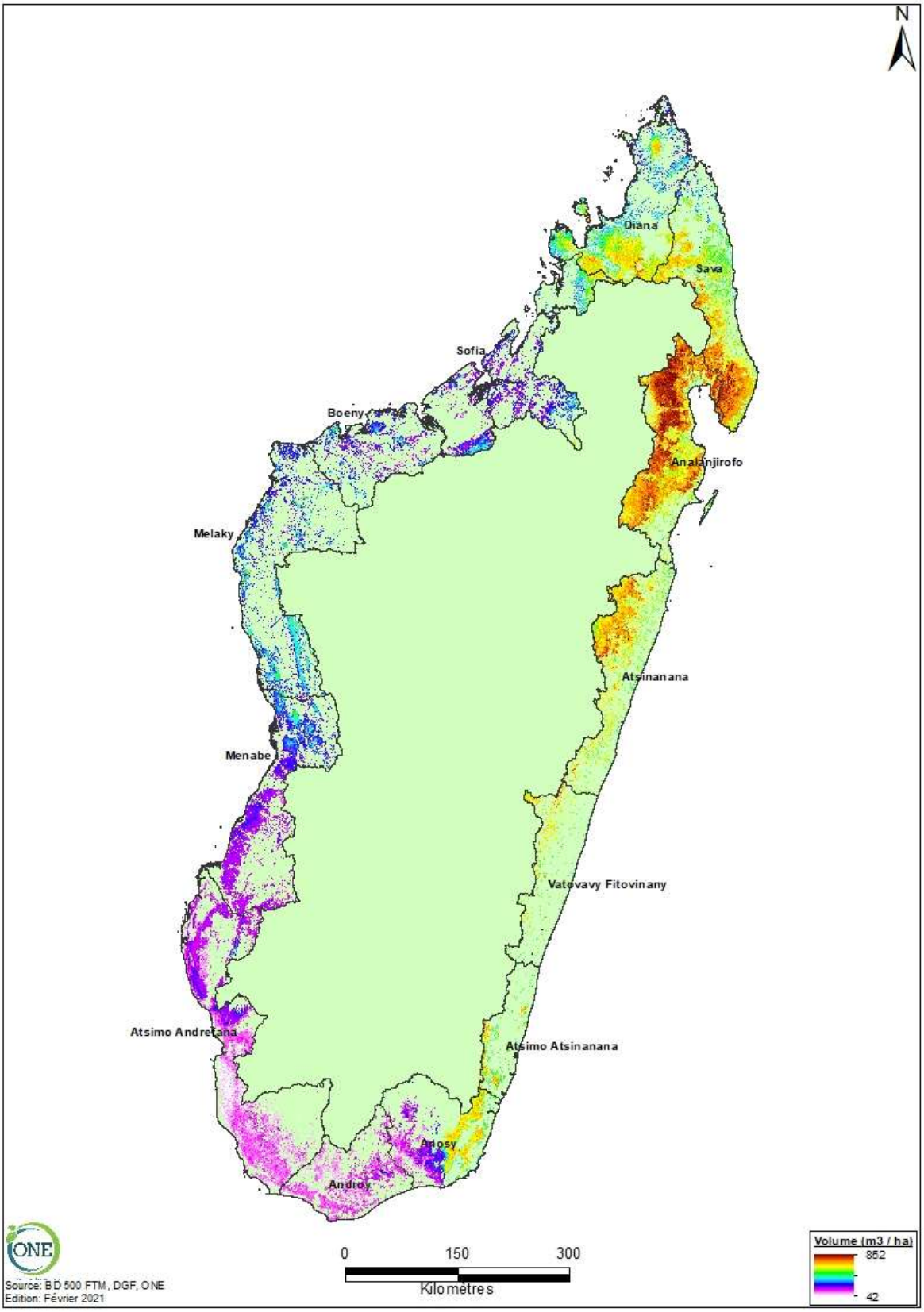


Table 54: Evolution of forest cover in coastal areas

2000	2005	2010	2015
7,048,592	6,882,459	6,495,936	5,653,144

Source: ONE 2020

4.8.1.2. Situation of forest products exports

In 2017, the export of floristic forest products for 2017 concerns the main and ancillary CITES and non-CITES products. The export of forest products in 2017 increased significantly by 41.5% compared to the previous year thanks to ancillary products. Since 2016, the export of ancillary products has grown considerably, a sharp increase of 276.44% in 2017. It is worth noting that it has previously contributed the least to exports. The earnings generated by the export of essential oils and medicinal plants have, at the same time, increased by 48.3%.

4.8.1.3. Summary of the evolution of forest products exports earnings (TFP, NTFP CITES and non CITES) in Ariary (RAEM, REF 2017)

Pour Concerning the export of wood products, an increase of 26.3% was noted in pine wood export earnings. As for other woods, a tiny increase of 1.02% was recorded. The value of export for finished products which include furniture, furnishings, handicrafts products/articles, boat models and musical instruments has decreased by 7.19% during 2017.

Table 55: Pressure on forest resources

Ecoregion	2005-2010	2010-2013
Humid	0,5	0,94
Dry	1,8	2,29
Spiny	1,69	1,66
Mangroves	0,32	0,2
TOTAL	**4,31**	**5,09**

Source: ONE, 2015

One of the main pressures on Madagascar's forest resources is the illegal logging of rosewood and ebony. Inventories of seized timber from overseas were carried out.

The seizures of rosewood and ebony were conducted outside Madagascar. These stocks are illegal under Malagasy law as they were smuggled out of the country during the periods when exports were prohibited. Nevertheless, the government will refer to the United Nations Convention against Transnational Organized Crime, known as the "Palermo Convention" (adopted by the UN on November 15, 2000 and ratified by Madagascar by Decree No. 2005-021 of January 05, 2005). Agreement with each signatory country on how to proceed with these products.

In the Comoros, 15 containers transporting around 300 T of wood were seized on June 19, 2011. These products have already been repatriated to Madagascar and are currently accounted for with those seized in Madagascar.

In Mauritius, 6 containers transporting around 120 T of rosewood were seized on June 22, 2011.

In Zanzibar, conducted under Operation Cobra II, 781 logs of rosewood weighing 110 tons were seized in February 2014.

In Singapore, 30,650 logs of rosewood weighing 3,372 tons were seized in the Port of Singapore on March 17, 2014.

In Sri Lanka, 28 containers of Malagasy rosewood were seized on April 2, 2014. They contained 3,669 logs weighing 420 tons; the containers came from Zanzibar and were intended to be shipped to Hong Kong via Sri Lanka.

In Kenya, 35 containers carrying 4,400 rosewood logs weighing 640 tons were seized on May 26, 2014 at the port of Mombasa.

In Hong Kong, 7,015 rosewood logs estimated to weigh over 1,000 tons were seized in the port on October 8, 2015.

Source: CITES – 2016

4.8.2. Charcoal

Wood energy is the single most accessible source of domestic energy in Madagascar. It occupies more than 95% of the national energy supply. According to the 2017 Energy Balance, 97% of Malagasy households depend on fuelwood for cooking. The majority of Malagasy charcoal makers still use traditional grindstones with low energy efficiency (estimated between 10 and 12%).

Table 56: Estimate of the potential for fuelwood production in Madagascar in 2015

	Fuelwood potential (m3)	Rotation (ans)	Usable volume (m3/an)
Humid dense forest	14,297,144	20	357,429
Dry dense forest	18,336,039	20	458,401
Thickets	2,765,051	15	92,168
Formation with woody elements	144,164,669	10	7,208,233
Sub-total	**179,562,903**		**81,116,231**
Energy-based reforestation	7,369,453	7	1,052,779
Total	**186,932,356**		**9,169,010**

Source: MEEFM and Applied Research Laboratory 2015

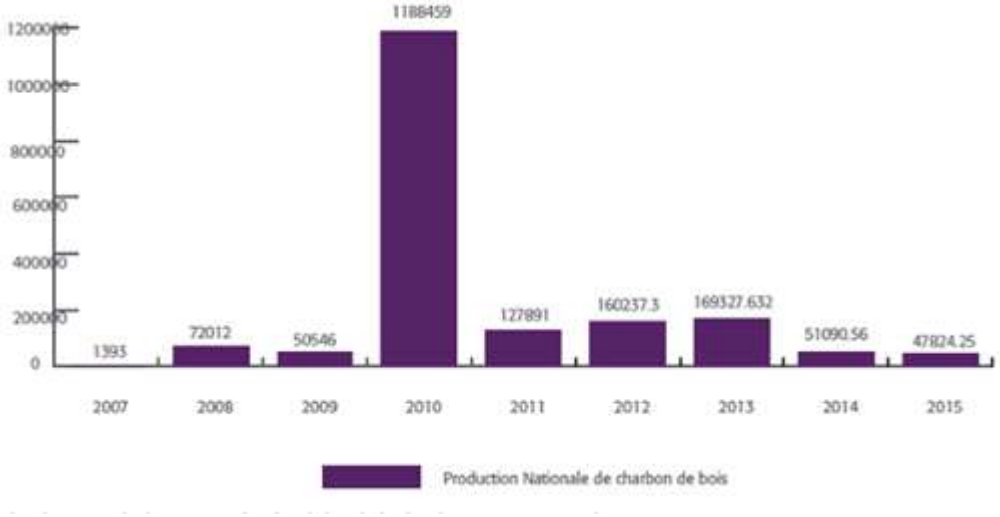
The current capacity for sustainable production is therefore largely exceeded and the rest is covered by unsustainable use of resources. Sample testing by administrative region already reveals deficit situations throughout Madagascar.

Figure 42: Production of firewood from 2007 to 2015 (volume (cubic meters))



Source: Directorate General of Forests, Directorate of Forest Resources Development

Figure 43: National charcoal production between 2007 and 2015 (volume (cubic meters))



Source: Directorate General of Forests, Directorate of Forest Resources Development

Free access to marine resources makes coastal areas, especially those around mangroves, a privileged migration zone. Indeed, this ecosystem provides the materials needed for human settlement and firewood.

4.8.3. Mangrove cover in Madagascar

Mangroves cover an area of 300,000 ha, 98% of which are located along the west coast, mainly on the bays, while those on the east coast are small and are mainly located in the North East, between Mananara North and Antsiranana.

Table 57: Total surface area of mangroves

Regions	Geography		Surface area of mangrove (ha)
	Districts	Communes	
DIANA	Antsiranana I-II, Ambilobe, Ambanja et Nosy Be	15	81,724
Sofia	Antsohihy, Analalava	07	76,932
Boeny	Mahajanga I-II, Soalala, Mitsinjo	09	103,222
Menabe	Belo sur Tsiribihina, Manja et Morondava	06	66,638
Melaky	Maintirano, Antsalova, Besalampy	10	54,332
Atsimo Andrefana	Toliary I- II, Morombe	15	10,505

Source: 2019 MEDD mangrove inventory report

4.8.3.1. Exploitation of mangroves

Madagascar has experienced an overall net loss of mangroves. The rate of mangrove loss decreased from 2000 to 2015 but the trend reversed between 2015 and 2018, with a significantly higher loss of mangroves. The development of aquaculture, salt works, agriculture or human settlement are mainly the reasons for converting some part of mangrove areas.

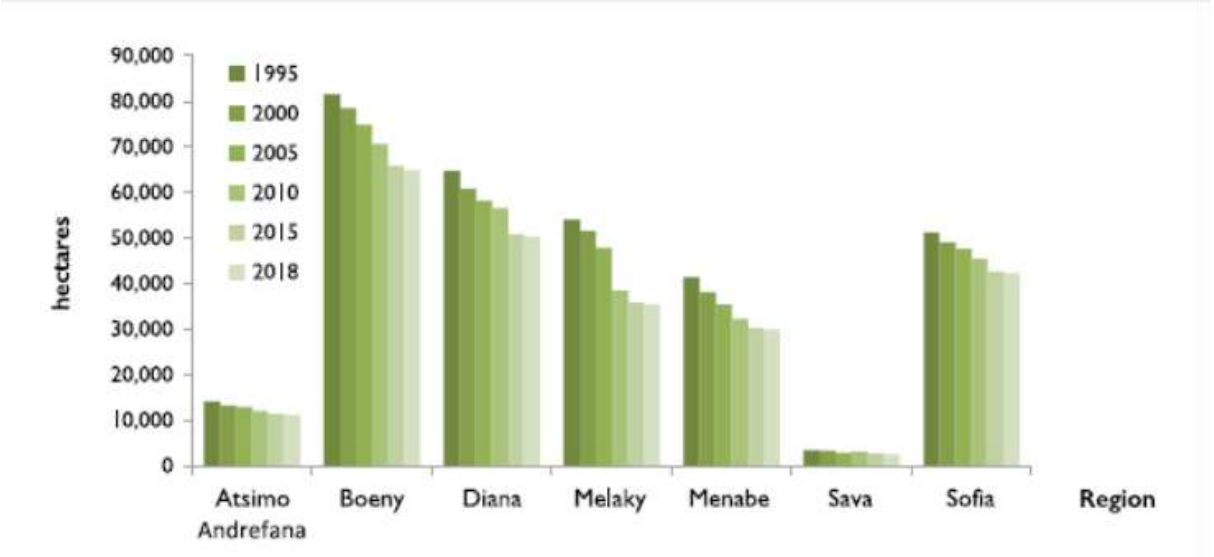
Converting mangrove soil to agriculture can only happen when it is completely desalinated. The process results from the accumulation of sediment from the upstream, putting the affected area out of reach of the tides. It is then cleared for agricultural purposes. The exposed parts to *Avicennia marina* can be used as pasture with the herbaceous tanne to *Sporobulus virginicus* in dry season.

Loss of employment due to political crises in large cities increases pressure on natural resources. Free access to marine resources makes coastal areas especially those around mangroves a privileged migration area. Indeed, this ecosystem provides the materials needed for human settlement and firewood.

The exploitation of mangroves for the production of fuelwood is an important factor of deforestation in the West coastal areas.

The water regime variation also has direct effects on mangroves, phanerogam meadows and other plant populations through the downstream transport of sediment. Some areas of the mangrove forest can only be flooded by high spring tides and the surface soil therefore becomes dry. This prevents the mangrove from regenerating, as is the case with Antsoherimasiba Antrema. Taken together, these impacts have become a major concern.

Figure 44: Exploitation of mangroves



Mangroves are concentrated on the west coast, they are exposed to continuous threats ranging from conversion to rice fields, selective cutting of firewood and construction wood, to sedimentation which is due to upstream deforestation.

Mahajanga district has the largest degraded area, which is estimated at 40% of all the mangroves in the district. With the area which is identified as potentially degraded, the province of Mahajanga in the north-west has the largest range of mangroves but also the most degraded area.

Backfilling tannes and even mangrove areas in order to build houses has become more and more common around large coastal towns. This is true of the mangroves of Nosy-Be, Mahajanga, Toliara and Morondava.

Table 58: Mangrove production potential

Density (stem/ha)					Basal area (m^2) ; Dhp > 5 cm	Volume per ha (m^3) ; Dhp > 5 cm	
Region	*< 2 cm*	*2 – 2,5 cm*	*2,5 – 5 cm*	*Dhp > 5 cm*		*Total*	*Fût*
Atsimo-Andrefana	40	53	159	383	2,80	7,86	6,58
Boeny	123	153	809	309	3,18	10,19	8,70
DIANA	856	214	407	373	2,15	7,64	5,78
Melaky	50	66	517	448	3,71	11,58	9,28
Menabe	202	134	364	469	2,72	8,87	8,06
Sofia	155	195	840	339	2,30	8,21	8,00

Source: 2019 MEDD mangrove inventory report

4.8.3.2. Reforestation

In 2017, the restoration and reforestation of 495 ha of mangrove includes:

- 75 ha in the Menabe region
- 10 ha in the SAVA region
- 45 ha in the Boeny region
- 45 ha in the Atsimo Andrefana region
- 230 ha in the DIANA region
- 90 ha in the Melaky region

In total, 18.2% of the mangroves in Madagascar are currently protected. Most protected areas suffer a net loss of mangroves, with the exception of the Analamerana Special Reserve, which shows a net gain. Menabe Antimena experienced the most overall loss.

Figure 45: Mangrove reforestation



Souce: MRHP

In 2019, 961 ha of mangrove were reforested for the benefit of 8,007 local communities, fishermen, collectors, fishermen's associations, villages in the Atsimo Andrefana, SAVA, Boeny, DIANA regions, Atsinanana, Melaky, SOFIA and Menabe (funded by: RPI, NGO FANAMBY, GIZC, WWF)

4.9. Energy and marine renewable energy

The marine renewable energy sector is not yet developed in the country while the potential offered by Madagascar's maritime environment is considerable such as the waves in the East Coast, the strong wind from the trade wind coming from the South East or, the monsoon from the West. The South – South –West region has enormous potential in terms of number of sunny days which is favorable to the installation of photovoltaic solar energies.

In terms of fossil energy, significant evidence of the presence of natural gas is found in the Mahaboboka oil block in the southwestern part of Madagascar. This field is under exploration but could be a huge potential for blue energy which could substitute the excessive use of charcoal.

Currently, with a view to reducing its GHG emissions, the QMM project in the Anosy Region plans to set up a photovoltaic plant with an (annual) capacity of 52 Kt, with 18,000 solar panels of 8,424 kw, and wind power of 10,000 kw in the Ehoala Park Concession which is an industrial zone located around Port Ehoala.

For non-renewable energy (Anne Georgelin, 2016) the electricity supply is provided by JIRAMA (JIro sy RAno Malagasy) company which was created in 1975. It operates 115 sites and provides electricity generation. In 2014, the electricity generation was 1,487 GWh; 1,049 GWh of which were provided by JIRAMA whereas 438 GWh were provided by small private operators.

In rural areas, it is ADER (Rural Electrification Development Agency) which is in charge of providing electricity through some thirty private operators.

Regarding energy transportation infrastructure: there are three interconnected networks (Antananarivo-Antsirabe), Fianarantsoa and Toamasina.

Oil products:

The country imports all seven types of petroleum products (gasoline, gas, diesel, lamp oil, aviation gasoline, fuel jet and fuel oil.) The importation is dominated by diesel. The demand for petroleum products is expected to grow by 0.5% on average in 2020.

The former Tamatave oil refinery is no longer functional. However, a private company (GALANA) manages an oil terminal in Toamasina in the Eastern Region.

Table 59: Share of the energy sector in GDP

	2014	2015	2016	2017	2018
Contribution of the energy sector to the GDP	1,1	1,2	1,2	1,2	1,3

Source: MEF

Table 60: Growth rate (annual variation in %)

	2014	2015	2016	2017	2018
Growth rate of the energy sector	4,2	4,1	8,3	6,6	8,4

Source: MEF

4.10. Protected areas

Classified as one of the 05 World Mega Biodiversity, Madagascar through the 2003 Durban Vision, has committed itself to triple the surface area of its terrestrial protected areas to achieve the goal of 6 million Ha. In 2015, this goal was reached, bringing the New Protected Areas created under the Protected Areas System of Madagascar to 129.

The creation of PAs meets the objectives of preserving Madagascar's biodiversity and also the development of local communities living around these protected areas.

In 2014, the State of Madagascar also pledged to triple the number of Marine Protected Areas at the World Parks Congress in Sydney.

These commitments demonstrate the richness of the big island's biological diversity but also the high level of anthropogenic threat and the irrational exploitation of natural resources which require an appropriate response to ensure the preservation of this unique biodiversity.

Locally Managed Marine Areas (LMMAs) are defined by the MIHARI network as a primarily marine and/or coastal area that is managed locally by coastal communities, landowners and/or local government officials who reside or are based in the area in question". The first LMMA was created in Madagascar in 2003. It was built upon the establishment of fishing reserves and closures. The network would now have more than 100 community associations managing more than 12,000 km² with nearly 150,000 beneficiaries. (Tany Meva, 2018: http://www.tanymeva.org/cepf/zones-dintervention -mad-io/gestion-locale-des-ressources-marines-reseau-madagascar/)

Table 61: Situation of marine protected areas in Madagascar, 2022

	Name of the Site	Region	District	Surface area	Category	Status	Management type	Marine or land PAs	Promoter
1	Nosive Androka	Atsimo Andrefana	Toliary, Ampanihy Ouest	91,445	NP	II	Collaborative co-management	Land with marine part	MNP
2	Kirindy Mitea	Menabe	Morondava, Manja	156,350	NP	II	Collaborative co-management	Land with marine part	MNP
3	Nosy Tanikely	DIANA		180	NP	II	Collaborative co-management	Land with marine part	MNP
4	Nosy Hara	DIANA		125,471	NP	II	Collaborative co-management	Land with marine part	MNP
5	Sahamalaza Iles Radama	Sofia		26,035	NP	II	Collaborative co-management	Land with marine part	MNP
6	Lokobe	DIANA		862	NP	II	Collaborative co-management	Land with marine part	MNP
7	Nosy Mangabe	Analanjirofo	Maroantsetra	729	NP	II	Collaborative co-management	Land et marine	MNP
8	Reserve speciale Pointe à larrée	Analanjirofo	Soanerana Ivongo	770	RS	IV	Collaborative co-management	Land with marine part	MBG

	Name of the Site	Region	District	Surface area	Category	Status	Management type	Marine or land PAs	Promoter
9	Complexe Tsimembo Manambolomaty	Melaky	Antsalova	62,745	PHP	V	Collaborative co-management	Land with marine part	TPF
10	Complexe Zones Humides Mahavavy Kinkony	Boeny	Mitsinjo	302,000	PHP	V	Collaborative co-management	Land with marine part	ASITY
11	Velondriake	Atsimo Andrefana	Morombe	63,985	PHP	V	Collaborative co-management	Land with marine part	BLUEVENTURE
12	Loky Manambato	SAVA	Vohemar	250,000	PHP	V	Collaborative co-management	Land et marine	FANAMBY
13	Menabe Antimena	Menabe	Morondava, Belo /Tsiribihina	210,312	PHP	V	Co-management shared type	Land with marine part	FANAMBY
14	Ambatoatsinana	Anosy	Tolagnaro	1,365	PHP	V	Collaborative co-management	Land with marine part	QMM
15	Andreba	Analanjirofo	Mananara Avaratra	39	PHP	V	Collaborative co-management	Land with marine part	WCS
16	Ankarea	DIANA	Ambilobe	135,556	PHP	V	Collaborative co-management	Land with marine part	WCS
17	Ankivonjy	DIANA	Ambanja	139,410	PHP	V	Collaborative co-management	Land with marine part	WCS
18	Nosy Antsoha	DIANA	Ambanja	28	PHP	V	Collaborative co-management	Coastal and marine	Lemuria land
19	Site Bioculturel d'Antrema	Boeny	Mitsinjo	20,620	RNR	VI	Collaborative co-management	Land with marine part	MUSEUM
20	Soariake	Atsimo Anrefana	Toliary II	38,293	RNR	VI	Joint management	Marine	WCS
21	Ambodivahibe	DIANA	Antsirananana II	369,266	RNR	VI	Collaborative co-management	Marine	CI
22	Ranobe Bay	Atsimo Anrefana	Toliary II	42,404				Marine	Reef Doctor







5. *Chapter 5. Oceans policy and governance*

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Coastal development which does not take enough consideration of the environment can highly compromise the integrity of the marine and coastal ecosystems. Oceans and seas's ability to maintain their diversity and provide a wide range of services to human beings is weakened by the deteriorating condition of marine areas, the overall decline in diversity and productivity that threatens coastal communities. Overfishing, pollution and habitat destruction have led to the decline of marine and coastal ecosystems.

The emergence, in 1958, of a structured law of the sea contributed to significant developments at the international, regional and State levels, through the adoption of the four Conventions of Geneva on the Law of the Sea, and then in 1982, by the United Nations on the Law of the sea or the Montego Bay Convention. Then, the acceptance of Integrated Coastal Zone Management (ICZM) as a method of governance at the end of the 1970s had an impact on coastal law. Thus, the Rio Conference of 1992 highly innovated and consecrated, more particularly Agenda 21 (Chapter 17), the need for the protection of the oceans and seas along with the protection of coastal areas. Among the management objectives of this fragile environment is the commitment of the riparian States to achieve integrated management and sustainable development of the coastal zones and the marine environment under their jurisdiction.

Madagascar being an island surrounded, in the East, by the Indian Ocean, and in the West, by the Mozambique Channel, the maritime dimension is an important element of the Malagasy culture and identity. In the current administrative division, only the province of Antananarivo does not have a coastline. Madagascar thus has diversified and abundant marine resources that are exploited and valued by different types of actors for conservation, local consumption and the domestic market as well as for export to Europe or Asian countries.

For the country, this wealth and the people who depend on it are threatened. The preservation and sustainable management of these fragile ecosystems have therefore become a primary objective for the country, which has made the commitment to triple the surface area of its marine protected areas and to achieve Sustainable Development Goal No. 14[33]: Priority has been placed on the reduction of marine pollution (target 14.1); the sustainable management of marine and coastal ecosystems (14.2) and the effective management of fisheries (14.4).

In the present update, the following institutions and organizations are involved in ocean governance and have actively collaborated in providing data for this chapter.5:

- Ministry in charge of the environment: Ministry of Environment and Sustainable Development, co-author
- Ministry responsible for decentralization: Ministry of Interior and Decentralization, co-author
- Ministry responsible for maritime transport: Ministry of Transport and Meteorology, co-author
- Ministry responsible for fisheries: Ministry of Fisheries and Blue Economy, co-author
- Ministry in charge of national defense: Ministry of National Defense
- Ministry in charge of land use planning: Ministry of Land Use Planning and Land Services
- Ministry in charge of strategic resources: Ministry of Mines and Strategic Resources
- Entity responsible for integrated coastal zone management: National Committee for Integrated Coastal Zone Management (CNGIZC), co-author

[33] SDG 14 – AQUATIC LIFE: "Conserve and sustainably use the oceans, seas and marine resources for sustainable development".

- Entity in charge of maritime and river transport: Agence Portuaire, Maritime et Fluviale (APMF), co-author
- Entity in charge of combating marine oil pollution: Body responsible for combating marine oil pollution events (OLEP)
- Entity responsible for managing Marine Protected Areas: Madagascar National Parks (MNP), co-author

5.1. Terrestrial administrative regions (coastal districts and communes)

Madagascar is the fourth largest island in the world and has the longest coastline in Africa with 4,828 km. In fact, Madagascar is an archipelago composed of the main island, which is called Tanibe by the local population and which is surrounded by about 200 small islands and islets. Madagascar is bathed by the Indian Ocean on its eastern side and by the Mozambique Channel on its western side. Fishing is the main activity in Madagascar's waters and the main fishing areas are located in the northeast, southeast and west off the coast. There is offshore oil and gas exploration in the Mozambique Channel, particularly off the coasts of Morondava and Maintirano, but there are offshore oil blocks all around Madagascar's coastline.

Madagascar was once composed of several kingdoms and unified into a single kingdom in 1789 by King Andrianampoinimerina[34]. In 1896, Madagascar was officially declared a French colony. By referendum in 1958, Madagascar was an "autonomous Republic within the French Community" and on June 26, 1960, Madagascar regained its independence.

From 1958 to 2010, the Malagasy constitution has undergone a number of modifications and amendments. The Constitution affirms the principle of territorial integrity without specifying that the territory extends to the territorial sea. Madagascar was formerly composed of six Provinces, five of which have coasts, but there were no legislative provisions affirming provincial jurisdiction over the territorial sea or even the exclusive economic zone. Madagascar has been since then divided administratively into 23 "Regions"[35], 14 of which are on the seafront, but here again there is no legislative or regulatory provision extending the jurisdiction of administrative territorial authorities to the sea.

5.1.1. The legal administrative subdivision

There is no specific legal text on coastal districts and communes. The existing texts on terrestrial administrative regions are related to the texts implementing the framework laws on decentralization and deconcentration[36]. In particular, Decree No. 2015- 592 of April 1, 2015 on the classification of

[34] Michel Prou, Malagasy: "One Step More" towards the History of Madagascar in the 19th century, Volume 1, L'Harmattan, 1987.

[35] Law n° 2021-012 amending appendix n° 01 of the amended Law n° 2014-020 of September 27, 2014, relating to the resources of the Decentralized Territorial Collectivities, to the methods of elections, as well as to the organization, the functioning and responsibilities of the bodies under their supervision (Creation of a 23rd Region)

[36] Organic law n° 2014-018 of September 12, 2014 governing the competences, the methods of organization and functioning of the Decentralized Territorial Collectivities, as well as those of the management of their own affairs.

Communes into Urban Communes or Rural Communes (amended by Decree No. 2015-817 of May 06, 2015) organizes Provinces, Regions and Communes:

- Total number of regions = 23, 14 of which are on the seafront
- Total number of rural communes = 1619
- Total number of urban communes = 76
- Total number of Fokontany = 18251

Decree No. 2015-593 of April 1, 2015 creating the Administrative Circumscriptions and organizing the Administrative Circumscriptions into 6 provinces, 24 prefectures, and 117 districts includes specific provisions about the island of Nosy-Be and Sainte Marie: The territorial limits of the Police Prefecture of Nosy Be coincide with the territorial jurisdiction of the former District of Nosy Be. The territorial limits of the Prefecture of Police of Sainte Marie coincide with the territorial jurisdiction of the former District of Sainte Marie.

The list of coastal Regions, Prefectures and Districts by Province that is provided by the Ministry of the Interior and Decentralization gives an overview of the importance of taking coastal Regions into account in Madagascar.

List of Regions, Prefectures and Districts with coastlines

Province of ANTSIRANANA

- DIANA Region (Antsiranana I Prefecture), Districts: Antsiranana II, Ambilobe, Nosy be, Ambanja
- SAVA Region: (Sambava Prefecture), Districts: Vohémar, Sambava, Antalaha

Province of FIANARANTSOA

- ATSIMO ATSINANANA Region: (Farafangana Prefecture), Districts: Farafangana, Vangaindrano
- FITOVINANY Region: (Manakara Prefecture), Districts: Manakara, Vohipeno, Ikongo
- VATOVAVY Region: (Mananjary Prefecture), Districts: Mananjary, Nosy Varika, Ifanadiana

Province of MAHAJANGA

- MELAKY Region: (Maintirano Prefecture), Districts: Besalampy, Maintirano, Antsalova
- SOFIA Region: (Antsohihiy Prefecture) Districts: Antsohihy, Analalava, Boriziny
- BOENY Region: (Mahajanga I Prefecture) Districts: Mahajanga, Mitsinjo, Soalala

Province of TOAMASINA

- ATSINANANA Region: (Toamasina I Prefecture), Districts: Toamasina, Brickaville, Vatomandry, Antanambao- Manampotsy

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- Amended Law No. 2014-020 of September 27, 2014 relating to the resources of Decentralized Territorial Collectivities, the methods of election as well as the organization, functioning and responsibilities of the bodies under their supervision.

- ANALANJIROFO Region: (Fénerive Est Prefecture), Districts: Maroantsetra, Mananara Nord, Soanierana Ivongo, Fenoarivo Atsinana,
- Sainte Marie Prefecture

Province of TOLIARY

- ANOSY Region: (Tolagnaro Prefecture), Districts: Tolagnaro, Amboasary
- ANDROY Region: (Ambovombe Prefecture), Districts: Beloha, Tsihombe, Ambovombe-Androy
- MENABE Region: (Morondava Prefecture), Districts: Belo sur Tsiribihina, Morondava, Manja
- ATSIMO ANDREFANA Region: (Toliary I Préfecture), Districts: Morombe, Toliary, Betioky-Atsimo, Ampanihy

5.1.2. Integrated approach to Integrated Coastal Zone Management

Sustainable management of marine ecosystems should not be separated from Integrated Coastal Zone Management (ICZM), which is of global ecological and socio-economic importance. Trends over the past two decades show increasing coastal pollution, accelerating destruction of coastal marine habitats, and declining catches of marine fish species due to overfishing and pollution in many areas.

Experiences with Integrated Coastal Zone Management (ICZM) from around the world have highlighted the issues and key attributes of ICZM, in particular the sustainable management of fisheries and the ecosystem approach it promotes, the conservation of biodiversity and the important role of marine protected areas, the fight against land-based pollution[37], the management of water resources and watersheds, and the management of risks related to natural disasters or climate change.

International provisions state that each coastal State should consider establishing or, where necessary, strengthening appropriate coordination mechanisms, such as a high-level planning body, for the integrated management and sustainable development of coastal and marine areas and their resources, at both the local and national levels. This would include consultations with local universities and the private sector, non-governmental organizations, local communities, users, and indigenous or local populations.

In the case of Madagascar, in particular, the National Committee for Integrated Coastal Zone Management (CNGIZC), created in 2010[38] and attached to the Prime Minister, ensured the harmonization of the interventions of various actors working in the management of marine and coastal zones. However, a government communication published during the Council of Ministers of December 15, 2021, approved the dissolution of this Committee because of budgetary constraints. Despite this high-level decision, the current situation remains rather unclear as steps have not yet been taken to revise the ICZM Decree of 2010 or to formalize the dissolution of the Committee by repealing the 2012 decree on the organization and operation of the CNGIZC. Consequently, the situation of the current CNGIZC is on hold pending the revision of the decree cited above. The regional ICZM committees are still functional.

[37] Land-based pollution of seas and oceans is pollution of terrestrial origin which is brought by rivers and pipes.

[38] Decree No. 2010-137 on March 23rd, 2010 regulating the National Committee for Integrated Coastal Zone Management (CNGIZC) of Madagascar.

Order No. 22473/2012 on August 21st, 2012 establishing the structure and the functioning of the CNGIZC.

At the same time, the new strategic orientations of government policy, from 2020, focused on the creation of the Ministry of the Environment and Sustainable Development, the Ministry of Fisheries and the Blue Economy, the Ministry of Mines and Strategic Resources. In this regard, the United Nations 2030 Agenda includes SDG 14 on the conservation and sustainable use of the oceans, seas and marine resources. In consideration of this objective, the blue economy concept allows for the consideration and development of policy programs that simultaneously improve ocean health and economic growth, in a manner that is consistent with the principles of social equity and inclusion. "

The sectoral visions, embodied by the coordination of Maritime Spatial Planning (PSM) at the level of the Ministry responsible for Regional Planning, by the sustainable management of Marine Protected Areas at the level of the Ministry responsible for the Environment, by the adoption of the new concept of the Blue Economy at the level of the Ministry in charge of Fisheries, have raised the need for much more operational structures and tangible results for better protection of maritime areas and marine ecosystems.

A logic of intersectoral management of the maritime space is essential on the basis of the Maritime Spatial planning (PSM) that is being developed by the Ministry in charge of Spatial Planning, and which must constitute the basic tool for a protection of the blue economy. This management is based, in principle, on taking into account the sectoral attachment of ecosystems. By way of illustration, the management and conservation of marine biodiversity within Marine Protected Areas is the responsibility of the Ministry in charge of the Environment while the development of marine ecosystems (or fishery resources) is the responsibility of the Ministry in charge of Fisheries. With regard to the management of mangroves, an interministerial commitment between the Ministry in charge of the Environment and the Ministry in charge of Fisheries, intervened for a common management of this ecosystem, which is supported by USAID Hay Tao.

5.2. Administrative/legislative marine areas

The integration of environmental law into the Law of the Sea has strengthened the protection of the marine environment in all areas related to the sea and in particular, in coastal areas. At the institutional level, there are several international organizations and entities dedicated to the protection and preservation of the marine environment within the United Nations system. We can cite the International Maritime Organization (IMO) which has within it a Committee for the Protection of the Marine Environment (MEPC); the Intergovernmental Oceanographic Commission within UNESCO ; the Food and Agriculture Organization of the United Nations (FAO), the International Hydrographic Organization (IHO), the United Nations Environment Program (UNEP) with the Regional Seas programme.

The new Law of the Sea aims to generally preserve the marine environment and determines the obligations of coastal States with regard to the protection of the entire marine environment without spatial restrictions of any kind, i.e. including the territorial sea and inland waters.

As a result, pollution of the seas is now regulated at the regional or international level not only for pollution from the sea and ships but also for land-based pollution from the land, and confirms the territorial integration of the preservation of the marine environment, which brings together national coastal areas and even national watersheds with maritime areas.

5.2.1. Islands

Madagascar has a number of smaller islands, islets and smaller rock. Only a few of these small islands and islets are inhabited, Nosy-Be and Sainte-Marie being the largest of them. Nosy Be is located about 10 km off the north-northwest coast of the main island, about 321 km² wide, and has about 120,000 inhabitants. It is the first tourist destination of Madagascar. Sainte-Marie Island or Nosy Boraha is located about 30 km off the East-North-East coast of the island of Madagascar, about 222 km² in area,

and has about 30,000 inhabitants. It is also a very popular tourist destination, mainly for humpback whale watching.

Madagascar claims soverignty over four other islands in the Mozambique Channel: the archipelago of Nosy Sambatra or Gloria Islands, Nosy Nandalova or Juan de Nova, Be Dimaky or Bassas da India and Nosy Ampela or Europa. The Archipelago of Nosy Sambatra or Glorious Islands is located about 108 nautical miles from Cap d'Ambre, the northernmost point of Madagascar. The largest island of the archipelago is about 3 km long, the highest point is 14 m above sea level and the total surface area does not exceed 7 square km. Nosy Nandalova Island or Juan de Nova Island is located about 200 km off Cape St. Andrew, the westernmost point of Madagascar. The anvil-shaped island measures about 6 km at its longest point, 1.7 km at its widest and about 500 ha in area. Be Dimaky or Bassas da India is located about 189 nautical miles off the west coast of Madagascar. It is a 12 km wide atoll that is almost entirely submerged at high tide. Nosy Ampela or Europa is located about 162 nautical miles from the west coast of Madagascar, measures about 6 km from north to south and about 7 km from east to west, which makes with 30 km square the largest of these islands. The government of Madagascar affirmed in 1979 that, given their proximity to Madagascar, these islands had been visited periodically by traditional Malagasy fishermen for centuries. The United Nations General Assembly declared in 1979 and 1980 that these islands had been arbitrarily separated from Madagascar by France at the end of colonization.

5.2.2. Baselines

Decree No. 2018-1008[39] on August 14, 2018 states that Madagascar's baselines are composed of 2 types: normal baselines and straight baselines. Straight baselines are drawn in the Northeast, Northwest, West and Southwest, whereas normal baselines are drawn in the East, Southeast and West.

5.2.3. Maritime zones

Law No. 2018-025 of December 26, 2018 on maritime zones of the maritime space under the jurisdiction of the Republic of Madagascar (Maritime Zones Law) declares that the maritime zones of Madagascar are composed of inland waters, the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf. The inland waters are composed of "the waters located off the baselines". The law on public domain declares that the seashore up to the highest tide mark, salt ponds in direct communication with the sea and lagoons are part of the "natural public property" and are therefore inalienable, unseizable and imprescriptible.

Madagascar claims a territorial sea of 12 nautical miles, which is also declared a natural public domain. The right of unoffensive passage of foreign vessels is confirmed by Law No. 99-028 on the Maritime Code of Madagascar, but is not included in the Law on Maritime Zones.

Madagascar claims a contiguous zone of 24 nautical miles within which it "may prevent or prosecute all violations of its laws on public safety and sanitation, immigration, taxation and customs.

Madagascar claims an EEZ of 200 nautical miles, within which the Malagasy State exercises sovereign rights and jurisdiction in accordance with Article 56(1) of UNCLOS.

[39] Decree No. 2018-1008 of August 14, 2018 that sets the base lines from which the width of the different maritime areas under the national jurisdiction of Madagascar is measured.

Madagascar claims a continental shelf as defined in Article 76 of UNCLOS in which the Malagasy State has sovereign rights over the exploration and exploitation of mineral and other non-living resources. The law also provides that Madagascar may fix the limits of its continental shelf beyond 200 nautical miles from the baselines under the conditions provided for in UNCLOS.

In 2011, Madagascar submitted a request to the Commission on the Limits of the Continental Shelf (CLCS). It is currently awaiting seismic and hydrographic data for processing. The seismic data, once collected, will have to be submitted to a sub-commission, within the CLCS, which will deal in detail with the various points included in Madagascar's submission for the extension of its continental shelf beyond 200 nautical miles. The extended area of the continental shelf should be larger than the land territory.

5.2.4. Maritime borders

Being at some distance from any other country, Madagascar does not have any common territorial sea borders with any other country. However, this geographical situation means that Madagascar has common EEZ borders with several states. With regard to the island of Reunion, Madagascar and France have concluded an agreement on the delimitation of the EEZ and the continental shelf for the southeast of Madagascar.

To date, this is the only maritime delimitation agreement concluded by the Malagasy government. For the eastern and northeastern part of Madagascar, Madagascar has a common EEZ and continental shelf boundary with the island of Tromelin. Sovereignty over Tromelin is currently disputed between France and Mauritius. Between Madagascar and France, the sovereignty issue concerns Nosy Sambatra or Glorieuses, Nosy Nandalova or Juan de Nova, Bemadiky or Bassas da India and Nosy Ampela or Europa. Meanwhile, while France actually administers Tromelin, France has unilaterally drawn a 200-nautical-mile EEZ and continental shelf around it and has also unilaterally set an equidistance limit between the EEZ and the continental shelf of Madagascar and Tromelin. Madagascar has so far not protested this unilateral decision. An agreement on the delimitation can only be reached when the sovereignty dispute is resolved. For its northern part, Madagascar has a common EEZ and continental shelf boundary with the Seychelles, but the delimitation is still pending, probably due to the status of the Nosy Sambatra or Glorieuses archipelago. As mentioned earlier, Nosy Sambatra or Glorieuses are claimed by Madagascar, but France has drawn a 200-nautical-mile EEZ and continental shelf and has used equidistance to limit the common EEZ boundaries with Madagascar, Seychelles and Comoros. One important thing to note is that France and Seychelles have concluded a delimitation agreement with respect to Nosy Sambatra or Glorieuses. Madagascar did not protest or oppose the agreement either after it was concluded or after it was submitted to the UN. In the Mozambique Channel, from north to south, Madagascar also has common EEZ and continental shelf boundaries with France, with regard to Mayotte, with the Comoros, with Mozambique and with Nosy Fandalova or Juan de Nova, Bemadiky or Bassas da India and Nosy Ampela or Europa. None of these boundaries have been formally delimited by agreement. The delimitation of the EEZ and the continental shelf boundary between Madagascar and the Comoros is somewhat blocked by the situation of Mayotte, which the Comoros consider to be under their sovereignty, but which Madagascar recognizes as that of France. The delimitation of the EEZ and the continental shelf boundary between Madagascar and Mozambique is also pending, due to the situation of Nosy Fandalova or Juan de Nova, Bemadiky or Bassas da India and Nosy Ampela or Europa.

5.3. Legislation

5.3.1. International provisions

The 1982 Montego Bay Convention[40] provides for the sovereign rights and jurisdiction of the coastal State, and the rights and freedoms of other States, in the exclusive economic zone and the continental shelf, to ensure the conservation, exploration and exploitation of natural resources, including fish stocks, highly migratory species and marine mammals. The coastal State and relevant international, sub-regional, regional or global organizations shall also cooperate as is appropriate for this purpose.

The provisions of Agenda 21 (Chapter 17) encourage coastal States to implement plans and programmes for integrated coastal and marine area management and sustainable development at appropriate levels, and to implement methods based on prevention, precaution and forecasting to avoid degradation of the marine environment, as well as to reduce the risk of long-term or irreversible adverse effects on that environment.

5.3.2. National provisions

In terms of legislation, the governance of the oceans in Madagascar is governed by several texts, the main[41] ones being: the Maritime Code, the Law on Maritime Zones, the Management Code for Protected Areas, the Fisheries and Aquaculture Code , the Petroleum Code, the Law implementing the International Conventions relating to the protection of the marine and coastal environment against pollution by oil spills, the Law establishing the general regulations of the Dina in terms of public security, the ICZM Decree of 2010, the MECIE Decree. Gaps will be presented in terms of ocean governance.

[40] - Law n ° 2000-020 of 11/28/2000 authorizing the ratification of the 1982 United Nations Convention on the Law of the Sea, UNCLOS, Montego Bay, 1982

- Decree n ° 2001-337 of 04/19/2001 ratifying the 1982 United Nations Convention on the Law of the Sea

[41] - Law n ° 99-028 of February 3, 2000 recasting the Maritime Code (2000 Maritime Code);

- Law n ° 2018-025 of December 26, 2018 relating to the maritime zones of the maritime space under the jurisdiction of the Republic of Madagascar;

- Law n ° 2015-005 of February 26, 2015 recasting the Protected Areas Management Code;

-Law No. 2015-053 of 03/02/2016 on the Fisheries and Aquaculture Code, amended by Law No. 2018-026 of November 21, 2018;

- Law n ° 2004-019 of July 6, 2004 implementing the International Conventions relating to the protection of the marine and coastal environment against pollution by oil spills;

– Law No. 2001-004 of October 25, 2001 on the general regulation of Dinas in terms of public security

-Decree n ° 2010-137 of March 23, 2010 regulating the integrated management of the coastal and marine areas of Madagascar;

- Order n ° 22473-2012 of August 21, 2012 setting the organization and functioning of the National Committee for Integrated Coastal Zone Management (CNGIZC);

-Decree No. 99-954 of December 15, 1999 amended by Decree No. 2004-167 of February 3, 2004 relating to the Compatibility of Investments with the Environment (MECIE)

a) The maritime code

The Maritime Code was adopted in 2000 and contained provisions on maritime zones. When it was adopted in 2019, the Law on Maritime Zones repealed part of the provisions of the Maritime Code related to maritime zones.

Gaps:

Some provisions which were repealed in the maritime code are not seen in the law on the maritime zones, such as the ones regarding the rights of the Malagasy State over its territorial sea about the conservation of the biological resources of the sea, the prevention of infringements of fishing regulations, and the protection of the marine environment, namely against pollution. It is also the same regarding the sovereign rights of the Malagasy State in its exclusive economic zone for the purposes of exploration and exploitation, conservation and management of natural resources, whether biological or non-living, of the waters overlying the seabed, of the seabed and its subsoil, as well as other activities aimed at the exploration and exploitation of the zone for economic purposes.

b) Extent of the continental shelf

Additional data to follow up on Madagascar's application for the extension of its continental shelf beyond 200 nautical miles from the baseline is not yet ready.

Gaps:

Lack of a national entity responsible for coordinating activities related to the extension of the continental shelf.

c) Law on the maritime zones

Organizationally speaking, in terms of maritime governance, the Law on Maritime Zones highlights the place of the "Ministerial Department in charge of the Sea" as the main actor or leader, particularly in terms of delimiting maritime zones around Madagascar.

Gaps:

There is no implementing regulatory text in the Law on Maritime Zones so as to identify the "ministerial department in charge of the Sea", the ministerial departments having attributions regarding the activities at sea are those in charge of: maritime transport, fishing and aquaculture, mines and strategic resources, scientific research, nautical tourism, energy and hydrocarbons, land use planning, the environment, etc ….

A national framework for the blue economy should be implemented: appoint a national entity responsible for coordinating sectoral policies and activities related to the blue economy. Decree No. 2017-936 of October 11, 2017 creating the national framework for the implementation of the Blue Economy in Madagascar has been adopted but has not been applied. Since 2021, the Ministry of Fisheries and Blue Economy has been created and it is responsible for coordinating activities related to the blue economy, however the relationship between this Ministry and the other ministries involved with the blue economy are not clearly defined by texts.

d) The new Protected Areas Management Code

The new law of 2015 recasting the Protected Areas Management Code points out the commitment made by Madagascar at the World Parks Congress held in Durban in September 2003, to increase the surface area of Protected Areas in Madagascar from 1.7 to 6 million ha. It established Madagascar's System of Protected Areas, including approved private Protected Areas, community Protected Areas, and **Marine Protected Areas**, which are recognized as having a prominent place in a country with a substantial marine territory.

Thus, in accordance with the Durban vision, the creation of locally managed marine areas or Locally Managed Marine Areas (LMMA) [42]in Madagascar has increased considerably since 2004.

Gaps:

(i) Absence of clear legal provisions on Marine Protected Areas. The legal framework reflected by the COAP is tailored for terrestrial protected areas both in terms of procedures establishments and management procedures for protected areas [43]:

- the definition of the MPA, the specific objectives for MPAs in accordance with the 2008 IUCN Guidelines on MPAs
- the absence of a scientific committee to ensure management based on rigorous scientific data (science-based management) and provide the various bodies of management structures with informed and independent scientific advice on issues relating to the creation, management and monitoring of PAs. (composed of national scientists and possibly international experts from the region or beyond).
- imprecision on the level of involvement of stakeholders in the surveillance, monitoring and application of PA regulations.
- the absence of offenses and penalties specific to MPAs in the COAP,
- the ambiguities of compensation measures in relation to the possibilities of carrying out extractive activities in category V and VI PAs,
- the uncertainties of competences related to sea for the CTDs
- The implementing decree focuses more on forest management and no clear consideration of the "marine" aspect
- Application of texts on offenses in MPAs confused between the Fisheries Code and the COAP: The penalties related to offenses in the Fisheries Code are less reprehensible compared to the penalties for offenses in the COAP, especially in PAs (crime). The fishing code does not consider the values of protected species. In addition to that, the vagueness in the role of finding marine offenses in Marine Protected Areas (MEDD or the Ministry responsible for fisheries at the regional level).

(ii) There is some confusion between the SAPM committee and the steering committee in charge of fulfilling the Sydney promise about the main directives or guidelines: regarding the definition of the main guidelines or the strategic focus in the creation of PAs (cf. Article 20, 1st indent of the interministry Order No. 52 004 / 2010 of December 20, 2010 on the creation of the SAPM commission: (…), the development of the technical or reglementary tools on the creation and the management of sites, (…), and article 2, 2nd indent of the Order No. 23960/2016 of November 09, 2016 setting the steering committee to implement the Sydney Promise: Act as a platform to guide, to coordinate, to cooperate, to validate, to monitor and evaluate the different phases of the process (design, planning,

[42] LMMA: Ecosystem approach consisting of locally managing resources in a defined marine and/or coastal area, to ensure the sustainable development of local communities as well as the maintenance or restoration of biodiversity.

43 Governance and management of the New Protected Areas of Madagascar – Example of the areas of intervention of the HaFaFi project, by Catherine GABRIE, Vonjy RASOLOARISON, Saholy RAMBININTSAOTRA – September 2015

creation, management, developing texts and tools, etc, …) to implement the Sydney Promise.

e) LMMA (Locally Managed Marine Areas)

The experience of local management of marine areas (LMMA) was adopted in Madagascar in the early 2000s and successfully contributes to the preservation of marine resources: temporary closures of fisheries, restoration of degraded mangroves, emergence of seaweed farming or sea cucumber aquaculture, etc. A specific feature in Madagascar is that all the approaches have in common the adoption of "Dina" or collective agreements which are rules for sustainable use applied for all local management in Madagascar.

The LMMA structure is often composed of a large management committee (the governance structure), a Dina Implementation Committee (KMD), and a village committee, with decision-making meetings within the villages[44].

The management committee often takes the form of a community association governed by Ordinance No. 60-133 of October 3, 1960 establishing the general regime for associations. The associations involved in fisheries management are made up of fishermen but also non-fishermen. In this respect, a fisherman can be granted a membership card provided he belongs to an officially authorized association in the region.

The need for better information sharing between community associations and other stakeholders including supporting organizations led to the establishment, in 2012, of a national LMMA network or MIHARI network. The objective of the network is to ensure the sustainable management of marine and coastal resources for the well-being of LMMA communities and their future generations, and for the interests of traditional Malagasy fishermen. Currently, the MIHARI network has 219 LMMAs spread over 12 regions of Madagascar.

At the same time, the Ministry in charge of the Environment and Sustainable Development, aware of the legal vacuum in the sustainable management of MPAs, is currently carrying out a diagnostic study of the gaps relating to the legal mechanism governing MPAs and LMMA structures in Madagascar.

LMMAs can be set up by « Dina »:

The LMMAs established by Dina or collective agreement form the fundamental approach of this mode of management. They allow the establishment of temporary or permanent reserves of fishery resources or mangroves, as well as the establishment of restrictions on fishing gear and prohibited practices in the area. Law No. 2001-004 provides for the approval of the Dina by the courts and the establishment of the Dina Implementation Committee or “Kaomity Mpanantanteraka ny Dina” (KMD).

LMMAs can be set up by transfer of management:

These LMMAs are set up:

- Either through the GELOSE [45]Law, which governs the transfer of natural resource management to local communities,

[44] MIHARI – Reference guide for Locally Managed Marine Areas (LMMA) in Madagascar.

[45] Law No. 96-025 on September 30, 1996 related to the local management of Renewable Natural Resources

- Either through Decree No. 2016-1352 and Ministerial Order No. 29211/2017 which implement the provisions on the sustainable management of fisheries resources provided for by the Fisheries Code[46].

LMMAs can be implemented through Marine Protected Areas (MPAs)

These LMMAs are more elaborate and benefit from the status of protected area of category V (Protected landscape/seascape) or VI (Protected area for the sustainable use of natural resources) of the IUCN classification, where the sustainable management of resources is compatible with the goal of conservation. The management of this type of LMMA can be joint with the promoters.

Gaps:[47]

For Dina:

- The application of Law No. 2001-004 is more suited to the fight against insecurity than to the management of natural resources;
- Homologation is not guaranteed and may take a long time;
- The application of the Dina by the Kaomity Mpanatanteraka ny Dina or Executive Committee of the Dina and the police is not rigorous enough in the case of sustainable management;
- If users are in the minority, it is more difficult to assert their interests.

For the transfer of management of natural resources or TGRN (GELOSE law No. 96-025):

- The procedure is long and costly because it may require several steps and consultations by experts
- Differences in procedures between the TGRN and the TGRH
- The contract must be renewed periodically, which requires repeating certain long and costly steps

For the transfer of fisheries resource management or TGRH: (Decree No. 2016-1352 on November 08, 2016 and inter-ministerial Order No. 29211-2017)

- Development and local planning depend on the existence of the Fisheries Development Plan of the region
- No differentiated status for the fishery resource management committee (we talk about grouping)

For the Marine Protected Area:

- The procedure is long and costly because it may require several steps and consultations by experts
- Inertia of local authorities in the case of infringements in MPAs

f) Natural Resource Management Transfer (TGRN)

The GELOSE[48] or Secure Local Management law provides for a form of management of renewable natural resources. It is about transferring to grassroots communities the management of some natural resources, falling within the domain of the State or local authorities, which are included in their territory in order to involve them effectively in their management.

Three categories of actors are involved in this new concept of development and conservation of natural resources:

[46] Law No. 2015-053 on February 03, 2016 on Fishing and Aquaculture Code

[47] Cf Guide on LMMAs in Madagascar, 2019

[48] Law No. 96-025 on September 30, 1996 on local management of renewable natural resources local management

- Local grassroots communities
- Commune officials (mayors and Commune councillors)
- And the technical services for the supervision of resources (deconcentrated services in charge of forests, pastoral or fishery resources).

Thus, the transfer of natural resource management (TGRN) from the State to local populations is carried out according to a tripartite contract between the local grassroots community (Coba), the Commune (territorial collectivity) and the technical service responsible either for forests, or pastoral or halieutic resources (technical supervision of resources). This contract is established for a period of three years, and it can be renewed. The TGRN also involves the establishment of a "Dina" within the community to facilitate resource management.

In management transfers under GELOSE, each stakeholder has a specific role, in particular the communities in charge of the implementation and monitoring of the area, the communes, and the decentralized technical services in charge of supporting these communities. These roles are shared in a book that specifies each part's responsibilities.

Gaps:

The analysis show that very little transfer of management is effective today in Madagascar. This situation is due to a lack of in-depth knowledge of the perceptions of the actors of their territory and the management of resources, of good understanding of the social organization of communities, local authorities, customary paths of decision-making, dialogue and consultation between villagers within a village and between villages, knowledge of traditional resource governance…. They are also due to the fact that the State and the deconcentrated services do not play their role in the natural resource management process.[49]

Lack of motivation of some VOI[50] (Vondron'Olona Ifotony or VOI) due to the fact that some managers of Protected Areas do not respect their commitments and do not fulfill the responsibilities set in co-management.

g) Fisheries Resource Management Transfer (TGRH) or MARINE GELOSE

(**Order No. 29211/2017 of November 28, 2017 that sets the terms and conditions for the transfer of management of fisheries resources and aquatic ecosystems**)

A fisheries management plan is used to implement the methods for transferring the management of fisheries resources and aquatic ecosystems to groups of fishermen. Therefore, fishing groups can place a request to the Ministry in charge of Fisheries and Aquaculture for the implementation of a Locally Managed Fishing Area (APGL) through fishing reserves or areas established by transfer of management.

Community regulations by way of "Dina" govern the methods of management of fishery resources and aquatic ecosystems by groups of fishermen. Their commitments on part or on all their APGL may consist of payment for ecosystem services (carbon sequestration), to the exercise of ecotourism

[49] Governance and management of the New Protected Areas of Madagascar – Example of the areas of intervention of the HaFaFi project, by Catherine GABRIE, Vonjy RASOLOARISON, Saholy RAMBININTSAOTRA – September 2015

[50] VOIs are the grassroot communities (COBA) who benefit from the transfer of the management of the natural resources.

activities, systematic reforestation of mangroves, restoration of banks, restocking of water bodies, community monitoring of the managed area.

The APGL can be managed by the group, or through collaboration with a non-governmental organization that received permission from the Ministry in charge of Fisheries and Aquaculture with the required technical capacities. The Ministry monitors and supervises the activities carried out by the fishermen's group. For its part, the NGO is required to facilitate the development of community management of fisheries resources by promoting methods and practices that guarantee good governance; to set up and implement a capacity building program for local communities that is related to the management of fisheries resources.

The LMMAs set up through Decree No. 2016-1352 and Ministerial Order No. 29211/2017 are based on a contract with the Ministry responsible for fisheries and aquaculture.

Gaps: [51]

- vagueness regarding the rights of local populations in the co-management of marine fisheries resources.
- resources should be legally upgraded given the fact that the local population is not limited to COBAs

h) The « Dina » or Collective Agreements

The implementation of the Dina in Madagascar is founded on law No. 2001-004 issued on October 25, 2001 on the general regulation of the Dina in terms of public security (eg theft of oxen). Traditionally, the Dina are typically Malagasy collective agreements, and constitute a set of customary rules for the organization of society (social norms or codes of conduct). As such, they represent the real will of the population that instituted them.

The Dina is adopted by the majority of the members of the Fokonolona[52], aged 18 and over, who attend the general assembly when it involves a hamlet, a village or a Fokontany. In all cases, the Dina only becomes enforceable after its approval by the territorially competent judicial court.

i) Mangrove management

The management of mangroves was once the subject of the forestry law and the fisheries law. After noting the contradiction between the legal provisions causing major difficulties on the field, the fishing code was amended in 2018 by excluding the mangrove aspects, both technical and repressive. Furthermore, upon consultation between the two ministries involved in the whole process (Ministry in charge of the Environment and Sustainable Development, and Ministry in charge of Fisheries and the Blue Economy), based on the interaction of systems in the management of renewable natural resources, a draft inter-ministerial order has been drawn up and signed by the two ministers. Unfortunately and so far, said order has not yet received a registration number.

[51] Governance and management of the New Protected Areas of Madagascar – Example of the areas of intervention of the HaFaFi project, by Catherine GABRIE, Vonjy RASOLOARISON, Saholy RAMBININTSAOTRA – September 2015

[52] Fokonolona are the inhabitants of a fokontany which is an administrative subdivision at the level of the Communes.

In parallel with these legal aspects, consultations on the development of strategies and action plans for the integrated management of mangroves were also initiated by the two ministries, resulting in the creation of a joint ad hoc committee to monitor priority actions which are defined in the two aforementioned documents. However, it should also be noted that the said Committee has not yet been set up.

j) The National Committee for Integrated Coastal Zone Management (CNGIZC)

ICZM decree No. 2010-137 set up the "National Committee for Integrated Coastal Zone Management" to ensure the coordination of integrated coastal zone management (ICZM) at the level of the big island. The CNGIZC, which is an intersectoral platform, was attached to the Prime Minister to assist the Prime Minister's office in the coordination of all actors and the implementation of the National Policy for the Integrated Coastal Zone Management, the National Strategy for the Sustainable Development of Coastal and Marine Zones, and the National Action Plan for Sustainable Development in Coastal and Marine Zones.

It is a body for consultation, brainstorming, orientation and coordination of interventions and stakeholders in coastal areas of Madagascar. It has ramifications at regional and communal level with the establishment of regional and local committees at the level of decentralized territorial collectivities. It is composed of multisectoral and multidisciplinary members from Ministries, national and international organizations, ...

Gap:

The dissolution of the CNGIZC is not very clear: Following the government communication of December 15, 2021 which approved the dissolution of the CNGIZC, the government has not undertaken to date any official act to repeal the CNGIZC or to review the GIZC decree of 2010 in order to adapt it to the context of new state policies (concept of Blue Economy, sustainable development, maritime spatial planning, etc.). The coordination of the governance of the oceans and maritime spaces still remains rather vague despite the existence of the Department in charge of Fisheries and the Blue Economy.

k) The MECIE decree

The decree relating to the compatibility of investments with the environment (MECIE decree) establishes procedures relating to the environmental impact assessment in Madagascar for public or private investment projects likely to affect the environment.

Gap:

This decree does not include specific provisions for the protection of the marine environment as well as marine and coastal areas.

l) Concerning national defense

In the absence of inter-ministerial coordination, coastal and marine governance is ineffective because the entities or departments involved in the process remain compartmentalized, each giving priority to their own interests. With the new maritime strategy, we should be able to work together and rationalize the control and surveillance system at sea. However, the lack of means (high seas patrol boats, coastal surveillance radar) and logistics is a major handicap in the implementation of the law.

Gaps:

It goes without saying that there are areas that affect several ministries at the same time and that therefore, harmonization of legal texts remains a priority. The lack of coordination among the various departments involved in monitoring and control creates additional costs for the Malagasy State.

The fisheries and aquaculture sector suffers from insufficient (human, material and financial) resources in the implementation of policies and legislation.

m) The Petroleum Code

The Petroleum Code dates from 1996 and no decree is so far available to ensure its implementation.

Gap:

A legal vacuum exists with respect to the delimitation of the national hydrocarbon mining domain and the Charter of Responsibility for the upstream oil sector. Nevertheless, the legal and institutional framework has been improving since 2009.

n) International conventions and treaties

Problems in the implementation of international conventions and treaties (bilateral, regional or international):

International conventions have been ratified but their implementation is not legislated, at least not immediately.

Gap: The implementation always has a theoretical aspect whereas the practice must be applied as it is.

o) Gaps in national legal texts

Gap:

Many texts do not take into account the legal aspects and create a serious legal vacuum.

5.3.3. Adopted policies and strategies

The exploitation of marine resources must take into account the challenges of sustainable development. These issues bring together populations that are highly dependent on available resources to satisfy their food and monetary needs with national or international public policies. These policies tend to reconcile local development aspirations with international recommendations concerning the management of natural resources and, more generally, the management of biodiversity and ecosystems.

Environment sector (parks and marine fauna)

- Decree No. 2015-1308 of December 22, 2015 establishing the national policy on the environment for sustainable development (PNEDD)
- Decree No. 2016-128 adopting the National Strategy and Action Plans for Biodiversity in Madagascar from 2015 to 2025
- National Policy for Integrated Coastal Zone Management and its national action plan (2011-2015)

Fishery and aquaculture sector

- Blue Policy Letter ;
- National Strategy for Good Governance of Maritime Fisheries in Madagascar ;
- National Strategy for the Sustainable Development of Aquaculture ;
- Agriculture, Livestock and Fisheries Sector Program (PSAEP/CAADP) ;
- Fisheries Development Plans ;
- FAO Code of Conduct for Responsible Fisheries ;
- Policy Framework and reform strategy for Fisheries and Aquaculture in Africa;
- Indian Ocean Tuna Commission (IOTC) Resolutions ;
- Guide for officials of the Ministry of Fisheries and Fishery Resources;

Maritime transport sector

Draft national marine transport policy (NMTP) of Madagascar (in progress)

Land use planning sector

- National Land use planning Policy (PNAT)
- National Land Tenure Policy (PNF)
- Provincial Land Use Planning Scheme
- National Land Use Planning Scheme (SNAT)
- Regional Land Use Planning Scheme (SRAT)[53]
- Master Plan for Maritime Spatial Planning (Marine Spatial Planning Atlas phase)
- Urban Master Plan/Detail Plan (PUDi/PUDé)
- Inter-communal land use plan (SAIC)
- Communal land use plan (SAC)
- Local tenure plan (PLOF)

ICZM sector

- National sustainable Development Policy for the Integrated Coastal and Marine Zones Management of MADAGASCAR
- National Strategy for Sustainable Development of the Integrated Coastal and Marine Zones Management of MADAGASCAR
- National action Plan for the Integrated Management of Coastal Zones (PANGIZC: 2019 – 2023)
- Regional ICZM action plans for the implementation of PANGIZC: Regional Action Plan for ICZM Atsinanana, Menabe, Boeny, Vatovavy Fitovinany.

National Defense Sector

- General Policy of the State
- Draft of the Defense Concept in progress
- Draft of the maritime strategy in the process of finalization

Oil Sector

- Development of the draft of the national oil policy letter by the Departments in charge of Strategic Resources[54]

Climate change

- National Action Program for Adaptation to Climate Change (PANA), 2006
- National Climate Change Control Policy (PNLCC), 2011
- National Action Plan to Combat Climate Change (PANLCC), 2019

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[53] –Decree No. 2019-1931 relating to the instruction, development, validation and implementation of the SRAT
-Decree No. 2019-1932 relating to the development, examination, validation and implementation of Urban Plans
-Decree No. 2019-1934 relating to the instruction, development, validation and implementation of the SAC/SAIC

[54] See Annual Activity Report of the Ministerial Department in charge of Strategic Resources in 2020

- National Climate Change Adaptation Plan (PNA), 2019

Disaster and Risk Management

- Law No. 2003-010 of September 5, 2003 relating to the national policy of disaster and risk management
- National strategy for risk and disaster management

5.4. National, provincial and local authorities in coastal / marine affairs

International law, as reflected in the provisions of the United Nations Convention on the Law of the Sea, sets out the rights and obligations of States and provides the international basis on which all efforts to protect and develop the marine environment, coastal areas and their resources in a sustainable manner must start. Coastal and developing States such as Madagascar, whose economies are dependent on the exploitation of marine living resources, should take full advantage of the social and economic benefits of the sustainable use of marine living resources from their exclusive economic zone and other areas under their national jurisdiction.

However, the maritime potential is not managed equitably for Madagascar, which does not benefit from the advantages resulting from the exploitation of maritime resources. Thus, the economic performance of the country in the maritime domain remains weak. It is notably due to a weak regulatory framework, a lack of common vision and shared objectives, and failure to take into account all the interests of all stakeholders.[55]

The ongoing optimization of Marine Spatial Planning (PSM) in Madagascar, coordinated by the Ministry in charge of the land use planning, aims to design a methodological tool in order to improve the contribution of spatial and temporal management tools related to PSM. The objective is to maintain a balance between the exploitation, rational use and conservation of marine resources and biodiversity in the maritime area while taking into account the needs of the various stakeholders in this area. The MSP should lead to a better contribution of the maritime sector to the development of the country.

It is in this sense that several national authorities and bodies are concerned with the sustainable management and preservation of marine ecosystems.

5.4.1. Environment Sector

The Ministry in charge of the Environment: The Ministry of the Environment and Sustainable Development

The Minister in charge of the Environment and Sustainable Development (MEDD) is responsible for the design, coordination, implementation and monitoring-evaluation of State policy on the Environment and Sustainable Development[56].

In the context of ocean governance, the aforementioned decree provides within the MEDD for cross-functional internal and external structures ensuring the integration of the environmental dimension and sustainable development.

[55] WWF: « The effective management of the Malagasy's maritime space is on the right track » - December 03, 2021

[56] Decree No. 2022-482 on April 06, 2022 defining the tasks of the Minister in charge of the Environment and Sustainable Development as well as the general organisation of the Ministry.

For internal structures

It is:

- the Body for the Coordination of Strategic Actions for Green Diplomacy and Related Organizations (OC-DVOR) which is responsible for (…) ensuring the monitoring of international conventions on the environment ratified by Madagascar (…);
- The General Directorate of Environmental Governance (DGGE) whose mission is to protect, enhance and take care of the environment (…) of the system of protected areas (…)
- The Directorate of Protected Areas (…), a structure attached to the DGGE, which is responsible for ensuring the management of renewable natural resources and biodiversity, particularly at the level of Protected Area Systems
- The Support Department for the Promotion of the Green and Blue Economy, a structure attached to the DGDD, (…) which is responsible, with regard to the blue economy, for contributing to the promotion and enhancement of research as well as the use of marine ecosystems, including its biodiversity, for sustainable development.

For independent external structures but attached to the MEDD

It is:

- the body responsible for combating Pollution Events which is in charge of managing (preventive and curative) oil pollution situations at sea,
- the National Office for the Environment, which is responsible (…) for ensuring the compatibility of investments for the creation of Marine Parks with the environment (…)
- Madagascar National Parks which is responsible for the operational management of the created Marine Parks

For structures outside the MEDD

It is:

- The SAPM Commission which is responsible for the technical aspects of the creation of land, lake, marine and coastal parks
- The COPIL for the fulfillment of the Promise of Sydney which is responsible for the technical, legal and strategic aspects in the creation of marine and coastal parks and other similar forms (LMMAs, OECM)

L'Organe de Lutte contre l'Evènement de pollution marine par les hydrocarbures (OLEP)

OLEP is an organization with administrative and financial autonomy, under the technical supervision of the Ministry in charge of the Environment and under the financial supervision of the Ministry in charge of Finance. Regional branches can be created on the territory or on the sites of the storage center of control materials.

OLEP's mission is to prepare and coordinate response operations against pollution events in the marine and coastal environment, namely accidental spills of hydrocarbons and noxious and potentially hazardous substances (all cargoes combined within the content of the OPRC-HNS Protocol). Upstream, it is responsible for emergency planning (the emergency response plans to which vulnerability maps are annexed are the outputs), prevention, preparation and pre-positioning of response equipment on the coast. Downstream, it is responsible for crisis management, remediation, compensation (application of the polluter pays principle), and its restoration.

OLEP is the host of the IOC Sub-regional Coordination Center for Response according to the IOC Council of Ministers on October 31, 2003. This center is currently assisted by the CRFIM Madagascar (Regional Center for the Fusion of Maritime Information) and the CRCO-Seychelles (Regional Coordination

Center for Operations) of the IOC MASE Program. The Regional Response Center is unofficially hosted by SAMSA /SEAGNEP South Africa.

The delimitation of competence is in relation to the tier (level) of response, and whether the operations are on land or at sea. OLEP ensures the general coordination, but for operations at sea, APMF and the Navy ensure the secondary steering. Territorial structures are essential for onshore operations (SCAT: coastal assessment and clean-up techniques).

The national policy is yet to come. The national plan, the prefectural and local plans are to be updated, with the governing texts upstream and the plan document downstream.

Attributions remain though unclear between the Port, Maritime and River Authority (APMF) and OLEP regarding the issuance of certificates releasing the responsibility of ship owners in case of oil pollution.

Level of response according to the quantity and how dangerous the spilled pollutant is:

Tier 1: local response,

Tier 2: response at the prefectural level

Tier 3: response at national level, which can even lead to a request for international assistance at the sub-regional level of the IOC, even at regional level (Southern and Eastern Africa: countries bordering the Mozambique Channel).

Madagascar National Parks (MNP)

Madagascar National Parks or MNP, was created in 1990 under its first name "ANGAP", or National Association for the Management of Protected Areas, association of private law recognized of public utility by the decree n ° 91-592 of December 4, 1991. The new name "MNP" of the Association is given following the decision of the EGM on October 29, 2008.

It should be noted that Madagascar National Parks currently benefits from a new statute adopted on May 04, 2021.

MNP is responsible for establishing, conserving and sustainably managing Madagascar's national parks. In 2020, it managed 43 Protected Areas including 5 RAMSAR Sites, 5 Biosphere Reserves and 7 UNESCO World Heritage sites.

5.4.2. Fishery and aquaculture sector

Ministry in charge of Fisheries: The Ministry of Fisheries and the Blue Economy

Given the dissolution of the CNGIZC, and in accordance with the provisions of article 21 of law 2018-025 of December 25, 2018 relating to the maritime zones of the maritime space under the jurisdiction of the Republic of Madagascar "(…) the ministerial department responsible for the Sea coordinates State activities at sea (…)". Decree No. 2021-856 of August 25, 2021 amended and supplemented by Decree No. 2022-101 of January 20, 2022 setting the powers of the Minister of Fisheries and the Blue Economy as well as the general organization of his Ministry confirms the provisions of the aforementioned law, stipulating that any mission relating to the coordination of actions at sea is the responsibility of the MPEB.

The Ministry has the Management and Planning Support Department to carry out these missions relating to the coordination of actions at sea set by the said Decree. This department is responsible for the Governance of the Sea and the Ocean, as well as the coordination of related activities in collaboration with all stakeholders of the Blue Economy. Among other things, it also provides Marine Spatial Planning.

In other words, any activity affecting the maritime space under the jurisdiction of the Malagasy State and the use of marine, coastal and aquatic ecosystems, whether for conservation or exploitation, must

involve the Ministry in charge of Governance of the sea and the ocean and the development of the Blue Economy.

Indeed, the insertion of the institutional coordination scheme is deemed necessary, which results in the establishment of a coordination structure and is composed of:

- A decision- making body: decision-making
- Advisory and technical body (By theme: PSM, ocean governance, marine and coastal environment, conflict management, ...), integrating all stakeholders (public sector, private sector, NGOs, civil society, communities, ...)
- Support body: PTF (TFP)

In addition, the structure takes the form of a cluster with a flexible operating mode. By virtue of its mission and powers, the MPEB will ensure coordination (preparation of meetings, monitoring of coordination actions, etc).

5.4.3. Maritime transport sector

Ministry in charge of Maritime Transport: The Ministry of Transport and Meteorology

The Minister in charge of transport and Meteorology[57] is responsible for defining and developing policies and strategic orientations in the field of transport and meteorology, in accordance with the General State Policy (PGE) and the Sustainable Development Goals (SDGs). More specifically, it is responsible for implementing State policy in the field of maritime and river transport, executing, monitoring and evaluating activities and studies within the framework of the development program for the maritime and river sub-sector.

Among his/her responsibilities:

- Ensure compliance with obligations arising from international and national conventions and agreements;
- Establish a legal environment conducive to the development of the transport sector;
- Promote the integrated, harmonious and orderly development of transport;
- Establish standards for good governance in the transport and meteorology sector;
- Ensure the inter-ministerial coordination of policies for the development of transport and meteorology with the decentralized territorial entities;
- Develop and ensure the application of program-contracts and means of structures intervening in its field of competence;
- Establish an incentive framework facilitating the activities of investors and operators in the perspective of Public-Private Partnership (PPP) ;
- Ensure better circulation of goods and people ;
- Develop and implement strategies relating to transport safety and security;
- Anticipate the harmful effects of climatic and meteorological hazards with a view to protect property and people ;
- Contribute to scientific and technical exchanges in the field of transport and meteorology ;

The Port, Maritime and River Agency (APMF)

[57] Decree No. 2021-863 setting the responsibilities of the Ministry of Transports and Meteorology as well as the general organization of his ministry

The decree No. 2012-391 of March 20, 2012 on the restructuring of the Port, Maritime and River Agency (APMF), amended and completed by the decree No. 2017-325 of May 20, 2017, sets its Statutes, its financing modalities, and creates the Higher Council of Ports, Maritime and River Transport and the Maritime Support and Operation Center. The APMF is a state-owned industrial and commercial establishement (EPIC), autonomous in administrative, technical and financial terms, under the budgetary supervision of the Ministry in charge of the budget, under the accounting supervision of the Ministry in charge of Finance and under the technical supervision of the Ministry in charge of Transport. Regional offices may be created in any other part of the country.

APMF is the maritime authority in charge of regulating the port, maritime and river sub-sector. Thus, it coordinates the implementation of the national policy in the field of this sub-sector by ensuring the administration of port, maritime and river affairs, maritime and river "security and safety", the concessioning authority of the ports, the supervision and control of self-managed ports, the regulation and management of the public port, maritime and river domains, the protection of the coastline and the marine environment, and the development and promotion of the sub-sector.

5.4.4. Regional planning sector

The Ministry in charge of land use planning: The Ministry of Regional Development and Land Services

The responsibilities of the Minister in charge of Regional Planning and Land Services are exercised within the framework of the achievement of the strategic objectives set out in the Initiative Emergence Madagascar (IEM). The Minister is responsible for the design, implementation and monitoring of State policy in terms of land use planning, housing and land services.

The Ministry includes a Department responsible for the Coordination, Planning and Valorization of the Maritime Territory whose mission is to elaborate and implement the planning scheme of the Malagasy maritime territory and how to value them, as well as the maritime spatial planning; to initiate reflections and studies on the development of the Malagasy maritime territory; to ensure the regularization of the Malagasy continental shelf; to harmonize the actions of the ministerial departments involved in the development of the maritime territory.

Other organizations and institutions support the Ministry in charge of the land use planning , in particular the National Council for Land Use Planning (CNAT), the Provincial, Regional and Communal Committees for Land Use Planning at the decentralized territorial collectivities level[58], the NCICZM and the ICZM Committees at the regional and local levels.

The National Council for land ues planning (CNAT)

The CNAT is responsible for issuing opinions and suggestions on the guidelines and conditions to enable the state and the decentralized territorial collectivities to implement the land use planning policy. It also issues opinions, at the request of the Government, on draft legislative or regulatory texts relating to land use planning. It ensures consistency between the national land use planning policy and other sectoral policies, particularly the economic and social development plans.

[58] Decree No. 2019-1933 setting the composition, structure and functioning of the provincial, regional and municipal committees for land use planning

Decree No. 2019-1935 setting the composition, the operating procedures and the duties of the CNAT

Provincial, regional and communal committees of land use planning

These Committees are set up at the provincial, regional and communal levels. They issue an opinion on issues falling within their remit, which are submitted to them, where appropriate, by the Head of Province, the Regional Governor, the Mayor or the local representative of the department in charge of land use planning. They are responsible for monitoring the development and implementation of territorial planning tools in collaboration with the Territorial Observatory; for assisting the provincial, regional or communal authorities in territorial planning actions; for bringing up problems which cannot be solved locally and require the intervention of the Interministerial Commission provided for by law No. 2015-051 of February 3, 2016; for ensuring the facilitation and permanent synergy of the actions they carry out; for issuing proposals and orientations concerning the vision of provincial, regional or communal land use planning.

5.4.5. Decentralization Sector

Ministry in charge of Decentralization: Ministry of Interior and Decentralization

The Minister in charge of Interior and Decentralization[59] has the general mission of developing and implementing the general policy of the State, led by the Government, on matters that fall within its competences and attributions.

Among its own responsibilities:

In the context of deconcentration and decentralization (Roles of seafront Regions and Communes):

- Develop and implement government policy on decentralization and deconcentration;
- Work for the effectiveness and efficiency of the administration of the territory;
- Promote effective decentralization and good local governance;
- Work for the achievement of the reforms of the administration of the territory and the decentralization
- Exercise the powers relating to the mission of State sovereignty, which are attributed to it by the legislation in force;
- Ensure the management of immigration and emigration;
- Manage associations and groups;
- Ensure civil protection, coordination of emergency relief activities, risk and disaster reduction and management of aid in the event of cataclysms;
- Promote and strengthen the free administration of decentralized territorial collectivities and ensure compliance with the legality of their actions;
- Develop and enforce rules guaranteeing citizens the exercise of public freedom;
- Promote democracy and support for citizen participation in this area ;
- Design and propose draft legislative and regulatory texts on deconcentration, decentralization and elections.

Among his shared responsibilities:

- Ensure the internal security of the State;
- Contribute to the preservation and maintenance of public order and security;

[59] Decree No. 2020-156 of February 19, 2020 setting the responsibilities of the Minister of Interior and Decentralization as well as the general organization of his/her Minister

- Work for the establishment and operating of the territorial public service;

Among the responsibilities of State Representatives [60]:

The Representative of the State (The Prefect at the regional level, The Head of District at the Communal level) represents the Prime Minister, Head of Government as well as each of the Ministers, members of the Government. To this end, it extends the functions of central administration at the level of its territorial jurisdiction:

- Ensures the implementation of the general policy of the State within the framework of its territorial jurisdiction and has authority over the heads of the deconcentrated services of the State established in its territorial jurisdiction.
- -Facilitates, coordinates and controls the activities of the various deconcentrated State services established in its district.
- Is responsible for public order and security. He chairs a structure which is responsible for defining the appropriate strategies and measures intended to preserve and maintain public order and security in his constituency.
- Supports and advises the administration bodies of the Decentralized Territorial Collectivities within the scope of his responsibilities.
- Is in charge of the legality audit of the acts of the Decentralized Territorial Collectivities.

Concerning the competences of the Region[61]

The mission of the Regions is to lead, energize, coordinate and harmonize the economic and social development of their entire territorial jurisdiction and to ensure the overall planning, land use and implementation of all development actions.

Among the fields of competence of the Region are:

- In terms of administration:
    - Implementing interregional and decentralized cooperation and developing partnerships
- In terms of economic and social development:
    - Identifying priority areas of the Region ;
    - Developing and implementing framework program and regional development plan ;
    - Programming and framing development actions on a regional scale, particularly in terms of hydro-agricultural development, fishing, industrial, artisanal and commercial promotion, promotion of the agricultural and livestock services sector ;
    - Establishing and implementing the regional land use plan ;
    - Implementing, at its level, appropriate actions and measures relating to natural disasters and public security and the creating and managing parks and recreational areas of regional scope.

Concerning Communal competences:

[60] Law No. 2014-021 on State representatives on August 22, 2014

[61] Organic law No. 2014-018 regulating the competences, the structure and functioning of all decentralized territorial collectivities as well as the management of their own affairs.

The Communes are responsible for identifying economic, social, cultural and environmental potential and needs and implementing related operations; as well as carrying out all other activities falling within its competence pursuant to specific legislative and regulatory texts.

Among the fields of competence of the Municipality are:

- In terms of administration:
  - Implementing inter-communal and decentralized cooperation and developing partnerships;
- In economic matters, planning communal development and implementing related operations:
  - Building and managing commercial infrastructure and facilities such as public squares and markets, cattle markets and vehicle parking areas, and any other income-generating facilities such as slaughterhouses, green spaces ;
  - Managing roads, service tracks, bridges and ferries of communal interest ; to local tourism.
- In social and cultural matters:
  - Planning communal development and implementing various actions related to the creation and management of parks and leisure areas of communal scope and promoting cultural identity
- In environmental matters:
  - Planning communal development and implementing related actions:
  - Contributing to, preserving, enhancing and managing the environment and natural resources;

Preventing and fighting against bush fires and deforestation.

5.4.6. Tourism sector

Ministry in charge of Tourism: The Ministry of Tourism

The Minister of Tourism is responsible for designing, coordinating, monitoring and evaluating the implementation of State policy in the area of tourism development. His/her mission is to promote the integrated, orderly and harmonious development of tourism so as to stimulate the growth of the sector by improving the offer, through a training policy in tourism professions.

The Ministry will be the lever of sustainable tourism, with the aim of transmitting a positive image of Madagascar on the external market.

This mission is common to the different hierarchic levels of the Ministry, to the different bodies and institutions attached to it and to the different projects implemented within the Ministry.

The National Tourist Office of Madagascar (ONTM) as well as the Regional Tourist Offices, which are spread throughout the island, assist the Ministry in the completion of its tasks.

5.4.7. National Defense sector

Ministry in charge of National Defense: The Ministry of National Defense

The responsibilities of the Ministry in charge of National Defense are exercised within the framework of the general State policy. The Minister of National Defense (MDN) executes the national defense policy, and implements all the resources at his/her disposal to preserve national sovereignty, territorial integrity and national security. More specifically, within the framework of the rapid development program, the MDN's mission is to contribute to the re-establishment of the security situation throughout the country and to protect the population from fear, notably by fighting the dahalo phenomenon, securing roads, reducing illicit trafficking of all kinds, and finally by fighting corruption.

Institutions and organizations support the Ministry of National Defense in the preservation of the marine environment, in particular, the Staff of the National Navy. We can also mention the Naval Base of Antsiranana, the Marine Detachments (Mahajanga, Nosy Be, Sainte-Marie, Fort-Dauphin), the Commanders of Patrol Boats and Coastal Surveillance Vessels of the Malagasy National Navy who are authorized to detect offences at sea. It is also planned to set up 10 Defense and Security Zones with their respective Commanders and to set up 22 regional military delegates at the level of the Regions. The decree establishing the Defense and Security Zones and setting the principles governing them was adopted by the Council of Ministers on December 9, 2020.

A Memorandum of Understanding between the Ministry of National Defense and the Ministry of Environment and Sustainable Development within the framework of the fight against pollution at sea was concluded on December 23, 2016.

The Navy staff

The Navy Staff was created by decree No. 2020-318 of March 11, 2020. It reports to the Army force Chief of Staff and is responsible for organizing, preparing and maintaining the capacity of the National Navy to accomplish the following missions:

- Defense missions: Guarantee the national sovereignty in the waters under Malagasy jurisdiction; defend the maritime approaches of the territory; participate in joint missions.
- Coast guard missions within the framework of the action of the State at sea: to ensure the sovereignty and protection of national interests; to ensure maritime safety; to participate in maritime security; to participate in customs, fiscal and economic policing at sea; to fight against illegal activities at sea; to participate in the safeguarding of people and property; to support the protection of protected areas; to participate in the protection of the environment; to support sanitary control and working conditions at sea; to support the management of the marine heritage and public marine resources.

The Navy Staff is the central body in charge of the design, the leadership, the command and the preparation of the Navy. It is headed by the Chief of Staff of the Navy.

5.4.8. Upstream Oil Sector

Ministry in charge of Strategic Resources: The Ministry of Mines and Strategic Resources

The Minister of Mines and Strategic Resources, through the General Directorate of Strategic Resources, is responsible for implementing the State's policy on the development and exploitation of resources in the Upstream oil sector.

The maritime zones are equivalent to the international system required by the United Nations Convention on the Law of the Sea, ratified on August 20, 2001 by Madagascar. The national hydrocarbon mining domain is defined as all areas where prospecting, research, exploration, exploitation, processing and transportation of hydrocarbons are carried out. The extent of the continental shelf corresponds to the requirements of the United Nations Convention on the Law of the Sea: gentle slope, depth less than or equal to 2,500m.

Institutions and organizations support the MMRS in preserving the marine environment, in particular the Office of National Mines and Strategic Industries (OMNIS) which is responsible for the management of the national hydrocarbon mining domain.

5.4.9. Scientific Research Sector

Ministry in charge of Scientific Research: The Ministry of Higher Education and Scientific Research

The Minister in charge of Higher Education and Scientific Research implements the general State policy in terms of higher education and research, within the framework of achieving the strategic objectives set out in the Initiative Emergence Madagascar (IEM).

Among his/her responsibilities:

- Make higher education and scientific research a real engine of development in Madagascar;
- Promote professionally-oriented course, within faculties, schools, institutes, and various sites with high economic potential;
- Ensure a better environment for studies, training and research;
- Prioritize research and innovation themes;
- Enhance scientific research outcomes by establishing an entrepreneurial strategy (promotion of the economy) in order to achieve the best possible exploitation of the products resulting from the research;
- Systematize this investment option for research outcomes so that it becomes a real generating source of financial resources;
- Coordinate and control the activities of the organizations and institutions attached to his/her Ministry.

In terms of marine ecosystems, the Ministry responsible for Scientific Research is supported in particular by research organizations such as the National Center for Oceanographic Research (CNRO), the National Center for Environmental Research (CNRE), the Fisheries and Marine Sciences (IHSM), etc…

5.5. NGO / Private sector

5.5.1. Environment sector

- Protected Areas Managers
- The VOI (Community-based Organization)

5.5.2. Fisheries Sector

Technical and financial partners of the MAEP in the fisheries sector: WWF, WCS, Blue Ventures, CI, Durell, Reseau MIHARI, USAID-HAYTAO, ASITY Madagascar, ONG HONKO ; Reef Doctor

5.5.3. Upstream Oil Sector

Full-fledged actors in the elaboration of policy and strategies for the development of the upstream oil sector [62]:

- APPAM (Professional Association of the Upstream Petroleum Sector of Madagascar)
- OSCIE (Extractive Industries Civil Society Organization)

5.6. International relations, conventions and committees

5.6.1. Participation in regional instruments and organizations

[62] List of the entities consulted during the updating of the legal and political framework of the upstream oil sector.

Madagascar has been a member of the United Nations since 1960 and actively participated in the Third United Nations Conference on the Law of the Sea from 1973 to 1982, which led to the adoption of the 1982 United Nations Convention on the Law of the Sea (UNCLOS).

Madagascar has ratified the 1958 Convention on the Territorial Sea and the Contiguous Zone, the 1958 Convention on the Continental Shelf, the 1958 Convention on the High Seas and the 1958 Convention on Fishing and Conservation of the Living Resources of the High Seas. It became the 137th State to ratify UNCLOS with a declaration in 2001, and at the same time became the 102nd State to ratify the 1994 Agreement relating to the Implementation of Part XI of UNCLOS. Madagascar has not (yet) ratified the 1994 Agreement for the Implementation of the Provisions of UNCLOS relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.

Madagascar became a member of the International Maritime Organization (IMO) in 1961. In recent years, Madagascar has been a member of some IMO committees and working groups: MEPC, MSC, LEG, TC, LC/LP, Council, Assembly. Madagascar has also participated in the Organization's technical cooperation activities by hosting a sub-regional workshop on Particularly Sensitive Sea Areas (PSSA) in November 2019. Similarly, Madagascar became a member of the Food and Agriculture Organization of the United Nations (FAO) in 1966.

Madagascar became a member of the Organization of African Unity in 1963 and signed the Constitutive Act of the African Union in 2000. Madagascar is a signatory to the African Charter on Maritime Transport, the Revised African Charter on Maritime Transport and the African Charter on Maritime Security and Safety and Development in Africa (the Lomé Charter) but has not (yet) ratified them. Madagascar, through APMF, is a member of the Association of African Maritime Administrations.

Madagascar participates in the Regional Seas Program of the United Nations Environment Program (UNEP) through the 1985 Nairobi Convention for the Protection, management and development of the marine and coastal environment of the East African region with its Protocol concerning protected areas and wildlife in the East African Region and the Protocol concerning cooperation in combating marine pollution in cases of emergency in the East African Region, subsequently amended by the Protocol for the protection of marine and coastal environment of the western Indian Ocean from land-based sources and activities.

With respect to the Indian Ocean, Madagascar is a member of the South West Indian Ocean fisheries Commission and is also a party to the 1993 Agreement establishing the Indian Ocean Tuna Commission. Madagascar has signed the Southern Indian Ocean fisheries agreement but has not ratified it. In 2018, Madagascar became a full member of the 1998 Memorandum of Understanding on port State control for the Indian Ocean Region. Madagascar is a member of the Indian Ocean Commission (IOC), which is the only African regional organization exclusively composed of islands. Also in 2018, Madagascar signed two agreements, under the Regional Maritime Security Program (MASE), which aimed at strengthening state coordination for maritime security in the Western Indian Ocean: the agreement establishing the Regional Maritime Information Fusion Center (RMIFC), based in Madagascar, and the agreement that established the Regional Operations Coordination Center (RCOC) based in Seychelles. Madagascar is also a member of the Indian Ocean Rim Association (IORA).

5.6.2. Ratified international conventions on marine and coastal governance

Madagascar has ratified a fair number of IMO, UNEP, FAO conventions as well as other international instruments relevant to marine and coastal governance, the main one being the United Nations Convention on the Law of the Sea of 1982 or Montego Bay Convention.

International conventions under the aegis of the United Nations Environment Program (UNEP)

- Nairobi Convention for the Protection, Management and Development of the Marine Environment and Coastal Zones of East Africa, 1985;

- Protocol on Protected Areas and Wild Fauna and Flora in the East African Region,
- Protocol for the fight against telluric pollution in East Africa,
- Protocol on Cooperation in Combating Accidental Marine Pollution in the East African Region

International environnemental conventions

- African Convention on the Conservation of Nature and Natural Resources
- Convention on Biological Diversity (CBD)
- Convention on International Trade in Species of Wild Fauna and Flora (CITES)
- Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization relating to the Convention on Biological Diversity.

NB: The implementation of the Convention on Biological Diversity through the Aichi target (11) concerning marine protected areas is in progress.

- United Nations Framework Convention on Climate Change, 1992
- Kyoto Protocol, 1997
- Vienna Convention on the Protection of the Ozone Layer, 1985
- Montreal Protocol on Substances that Deplete the Ozone Layer, 1987
- Paris Climate Agreement, 2015
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989
- Rotterdam Convention on the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade, 1998
- Stockholm Convention on persistent organic pollutants
- RAMSAR Convention, 1971

International conventions in the fishing sector:

- United Nations Convention on the Law of the Sea
- Agreement for the purposes of the application of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of fish stocks whose movements take place both inland and beyond exclusive economic zones (straddling fish stocks) and highly migratory fish stocks, 1995 (Relevant Convention to be ratified)
- Code of Conduct for Responsible Fisheries, 1995
- Agreement on port State measures to prevent, deter and eliminate Illegal, Unreported and unregulated fishing, 2009

International conventions on maritime transport:

- United Nations Convention on the Law of the Sea
- International Convention for the Prevention of Pollution from Ships of November 2, 1973 supplemented by the 1978 Protocol (MARPOL 73/78), Annexes I to VI;
- International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC 1990) ;
- 1992 International Convention on civil liability for oil pollution damage (CLC 92);
- 1992 International convention establishing an International fund for compensation for damage due to oil pollution (IOPC Funds 92) ;
- 2000 Protocol on preparedness, response and cooperation against pollution Incidents by harmful and potentially hazardous substances (OPRC-HNS Protocol) ;
- 2001 International convention on civil liability for bunker oil pollution damage (BUNKERS 2001);

- 2001 International convention on the control of harmful anti-fouling systems on ships (AFS 2001);
- International convention for the control and management of ships' ballast water and sediments, 2004 (BWM 2004) ;
- Nairobi convention on the removal of wrecks, 2007 (NWRC 2007)

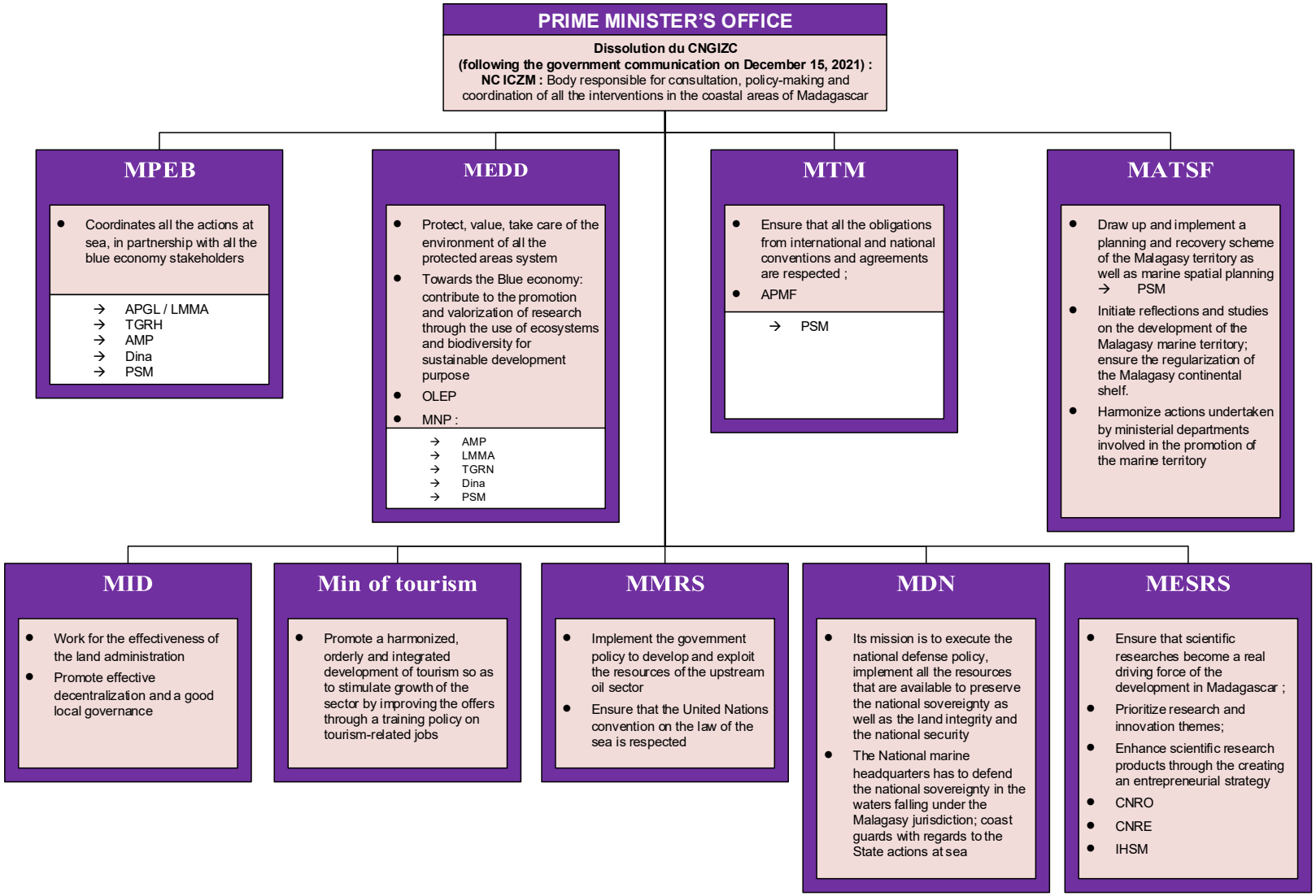
National laws on ratifications of international conventions relating to maritime transport:

- Law No. 2000 - 020 Authorizing the ratification of the 1982 United Nations Convention on the Law of the Sea.
- Law No. 98-022 Authorizing the ratification of the Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention).
- Law No. 2004-037 Authorizing the ratification of the International Convention of 1973 for the prevention of pollution by ships (MARPOL 73/78) and its appendixes.
- Law No. 2017-039 Authorizing the Accession of Madagascar to the 1988 Protocol to the 1974 International Convention on the Safety of Life at Sea (1988 SOLAS PROTOCOL).
- Law No. 2017-041 Authorizing the Accession of Madagascar to the 1989 International Convention on Assistance.
- Law No. 2001-011 Authorizing the ratification of the 1990 International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC Convention 90).
- Law No. 2017-035 Authorizing the Accession of Madagascar to the International Convention on the Control of Harmful Anti-Fouling Systems on Ships (AFS 2001).
- Law no. 2017-036 Authorizing the Accession of Madagascar to the Protocol of 2002 to the Athens Convention of 1974 relating to the carriage by sea of passengers and their luggage (PAL 2002).
- Law No. 2017-037 Authorizing the Accession of Madagascar to the 1997 Protocol to the International Convention for the Prevention of Pollution by Ships of 1973, as amended by the 1978 Protocol relating thereto (1997 MARPOL Protocol).
- Law No. 2017-038 Authorizing the Accession of Madagascar to the 1988 Protocol to the 1966 International Convention on the line of charges (Protocol 1988 LL).
- Law No. 2016-041 Authorizing the Adhesion of Madagascar to the Convention on the International Regulations of 1972 to prevent collisions at sea.
- Law No. 2016-042 Authorizing the Accession of Madagascar to the Protocol amending the 1976 Convention on the Limitation of Liability for Maritime Claims (LLMC 1996).
- Law No. 2017-040 Authorizing Madagascar's accession to the Nairobi International Convention on the removal of wrecks (WRC 2007).
- Law No. 2017-041 Authorizing the Accession of Madagascar to the 1989 International Convention on Assistance.
- Decree No. 2004-1018 Ratifying the 1973 International Convention for the prevention of pollution by ships (MARPOL 73188) and its appendixes.
- Decree No. 2015-856 Ratifying the 2001 International Convention on Civil Liability for Damage Due to Pollution by Bunker Hydrocarbons, adopted in London on March 23, 2001.
- Decree No. 2017-919 Publishing resolution MSC.255(84) relating to the adoption of the code of international standards and recommended practices applicable to a safety investigation of a maritime accident or incident or code for accident investigation, adopted on May 16, 2008 by the International Maritime Organization.
- Decree No. 2017-920 publishing resolution A.741 (18) on the adoption of the "international management code for the safe operation of ships and pollution prevention" as amended or "ISM code", adopted on November 4, 1993 by the International Maritime Organization.

- Decree No. 2017-921 Publishing resolution MSC.349 (92) relating to the adoption of the "code governing recognized organizations" as amended or "OR Code", adopted on June 21, 2013 by the International Maritime Organization.
- Decree No. 2018-392 Acceeding Madagascar to the 1988 Protocol to the 1966 International Convention on the line of charges (Protocol 1988 LL).
- Decree No. 2018-393 Acceeding Madagascar to the 1997 Protocol to the International Convention for the Prevention of Pollution from Ships of 1973, as amended by the 1978 Protocol relating thereto (1997 MARPOL Protocol).
- Decree No. 2018-395 Acceeding Madagascar to the International Convention on the control of harmful anti-fouling systems on ships (AFS 2001);

5.7. Institutional scheme of marine and coastal governance

In addition to the institutional scheme, a grid which gives a summary of marine and coastal governance is provided in the appendix of chapter 5, table 84.


PRIME MINISTER'S OFFICE
Dissolution du CNGIZC
(following the government communication on December 15, 2021) :
NC ICZM : Body responsible for consultation, policy-making and coordination of all the interventions in the coastal areas of Madagascar
MPEB
Coordinates all the actions at sea, in partnership with all the blue economy stakeholders
→ APGL / LMMA
→ TGRH
→ AMP
→ Dina
→ PSM
MEDD
Protect, value, take care of the environment of all the protected areas system
Towards the Blue economy: contribute to the promotion and valorization of research through the use of ecosystems and biodiversity for sustainable development purpose
OLEP
MNP :
→ AMP
→ LMMA
→ TGRN
→ Dina
→ PSM
MTM
Ensure that all the obligations from international and national conventions and agreements are respected ;
APMF
→ PSM
MATSF
Draw up and implement a planning and recovery scheme of the Malagasy territory as well as marine spatial planning
→ PSM
Initiate reflections and studies on the development of the Malagasy marine territory; ensure the regularization of the Malagasy continental shelf.
Harmonize actions undertaken by ministerial departments involved in the promotion of the marine territory
MID
Work for the effectiveness of the land administration
Promote effective decentralization and a good local governance
Min of tourism
Promote a harmonized, orderly and integrated development of tourism so as to stimulate growth of the sector by improving the offers through a training policy on tourism-related jobs
MMRS
Implement the government policy to develop and exploit the resources of the upstream oil sector
Ensure that the United Nations convention on the law of the sea is respected
MDN
Its mission is to execute the national defense policy, implement all the resources that are available to preserve the national sovereignty as well as the land integrity and the national security
The National marine headquarters has to defend the national sovereignty in the waters falling under the Malagasy jurisdiction; coast guards with regards to the State actions at sea
MESRS
Ensure that scientific researches become a real driving force of the development in Madagascar ;
Prioritize research and innovation themes;
Enhance scientific research products through the creating an entrepreneurial strategy
CNRO
CNRE
IHSM



6. Chapter 6. Maritime Space Planning and Management

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6.1. Introduction

Madagascar is an island country, classified as the fourth largest island in the world. Located in the southwestern part of the Indian Ocean, 400 km from Mozambique, its total area is 590,000 km² with a coastline of 5,600 km. In the coastal zone of the island there are mangroves with an estimated surface of 300,000 ha and 50,000 ha of surface suitable for aquaculture. The surface of the continental shelf of the Big Island is 117,000 km² and its Exclusive Economic Zone extends over 1,140,000 km². Madagascar thus has an enormous potential in maritime resources and very diversified marine biological resources. These resources are of undeniable economic and ecological interest for the country and are even the object of covetousness for other nations.

Madagascar's maritime space is a major asset for its opening towards other countries and presents a strategic advantage in its regional integration policy. However, Madagascar's maritime economy remains relatively weak and its maritime space, coveted by other nations, is at the same time subject to pressures causing degradation of its ecosystem and a risk of depletion of biological resources. Therefore, over the last few years, the Malagasy Government has taken initiatives by promoting the implementation of the Maritime Spatial Planning (MSP). The plan consists not only in facilitating the coordination of the use of the Malagasy maritime space for a better contribution of the maritime sector to the development of the country but also, in reviving the balance between exploitation and conservation at the level of the Malagasy maritime territory.

Thus, the above-mentioned initiatives are expected to lead to the establishment of a spatialized management system of the different portions of the Malagasy maritime areas which, in its turn, will:

- Reduce conflicts between sectors and create synergy between different activities
- Strengthen coordination between administrative bodies
- Protect the environment through early identification of the impact and possibilities of multiple use of maritime areas
- Encourage investment in the maritime sector

To achieve this, activities will be undertaken including:

- The establishment of the organizational and institutional framework
- Setting up the database management system
- Mobilization of stakeholders
- Design and development of spatialized management plans
- The establishment of legislative and regulatory measures about the areas and spatialized management plans
- Evaluation and capitalization

6.2. Marine spatial planning

6.2.1. Legal framework governing the maritime space in Madagascar

Au At the national level, some laws are to be considered in the implementation of MSP. These laws establish regulations for activities undertaken in the maritime space under the jurisdiction of the Republic of Madagascar both on the exploitation of marine resources and maritime infrastructures as well as on the protection of the marine environment.

- **Law No. 2015-051 of February 03, 2016 on the Orientation of the land use planning (LOAT);**
- The purpose of this law is to:

  (i) ensure a balanced distribution of population and activities throughout the national territory;

  ii) guarantee the coherence of public and private activities that contribute to the economic and social development of the territory;

  iii) generate, without being exhaustive or exclusive, the conditions for a development adapted to regional and local specificities. Within the meaning of this law, land use planning is understood to mean all public or private actions for the organization, structuring and physical development of the entire national territory and oriented towards a forward-looking vision. It applies to the entire national territory, whether by land, sea or air, in compliance with international conventions and texts in force.

- **Law No. 2018-025 of December 26, 2018 on maritime zones of the maritime space under the jurisdiction of the Republic of Madagascar**

This law defines the maritime zones, including the maritime space under the jurisdiction of the Republic of Madagascar. It provides for the coordination of activities carried out in these maritime zones by enhancing the existing texts in force governing each sector. It also advocates an integrated approach to the management of the maritime space for a common vision of activities at sea through the establishment of the blue economy supported by the Maritime Spatial Planning.

- **Law No. 2015-053 of February 03, 2016 on the Fishing and Aquaculture Code**

The purpose of the fishing and aquaculture code is the sustainable governance and management of fisheries resources for the preservation of aquatic ecosystems and the protection of the biological diversity of Malagasy waters. It defines and sets out the development and management of fisheries; the conditions for the exercise of fishing; the marketing and development of fishery products; the provisions applicable to maritime fishing vessels; the inspection and recording of fishing offences; sanctions and penalties; and the marketing of fishery products. This law also deals with the development and management of aquaculture; measures for the preservation of the environment; the marketing of aquaculture products; the conditions of exercise of aquaculture, the police in the field of aquaculture; infringements and penalties as well as the provisions for the control of the sanitary quality of the fishery and aquaculture products.

- **Law No. 2008-013 of July 23, 2008 on the public domain of the State and decentralized collectivities**

This law stipulates that the territorial sea as well as the gulfs, bays or straits enclosed in the land, the sea shore, the coastal strip, the salt ponds and salt marshes in direct and natural communication with the sea are part of the natural public domain of the State. The use of this public domain is the responsibility of the State.

- **Law No. 99-028 of February 3, 2000 recasting the Maritime Code**

The Maritime Code provides specifications for maritime administrations. It regulates maritime transport and trade activities in Madagascar. It also deals with events that may occur at sea as well as the operation of the ship, the disciplinary and penal regime and maritime insurance and litigation.

- **Law No. 2003-025 of September 5, 2003 on the Statutes of Ports**

This law defines a port as a group of land areas, maritime waters and facilities located on the shores or banks of rivers. This set of facilities meets the physical, natural and organizational conditions that allow the execution of port operations. The law on the statutes of ports classifies the ports and their management and specifies the role of the port authority. This law also deals with the operation of ports according to their status.

- **Law No. 2015-005 of February 26, 2015 recasting the Code of Protected Areas**

The recast of the Code of Protected Areas follows the commitments made by the Malagasy Authorities during the World Parks Congress in Sydney in November 2014 about the goal to triple the number of Marine Protected Areas and to integrate them in a harmonious global environmental landscape. It classifies in different statuses the Protected Areas including the Marine Protected Areas. This law also regulates the creation and modification, the management as well as the penal provisions related to the Protected Areas.

- **Law No. 2015-052 of February 3, 2016 on Urban Planning and Housing**

Among other things, this law is about the introduction of new planning systems such as the deferred development zone and the concerted development zone, as well as the development of different territorial planning tools available to urbanized or urbanizing Communes. In the case of this study, the coastal Communes or regions, both urban and rural, are the most involved because the provisions of Article 67, dealing with the protection of the coastline and lake areas, prohibit construction at a distance of less than twenty-five meters in width along the sea shore. This acts as a warning to the local authorities of the Communes not to lose sight of the strict and tireless control and monitoring of these areas, especially in the issuance of various permits.

Some implementing decrees of these laws which are listed below, without being exhaustive, define the concrete measures for the implementation of Maritime Spatial Planning in Madagascar:

- Decree No. 2010-137 of March 23, 2010 regulating the Integrated Management of Coastal and Marine Areas in Madagascar (GIZCM);
- Decree No. 2017-936 of October 11, 2017 creating the National Framework for the implementation of the Blue Economy in Madagascar; - Decree No. 2018-010 of January 11, 2018 on the general organization of maritime transport lines in Madagascar;
- Decree No. 2018-157 of February 27, 2018 creating a National Tripartite Maritime Labor Council;
- Decree No. 2018-1008 of August 14, 2018 setting the base lines from which the width of the various maritime spaces under the national jurisdiction of the Republic of Madagascar is measured.

6.2.2. National Coordination Committee of the MSP (CNC-PSM)

Given the specificity of maritime spatial planning as a national territory and in accordance with Article 37 of the LOAT, which provides for the possibility of legislating either by law or by regulation the practical modalities relating to the development, implementation, evaluation and revision of territorial planning tools, a National Coordinating Committee for Maritime Spatial Planning (CNC-PSM) has been set up to steer the process and to facilitate inter-sectoral coordination in the establishment and implementation of MSP.

Thus, the MSP National Coordination Committee is a decision-making and strategic body for MSP. Its main mission is to:

- Ensure the coherence of the different sectoral policies in the maritime field;
- Develop MSP on the basis of the best available scientific and socio-economic knowledge of the ecosystem and its dynamics;
- Coordinate all zoning operations within the framework of Maritime Spatial Planning in Madagascar;
- Reduce conflicts between maritime uses and between exploitation and protection;

The CNC-PSM is therefore presented as an interface structure between the technical and political dimensions of MSP. To this end, it ensures:

- Validation of all steps in the process of setting up the MSP
- Validation of the terms of reference and the results of studies launched in the framework of the implementation of the MSP
- Facilitation of cooperation with the Technical and Financial Partners in the framework of the MSP process
- Facilitation and technical support in the development of legal texts on regulatory measures
- Arbitration of conflicts arising from the process or application of Maritime Spatial Planning

However, as the principle in this study is to respect existing structures for a better coordination of all the steps to implement the MSP, the involvement of the National Council for Land Use Planning instituted by Decree No. 2019-1935 of October 31, 2019 setting the composition, operating procedures and responsibilities, the involvement of the National Council for Spatial Planning, established by Decree No. 2019-1935 of October 31, 2019, establishing the composition, operating procedures and powers, seems relevant and logical given that it is composed of, among others, all the ministerial departments and that its functions consist of overseeing the implementation of the Government's national policy, the coordination of sectoral spatial planning actions, as well as the development of a global vision and a spatial approach to the territory.

Thus, the opinion of the National Council for Spatial Planning will have to be taken into account during the deliberations of the MSP Coordination Committee before their execution and more particularly the decisions concerning the arbitration of conflicts before the referral to the Government. On this point, conflicts are always settled by negotiation. In case there is a failure to achieve conciliation, the final decision is the responsibility of the Government.

The MSP process is a public matter and is part of the State's action. For this reason, the National Coordination Committee of the MSP is mainly composed of a high-level representative of the:

- Ministry in charge of the land use planning
- Ministry in charge of the sea, fishing and aquaculture
- Ministry in charge of the Environment
- Ministry in charge of the Mine and strategic resources
- Ministry in charge of maritime transport
- Ministry in charge of Tourism
- Ministry in charge of National Defense and Territorial Security
- Ministry in charge of Public Finance

- National ICZM Committee

Representatives of other actors and stakeholders (NGOs, economic operators' groups, civil society organizations, local communities, etc.) involved in the process may join the CNC-MPS as advisors.

This CNC-MSP will be supported by a technical and operational support structure whose creation will depend on the choice made among the three scenarios presented below:

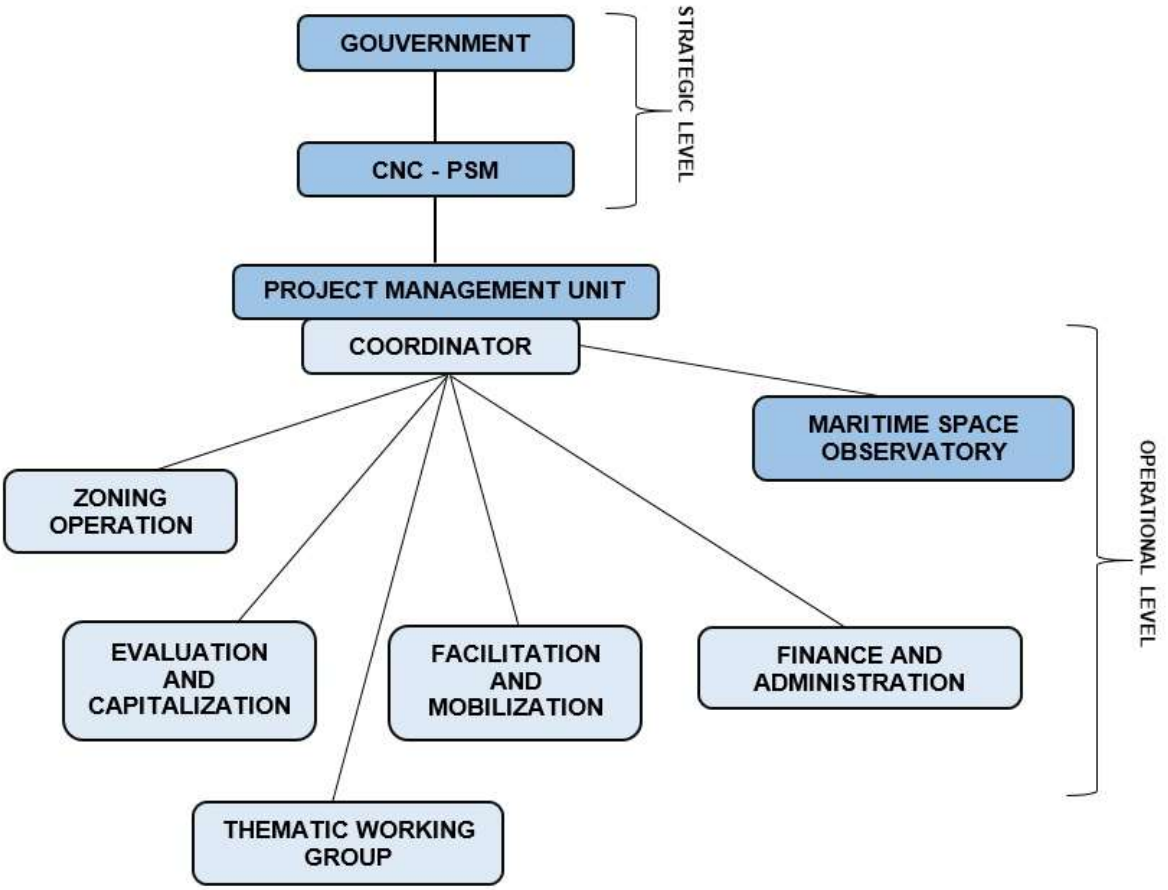
Scenario 1: Project Management Unit Structure

A Project Management Unit headed by a coordinator assists the Coordinating Committee for Maritime Spatial Planning (CNC-PSM) on the operational and technical level. This Unit will mainly be responsible for:

- Supporting and facilitating the reflections and consultations initiated at the national, regional and local levels on the MSP process
- Mobilizing, coordinating and harmonizing the interventions of partners and stakeholders in MSP
- Ensuring the proper functioning of the database management system networked for MSP
- Launching and supervising the technical work of zoning and the development of the Spatialized Management Plan at sea
- Ensuring the monitoring and evaluation of the implementation of the MSP
- Capitalizing on experiences that can contribute to the improvement of MSP in Madagascar

The Project Management Unit will be supported by a scientific group and a socio-economic group that will form a thematic group. It will ensure the administrative and technical activities in the implementation of MSP in Madagascar according to a procedure handbook which suits the Malagasy context.

Figure 46: Organizational chart of the Project Management Unit structure for the implementation of MSP



This structure has the advantage of being stable and insulated from institutional changes at the government level. Logically endowed with an autonomous budget as a project, it is more flexible on financial management while implementing the MSP. The Project Structure is, moreover, the most suitable for cooperation with traditional donors who can support this process.

On the other hand, this structure requires a great deal of political will on the part of the Government for its implementation and the existence of donors willing to finance the process. These aspects are major constraints in the implementation of this process. On the other hand, the establishment of such a structure, which is, by nature, exogenous to the institutional environment in the maritime sector, makes it difficult for the administration to internalize the process and ensure its continuity at the end of the project.

In this scenario, the governmental structures ensure their sovereign missions such as the establishment of the political orientation, the facilitation of activities through the development of institutional relationships, the establishment of legal texts governing the implementation of the MSP, the issuance of authorizations to carry out activities at sea according to the spatialized management plans, the follow up and control of the application of the texts in force as well as the undertaking of administrative and judicial measures in case the established rules are violated.

Scenario 2: Existing structures

In this scenario, the operational structure for the implementation of the MSP is essentially made up of the operational directorates of the Ministry in charge of land use planning, the Ministry in charge of the sea and the operational structure of the CN-GIZC. These existing structures, in close collaboration with the Ministry in charge of the environment and which are in support of the National Coordination Committee, which remains the deliberative body, ensure that activities are properly carried out within

the framework of the MSP process. The mission of these structures, in the implementation of the MSP, corresponds to the responsibilities of each one according to the texts that institute them.

- *Directorate within the Ministry in charge of land use planning*

This structure, following the orientations decided at National Coordination Committee of the MSP level ensures the technical preparation and the supervision of the zoning operations. It coordinates the development of the situational analysis as well as the establishment of the current and future trends at the level of the planning units. It also develops the spatialized management plans at sea.

- *Directorate within the Ministry in charge of the Sea*

It deals with the coordination of activities that can technically support the MSP process. It organizes and leads the reflection and support work at the level of the scientific and technical thematic groups in collaboration with the actors in each field of the maritime sector, in particular the department in charge of the environment. It will take charge of the coordination of the analysis work on the determination of the planning units and the maritime governance system taking into account the marine ecosystem. Within the blue economy development framework, the department in charge of the sea is responsible for the evaluation of the effects and impacts of spatialized management plans implementation as well as the capitalization of experiences that can improve the MSP in Madagascar.

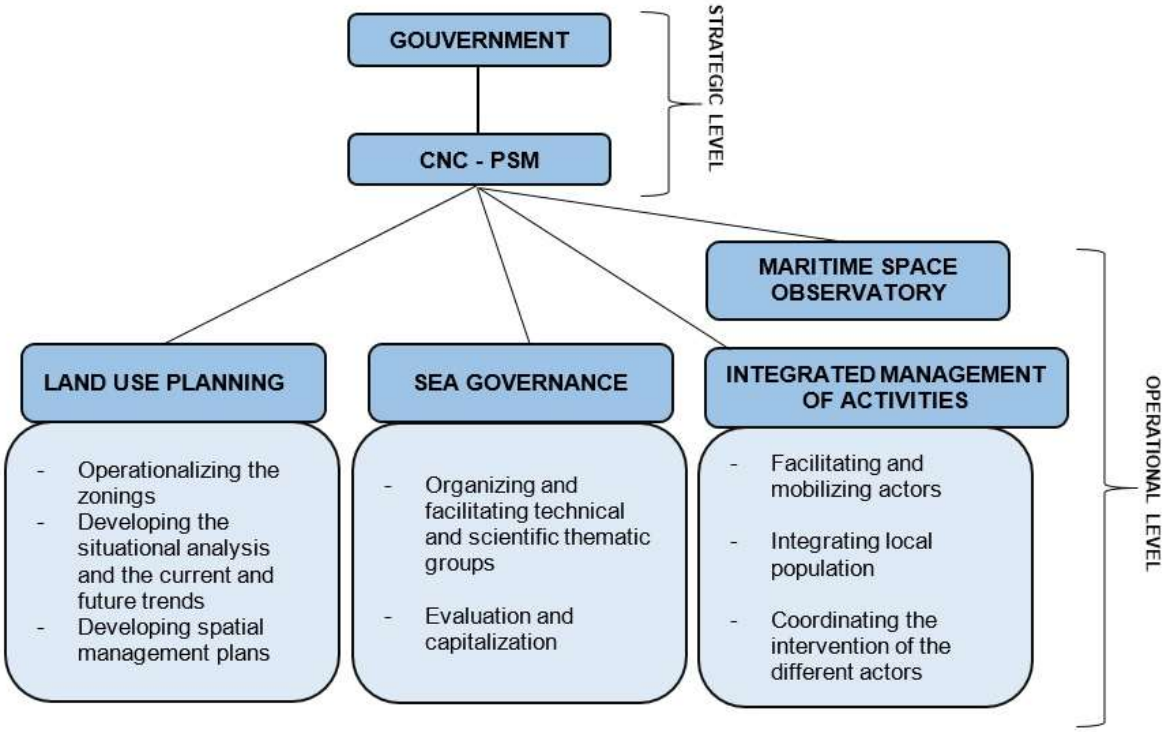
- *Operational structure of the National ICZM Committee*

The operational structure of the NC-ICZM, with its branches at the Decentralized Territorial Collectivities level, is responsible for facilitating and mobilizing stakeholders at the national, regional and local levels to integrate the MSP process. It promotes the participation of the local population, coordinates and harmonizes the intervention of each actor in the maritime sector in relation to their commitment to the integrated management of coastal and marine areas. It ensures, in the first place, the harmonization of the interests of the actors in the sector and the prevention of conflicts related to the exploitation of maritime and coastal areas.

- *Observatory of the Maritime Space*

Following the principle of valorizing existing structures, the Maritime Spatial Observatory, which is in charge of managing the database networked for the MSP, can be integrated into the system of the Observatory of Land use planning and Land services (OATF). This Observatory, although part of OATF, must be constituted as a department or service in its own right given its specificity with regard to the land territory.

Figure 47: Organization chart of the existing structure for the implementation of MSP



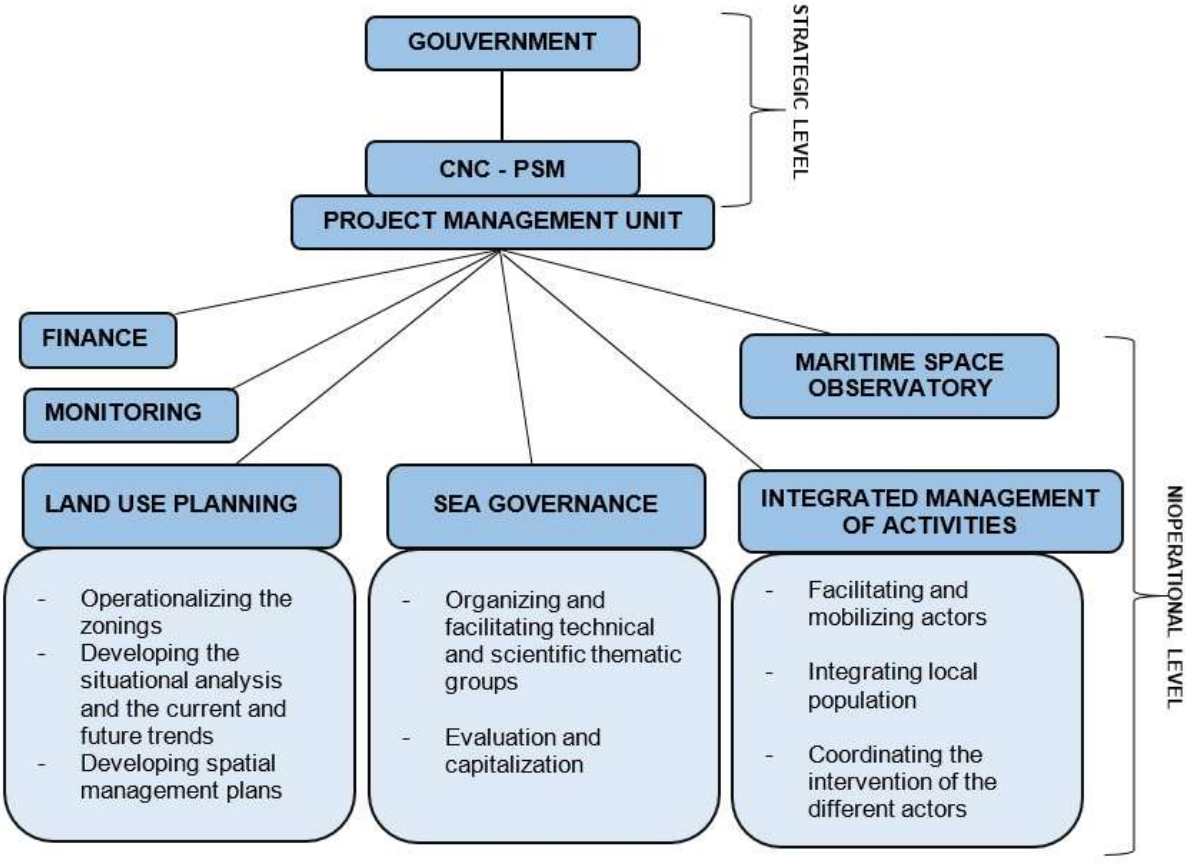
This scenario fits the current institutional set-up. It encourages the political will to initiate the MSP process and facilitates its implementation. The use of existing structures also gives a more sovereign character to the implementation of MSP and favors a better involvement of the actors and the continuity and sustainability of the process.

On the other hand, this scenario can be disrupted by change in government structure. It presents more difficulty in coordinating operational activities, in planning and financial management.

Scenario 3: Merged Structure

The two institutional and organizational schemes for the establishment and implementation of MSP described above can be merged into a single structure at the Prime Minister's Office, incorporating Integrated Coastal Zone Management. This structure will set up a Project Management Unit that coordinates the activities of existing structures within the ministries for the implementation of the process.

Figure 48: Organization chart of the Merged Structure for the implementation of MSP



In this scenario, the NCC-MSP will replace the NC-ICZM structure by including Integrated Coastal Zone Management in the MSP operational process. Indeed, both the MSP process and the ICZM approach aim at a better governance of the sea or ocean through an integrated management of multiple uses and activities in order to optimize the economic and social impacts in the framework of sustainable development and to avoid or reduce conflicts.

However, unlike MSP, ICZM activities mainly focus on the coastal part of the territory, therefore within the limits of the continental territory and very rarely in the maritime space. For its part, MSP covers the maritime space under national jurisdiction while integrating coastal areas because of the close links between coastal and marine ecosystems. Still, spatial management plans within the framework of the MSP process could be based on ICZM tools; which are characterized by an approach based on a consensus between the State, regional and local authorities of the coastal areas involved in the project.

Integrated Coastal Zone Management is defined as a continuous, proactive and adaptive resource management planning process for the sustainable development of the environment in coastal areas. The implementation of this approach is determined by the National Sustainable Development Policy and Strategy. It is logical that the promotion of integrated coastal and marine management can be included in the implementation of the MSP.

This is not obviously a divergent approach but rather a complementary one. MSP has the essential character of the maritime space "spatial planning" concept which underlies several objectives related to the coordination and management of activities through zoning methods as well as compliance with the associated measures whereas the planning of activities in the coastal zones by integrating the environmental dimension distinguishes ICZM. Moreover, according to the LOAT, "territorial planning tools are binding on the actors involved in land use planning. They serve as a reference framework for the policies, programs and projects of the ministries and Decentralized Territorial Collectivities."

This scenario combining the Project Management Unit structure and the existing structures, as well as the other scenarios, do not in any way remove the responsibility and central role of the Ministry in charge of land use planning in establishing and implementing the MSP, which the LOAT already provides for as previously discussed. The coordination structure would reflect the consideration of the interests of all stakeholders (CTD, public bodies, socio-economic actors, citizens according to Article 5 of the LOAT), including ICZM and the consideration of cross-sectoral and cross-cutting aspects of the maritime domain in the decision-making process of the MSP.

6.3. Implementation of the Maritime Spatial Planning

6.3.1. Establishing strategic and institutional framework

- **Concerning the National Land Use Planning Policy**

As the maritime space is part of the National Territory, Maritime Spatial Planning can be implemented within the framework of the National Land Use Policy (PNAT). The general objective of this policy is the development of the national economy based on the promotion of a market economy oriented towards the export of goods and services while respecting human beings, the complementarity of the Regions and the preservation of the environment. The MSP must contribute to the achievement of two specific objectives of the PNAT, namely: i) the integration of the national economy into the regional and international market, ii) the rationalization and improvement of the management and development of natural resources. The orientations of the PNAT to which the MSP can be integrated are:

- Territorial efficiency: at the level of the maritime space, the MSP represents the planning tool, the instrument and the basic reference framework for the coordination of all development actions at sea.
- Promotion of significant areas: the productive use of the different maritime areas must be the leading reason for their valorization.
- Sustainable management of natural resources: in all actions and at all levels, the integration of the environmental dimension is the main rule and the conservation areas as well as the sensitive areas must be maintained.
- Data and communication control: establishing or strengthening a unified system of mapping and territorial information is necessary to ensure the consistency and interchangeability of data and to better identify the spatial and economic dimension of interventions to be carried out as part of good governance of the maritime space.

- **Concerning the National Maritime Policy**

The national maritime policy should be one of the strategic framework documents for maritime spatial planning. Consultations between the ministerial departments involved in the Malagasy maritime space are necessary in the formulation of this policy. In 2012, the African Union released an "Integrated African Strategy for the Oceans and Seas - Horizon 2050 (AIM 2050 Strategy)" whose overall vision is to foster the creation of greater wealth from Africa's oceans and seas by developing a thriving, sustainable, safe and environmentally friendly blue economy. The document calls for an Africa that uses its own resources to take its rightful place in a multipolar, interdependent and more equitable world.

Inspired by this strategy and other ocean policies of countries such as France or Canada, the National Sea Policy should strengthen the sovereignty of the Malagasy State in the management of the maritime space under the jurisdiction of the Republic of Madagascar and would guide the development of the maritime economy for the benefit of the State and the Malagasy population. To this end, it should, among other things:

- Affirm the responsibilities and roles of the State at sea;
- Delimit our maritime space by integrating the scattered islands;

- Develop governance and enforce national legislation to promote the blue economy and defend our interests in the maritime sector;
- Harmonize national tools and strategic documents with international norms and standards;
- Ensure the security of the maritime space under the jurisdiction of the Republic of Madagascar.

Establishing this national sea policy, and eventually its strategic declination, is the responsibility of the Ministry in charge of the sea. It will also provide essential guidelines for implementing the Maritime Spatial Planning.

- **Institutionalizing the Maritime Spatial Planning process**

La The first action in implementing the MSP is to institutionalize the process. This is done through the establishment and enforcement of a regulatory text specifying, among other things:

- The definition of MSP and the justifications for carrying out this process ;
- The objectives and general principles that guide its implementation,
- The institutions involved,
- The coordination structure and the operational structure as well as the rules governing their functioning;
- The arrangements for database management and communication;
- The financial provisions.

This regulatory text reaffirms more precisely the binding force of the spatialized management plans induced by the implementation of the MSP and specifies the practical modalities for developing, implementing and reviewing these tools. Based on the laws from the analysis of the legal texts previously developed, in particular the LOAT, the drafting of this text must be done in a concerted manner with the involved entities before being proposed to the Government.

The institutionalization of the process first demonstrates the political will to plan the use of the maritime space for the development of Madagascar and facilitates the exploitation of all opportunities for technical and financial support to the MSP. The Coordination Structure will then take charge of the implementation of the other steps.

6.3.2. Mobilizing the stakeholders

Consultations, during periodic meetings in the form of thematic working groups, between the actors using the maritime zones must be maintained throughout the implementation of the MSP. Two types of meetings are to be organized and led:

- **Technical and scientific working groups**

This is a working group, composed of specialists and researchers in various fields of the maritime sector, to reflect, discuss and make proposals or recommendations of a technical nature on a scientific basis for the implementation of MSP. From this working group will come the criteria for the delimitation of a portion of the marine environment subject to zoning, the resources exploited as well as the pressures on this area, the current trend, the potential of the area and the future trend. This technical and scientific thematic group prepares and proposes to the MSP Coordination Committee the basic arguments for the zoning operations and the establishment of the spatialized management plan.

- **Stakeholder working groups**

This is a grouping of the different types of actors who use the maritime space. These meetings are organized to discuss and analyze the problems encountered by each entity and to coordinate the actions on the ground of the actors intervening in the maritime space. The stakeholder working groups should be extended to the regional and local level for a better integration of local stakeholders in the

process. From these meetings between stakeholders, the basis and nature of conflicts of interest between stakeholders, the contexts justifying MSP, the responsibilities, commitments and various recommendations of stakeholders in the implementation of this process should emerge. Thus, addressing the common interests of the Administration, economic actors and local communities is part of the results of this activity. The results of the stakeholder working groups are to be forwarded to the National MSP Coordinating Committee (CNC-MSP) for decision-making on the orientation of the zoning operation and the establishment of spatialized management plans.

6.3.3. Management of useful basic data for MSP

The actors in the maritime sector, through their missions and activities in the marine environment, hold and use basic data and information on the maritime areas of Madagascar; these data are very useful for Maritime Spatial Planning. The activities in the marine environment have as common characteristics the use of the sea as a main support and can be classified in 7 types of uses: Exploitation of fishery resources; Exploitation of sea salt; Tourism and recreational activities; Port and maritime transport activities; Protection, conservation and sustainable management of maritime areas; Exploitation of underwater mining resources; Energy production.

These activities generate data and information that can be biological, physical, oceanographic and technical and socio-economic data related to human activities.

A good management of these data and information based on an efficient spatialized information system results in adequate decisions on zoning and regulation of the use of the sea as well as the development of the maritime space. The Geographic Information System is indicated for representing the data in the Malagasy maritime space by associating the geographical coordinates and the collected data and the setting in the same format of the various information which form the inputs for other prioritization analysis and modeling software. Two specific software packages that have already been initiated in Madagascar are offered for this prioritization analysis: the MARXAN software and the ZONATION software. These equipments, the most used in several countries and specialized for the prioritization of conservation areas in spatial planning, allow to prioritize the distribution of the use of the sea according to the objectives that were set in a precise way within the framework of a clear vision and maritime space development policy.

Because these basic data and information which are useful for Maritime Spatial Planning are scattered over different actors, the need to implement a maritime space observatory is of utmost importance to enable the networking of these data. This observatory's purpose is to monitor, analyze and understand the social and environmental dynamics that result from the interaction of biophysicial and socio-economical activities in the different zones of the maritime space of Madagascar. The observatory acts then as a permanent exchange place as well as a data and knowledge sharing center between the different actors who are involved in the use of the sea and the implementation of the Maritime spatial planning. Conventions on data collecting and use of the information system between the Ministry in charge of Land use planning on behalf of the Maritime space observatory and other stakeholders of the PSM should be established to ensure that this system becomes operational. These conventions must contain in general information on the stakeholders; the purpose of the convention, the commitments and duties of each participant; the implementation mechanism; rules and confidentiality arrangements; conflict resolving; duration and termination.

6.3.4. Design and development of the spatialized management plan

The design and development of the spatialized management plan and the capitalization of the different information require a great number of actors because the human activities and the scientific information would enable a primary determination of the use of a considerable part of the marine environment. This step needs to rely on the operation of the zoning activities as well as the establishment of the use and management principles of the targeted space. Therefore, it is important

to mobilize all the stakeholders including the local actors to get involved in achieving this activity. It also requires a strong political and technical coordination as well as a logical and rational programming. It would be better to start the zoning of the maritime space of Madagascar at the level of the zones where a great number of maritime activities have been undertaken from a long time and where scientific or socio-economic data are available. Therefore, zoning operations extends over time and place over several years to cover all the maritime space and to update the already established zoning plans after the evolution of the biological, ecological, physical and economic contexts.

6.3.5. Evaluation and capitalization

The evaluation and capitalization aim to reinforce how relevant, effective and efficient the implementation of the MSP is. It also wants to consolidate the relationships between the stakeholders, to value the learning and to reconsider the objectives and the spatialized management plans.

The evaluation of the implementation of the MSP is focused on the feedback from the application of the spatialized management plans as well as its effects and impacts on the development of the maritime economy and the social dynamic of the populations that are affected by the activities on the sea. This evaluation allows as well the decision-making to reinforce the institutional capacity of the stakeholders involved in the process and the review of the plans or the promotion of the investments and can even go as far as to stop the issuance of authorizations in case the zone is saturated.

Three types of evaluation can then be considered:

- ***Internal evaluation***

This operation can be considered as a self-assessment because it will have to be performed by the CNC-PSM. The analysis of the monitoring indicators from the information available at the database management system and the process programming allows to assess or measure the performance of the operational structures and the other actors involved in the implementation of the MSP at a given time. The internal evaluation promotes the improvement of the implemented system. A good operating of the system will bring essential and needed data for the drafting or the review of the spatialized management plans.

- ***External evaluation***

This kind of evaluation is much more objective and enlightens the factors that could consolidate or weaken the MSP process since its implementation to its operating stage. External evaluation allows an objective assessment of how relevant, efficient and effective the process is as well as the plans that arise from it. At the same time, it helps to check its influence and the management of risks that were predicted. External evaluation is more appropriate for the improvement or the reorganization of the system operation on which the MSP process is based.

- ***Evaluation by the stakeholders involved in the process***

This approach allows and in a participative manner to evaluate at the same time the management capacity of the process, the operationalization of the spatial management plans and the collaborations between the stakeholders. This evaluation may take the form of a result capitalization workshop which will also provide as much information as possible. These results are useful to improve the process and to justify the prospections and researches to be developed.

- ***Documentation and capitalization***

All the actions which are undertaken in the MSP as well as the results that are obtained must be kept in different forms: photos, video, minutes, reports, articles and others … It is important to gather this information to make it possible to keep track of their progress in the implementation of the MSP. At the same time, the acquired information can be valued through external and internal institutional communications.

An analysis of the documented information promotes the development and the knowledge management which will be useful to reflect and to make strategic decisions on the MSP process. A good capitalization will guide the planning towards the review or the consolidation or the extension of the spatialized management plans or more generally the policy for the maritime territory development.

6.4. Monitoring, control and surveillance

This section describes how the spatialized management plan will be implemented and monitored, as it is a living document. It describes how the plan will be implemented, monitored, reviewed and adapted over time.

- ***Implementation agreement***

The general approach to implementing the plan is set out in an implementation agreement, which will be negotiated and signed by the authorities. The implementation agreement will include a work plan that incorporates priorities, roles and responsibilities and associated commitments for planning implementation, budget, monitoring, review and amendment, and procedures for fair dispute resolution.

- ***Priorities and implementation schedule:***

While all of the objectives and strategies identified in the plan are important elements for the preservation and development of each area, a number of key results and priority actions should be identified and scheduled. These priorities can be the subject of a "Charter of Accountability" which should outline the development and financing scheme and the practice of evaluating the implementation of priority projects in a few priority areas. For each identified development sector, a Sector Development Plan must be drawn up, emphasizing the objectives, the rationale for the actions, the description of the components, the opportunities, the technical and financial economic benefits, the threats of technical and financial non-achievement, the interrelationship, complementarity and integration with the other sectors, the effects and impacts indicators, the potential technical and financial partners, the skills needed for implementation and monitoring, foreign experiences, etc.

This sub-section thus consists of defining the priority objectives that will be translated into priority projects to be carried out, and then establishing an operational plan to ensure effective implementation of the plan in the next 5 to 10 years. However, the list should not preclude the identification of additional priorities as needed if an opportunity arises.

The priorities and the projects they generate will be spatialized and mapped.

- ***Funding for the implementation***

Effective implementation of the marine plan, both in the short and long term, will require both human and financial resources. Funding arrangements and potential partnerships will be explored.

- ***Indicators and monitoring***

Implementation indicators of the ecosystem approach will be selected to measure long-term ecosystem changes, including community and human health, that are potentially attributed to implementation of the Plan's recommendations. Indicators should reflect aspects of marine ecosystem attributes and how they will be measured.

- ***Evaluation, review and modification of the plan***

Progress in implementing the plan should be reviewed from the date of final approval of the plan. Implementation will involve the mobilization or creation of a technical coordination structure/team/body to guide and oversee the implementation process. This technical coordination body will be composed of representatives from the Decentralized Territorial Collectivities, Deconcentrated Technical Services and other key actors.



7. Chapter 7. Cost-benefit analysis

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7.1. Introduction

Ensuring that the marine and coastal ecosystems stay in a good operating shape is a matter of the utmost importance for the survival of Humankind and the nature itself, and this is mostly true for an island like Madagascar. Besides its financial value, these ecosystems also convey ethical and moral values which must be dealt with, provided that this differential treatment will not end up in exclusion or in total oblivion. The prospect of precaution might also lead to a change in the way some consequences of the choices are viewed (OCDE, 2002).

The fact remains that a great number of the services that ecosystems provide do not have any specific predefined value since they cannot be the object of any transactions on the market. This awareness has led economists to find ways to measure their utility variations due to a rise or a lowering of the quality of the environment in monetary terms in order to get commensurable magnitudes with the exchanges that are taking place on the markets.

Most of the resources can be used in different ways, therefore their opportunity cost is not equal to zero and all the choices we make can be assessed by looking at what we then will have to give up to get them. The quest for the best allocation of the resources, i.e determining the choices that will allow the fulfillment of the greatest social well-being must go through an analysis of their pertinence for which the economic evaluation offers a coherent framework. Although appealing to monetary value rises a number of problems, it opens up the opportunity to line it with a whole range of other choices, namely in their allocation in public finances.

Although the issue of biodiversity and ecosystem services is significantly more complex than that of climate change, it is possible to develop a cost/benefit approach through economic estimates of biodiversity-related ecosystem services.

These estimates are useful for evaluating the costs of certain changes in land use, such as the development of annual crops to the detriment of areas with permanent vegetation cover, and are evaluated as being equivalent to the costs of restoring ecosystems considered to be equivalent in ecological terms.

However, this approach has some weaknesses, namely:

- The difficulty of approaching, even in an approximate way, the value of remarkable biodiversity, which is the reason why we recommend that the economic approach is only used in a very subsidiary way;
- The contingent nature of these estimates, since they essentially concern use values, which are likely by definition to vary according to the intensity of these uses. For example, in the case of the value of wood production, which is most of the time exploited in a very informal way, of the value of drinking water production, which uses an important portion of the Value of water production of the forests while being a variable proportion, which encourages taking into account this long-term potential in the estimation of the reference values ;
- The lack of thorough studies on certain services that may represent potentially important economic values, such as protection services or those related to the modulation of river flows;
- These benefit-based approaches do not necessarily appear to be deterrent, on their own, to the development of highly profitable infrastructures (urbanization, industrialization, and transportation) and it therefore seems difficult to do without a regulatory approach in this case, at least in the areas that one wishes to protect.

The total economic value (TEV) of ecosystems (Pearce, 1993 ; Pearce and Moran, 1994; Turner, 1999) is classically broken down into use value and non-use value. The construction of a total economic value implies a form of aggregation of these different values.

Perman et al (2003) point out that there are several formulations, depending on whether the perspective is focused on the environmental costs (EC) of projects or, symmetrically, on the total value (TV) of the assets at risk, with EC = use values + existence values + option values + quasi-option values and TV = use values (direct and indirect) + non-use values (option, existence, etc.).

The basic premise of the economic evaluation method is that: "the positive ecological effect will not be significant until it is expressed in economic and social values, i.e. in impacts on people". The goal of evaluation is to clearly establish the value of each use and not necessarily to assign a total value to nature (Michael, 1995 in Kengen, 1997). The economic value of ecosystems is thus measured by the different forms of use of the goods and services they provide.

The second principle of economic evaluation is that "we should not try to evaluate everything" (Gregersen, et al., 1997). Many goods and services have impacts on people, but only those of tangible importance will be considered in this analysis.

The following table reflects the goods and services considered in the analysis:

Table 62: Goods and services taken into consideration in the cost-benefit analysis

CATEGORIES / SUB CHAPTERS	ITEMS TAKEN INTO CONSIDERATION FOR COSTS	ITEMS TAKEN INTO CONSIDERATION FOR BENEFITS
Supply goods and services		
Value of coastal food output: coastal agriculture / coastal resources	- Total insecticides/pesticides/ manure/direct use /farm infrastructure - Deforestation surface area / forest clearing surface in order to have lands for crops - Surface area of loss of habitats (mangroves, coral reefs) so as to have fish products. - Total cost of fishing efforts - Erosion of watersheds and coastal erosion - Waste and pollutions - Cost of energy production value - Cost of water production value for food and agriculture - Erosion costs - Costs of mining researches and exploitations - Setting up and operating costs of salt marsh	- Total value of coastal Districts / Regions farm production - Value of Districts and Regions livestock production - Total value of marine fishing resources: fish, seafood, algae in coastal Regions and Districts - Total value of forestry / timber resources in coastal Regions and Districts - Total value of medicinal plants in coastal Regions/Districts - Value of harvesting and hunting products - Value of honey production on mangroves and coastal forests - Value of coastal mining and marine products - Mining discounts and royalties - Value of submarine gas and petrol - Total resources of water for food and agriculture - Marine and hydro energy value

CATEGORIES / SUB CHAPTERS	ITEMS TAKEN INTO CONSIDERATION FOR COSTS	ITEMS TAKEN INTO CONSIDERATION FOR BENEFITS
		- Value of salt marsh production
Reduction of poverty	- Total values of income generating activities implemented by the projects and the partners to improve the income and to reduce the pressures on the ecosystems	- Household income - IDH
Total economic values of supply services		
Regulation goods and services		
Coastal protection	- Value of protection infrastructures - Value of upstream BV protection	- Value of property which have not been damaged by upwelling (see TBER) - Value of coral reefs
Climate regulation/ regulation of disturbances	- Reforestation, restauration and tree planting costs	- Value of reforestation, restoration, and tree planting - Total value of carbon sequestered by the different ecosystems
Coastal forestry (mangroves)	- Value of the restoring of mangroves	- Total value of carbon sequestered by mangroves - Total value of the production of sea foods
Implementation of the different measures	- Cost of the reinforcement actions	- Capacity building of the stakeholders - Improvement of the infrastructures - Reinforcement of the structures of intervention
Total economic value of regulating services		
Cultural goods and services		

CATEGORIES / SUB CHAPTERS	ITEMS TAKEN INTO CONSIDERATION FOR COSTS	ITEMS TAKEN INTO CONSIDERATION FOR BENEFITS
Cultural and cultual sites /Tourism	- Maintenance and protection costs of the sites - Cost of waste processing - Cost of the fight against sexual tourism	- Economic value of cultural and cultual sites, protection of the sites, improvement of the fame of the sites and coming of tourists - Value of the improvement of the infrastructures to host tourists - Value of hydrotherapy and thalassotherapy
Education	- Cost of infrastructures building - Cost of scientific researches	- Value of the population awareness on ecosystems value - Value of the sites where scientific researches are conducted
Total economic value of cultural services		
Support / back up goods and services		
Maintaining genetic diversity	- Cost of coral reefs protection - Cost of restoring mangroves - Cost to protect genetic zones	- Value of coral reefs - Value of mangroves - Value of marine PAs - Value of marine turtles' nesting zones
Cycle of nutrients	- Cost of sea and coasts decontamination	- Total values of nutrients
Total economic value of support services		
Values of ecosystems in a critical situation		
	- Costs to repair critical ecosystems	- Value of damaged coasts - Value of destroyed mangroves - Value of destroyed coral reefs
Ports and harbors		
	- Cost of maintenance and decontamination of ports and harbors	- Number of affected ports and harbors - Flow of goods – import and export values, taxes and levies

Carrying out a cost-benefit analysis of Madagascar's marine ecosystems thus presents several difficulties and requires repeated consultation meetings to establish the methodology to be used for the calculation.

This chapter will therefore only focus on presenting the contribution of the coastline to the economy through the services it provides.

In 2019, Madagascar has a GDP per capita of 471 dollars with a total gross domestic product of 12.73 billion dollars for a population of 25.06 million inhabitants.

7.2. Economic evaluation of the supplies

Economic evaluation of ecosystem services is an economic tool to quantify the benefits an ecosystem provides (in monetary units). It is one of the important tools in the economic evaluation of biodiversity. It mainly meets the need and desire to use the "economic language" to preserve nature and biodiversity so as to better integrate the environment into economic dynamics.

7.2.1. The fishery

Madagascar's marine and coastal waters are home to a large number of commercially important fish species, such as shark fins, wild eels, bichiques, squid, elves, crabs, wild shrimps, lobsters, tuna, other fish, octopus, and trepan (APR 2020). With 5,600 km of coastline, Madagascar has an enormous potential in fishery resources. The Ministry in charge of fisheries has identified twelve main fisheries.

Commercial fishing activities are found in the 13 coastal regions, but are more intense in the warmer western and southern regions of the country. In addition to industrial fisheries, artisanal fishing communities can be found along the entire coast, with different fishing methods and catching a variety of different species.

There are two kinds of fishing activities, namely, industrial and artisanal fishing. Recreational fishing is very limited along the coasts of the big island. The fishing products are intended for self-consumption, local sale and export. Most of the local consumption and sale comes from artisanal fisheries, while the export products come from small-scale, labor-intensive industrial fisheries and highly industrialized deep-sea vessels.

With regards to production, the following table reflects the evolution of the economic value of the fishery from 2013 to 2019.

Table 63: Local economic value of fish products for 2013-2019 period (in USD)

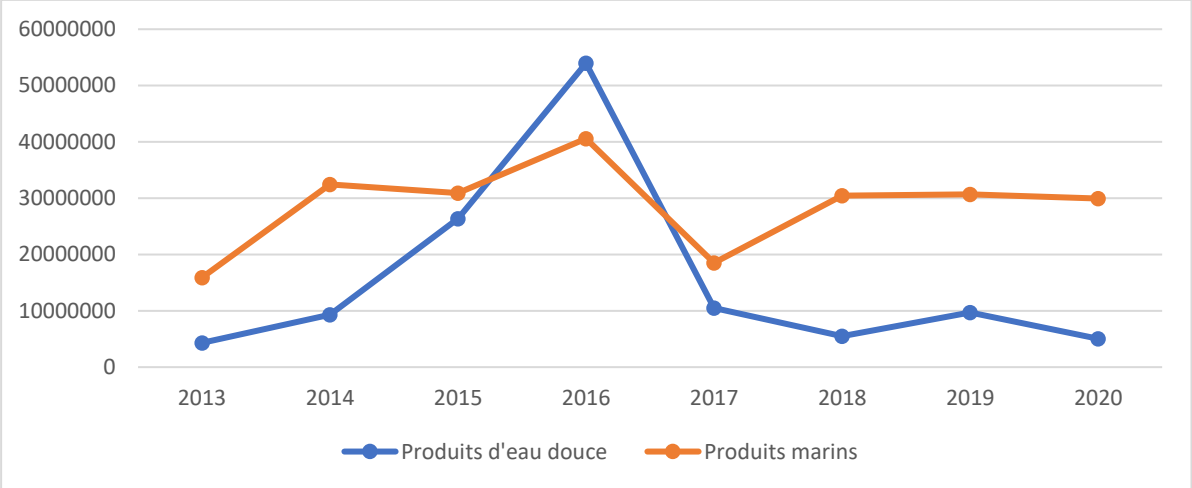
	Fresh water products	Marine products	Total value
2013	4,314,767.93	15,916,611.45	20,231,379.95
2014	9,329,792.58	32,444,080.49	41,773,873.64
2015	26,361,638.26	30,931,216.75	57,292,855.57
2016	53,960,107.09	40,573,263.63	94,533,371.28
2017	10,518,143.31	18,494,818.08	29,012,961.96
2018	5,516,861.80	30,432,559.53	35,949,421.89
2019	9,704,891.45	30,692,447.77	40,397,339.78
2020	5,060,319.28	29,938,926.75	34,899,246.03

(1USD = 3570,45679 Ar)

Source: MAEP/DGP/DOEP, 2021

Figure 49: Evolution of the local economic value of fish products from 2013-2020

A strong increase in the economic value of fresh water and marine products was observed in 2016. This is due to the increase of the royalties amount since 2014. Marine products contribute much more to the national economy compared to the production of fresh water.



Source: DGP/MAEP, 2020 (Data processing: ONE)

Table 64: Economic exports value of fish products from 2006 to 2021

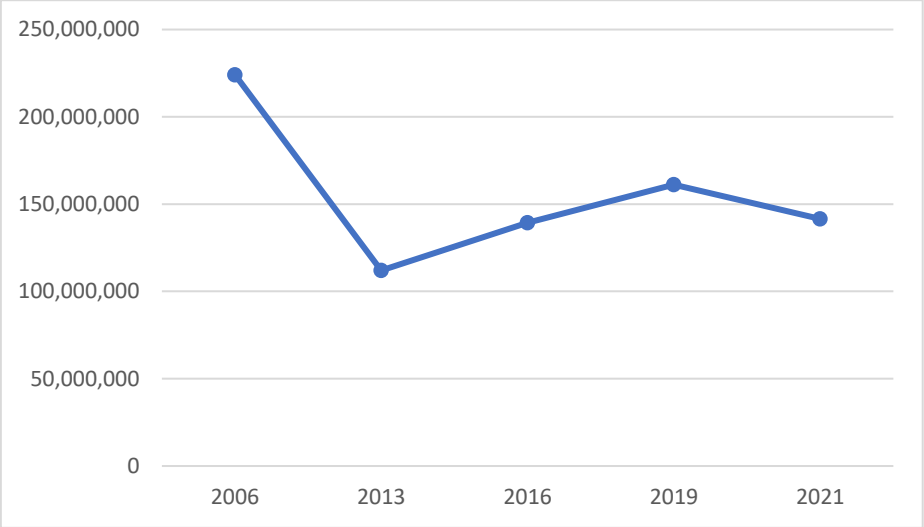
The value of exports of all fishery products has fallen from nearly 800 billion Ar in 2006 to 529 billion Ar in 2020 and 505 billion Ar in 2021. A significant shortfall in terms of foreign exchange for the State due to the decline in productivity of some stocks, particularly that of shrimp due to the spread of the White Spot virus in the waters of the Mozambique Channel, which led to a drop in its production from 2013.

Year	Value (in USD)
2006	224,060,765.30
2013	112,007,254.18
2014	115,451,274.96
2015	115,775,156.86
2016	139,257,239.26
2017	159,954,820.97
2018	141,977,000.45
2019	161,143,130.07
2020	148,580,087.90
2021	141,438,358.10

(1USD = 3570,45679 Ar)

Source: Comparison of ASH and Customs export data by OEPA, 2021

Figure 50: Evolution of the economic export value of fishery products from 2006 to 2021



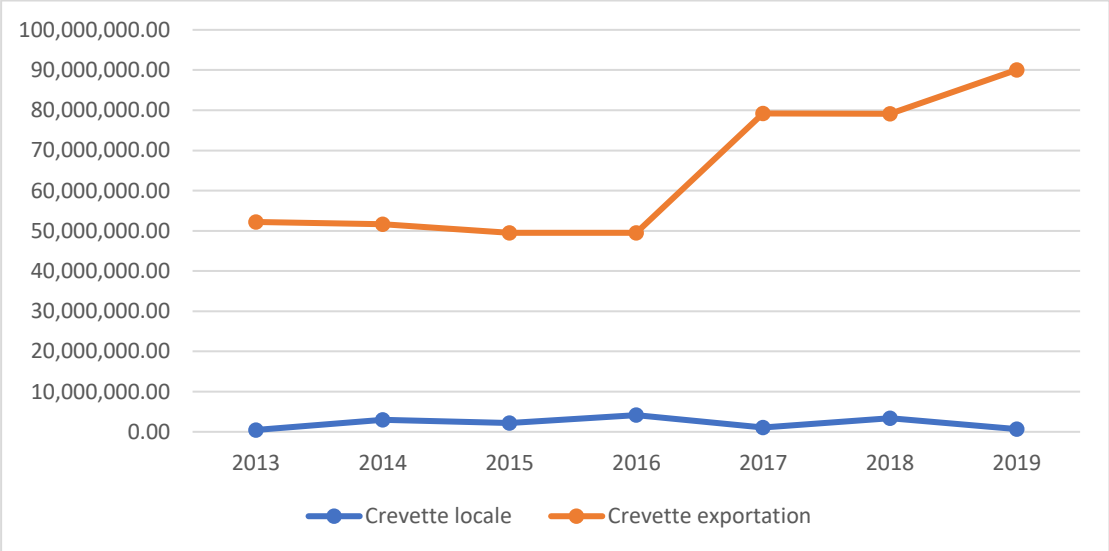
Source: OEPA/MPEB, 2021 (Data processing: ONE)

7.2.1.1. *Case study on shrimp fishing*

The structure of seafood exports is largely dominated by shrimp, followed by canned tuna. Shrimps (Peneidae) represent the first exported fishery product in both volume and value and the fourth item in value at the national level. In 2020, exports recorded a volume of 7,662 t, made up of 4,572 t of farmed shrimp products and 3,090 t of industrial fishing, representing a total value of 332 billion Ar, i.e. 62.80% of the total value of fishery exports.

In terms of the total value of Madagascar's exports, shrimp fishing represents 1.7%.

Figure 51: Evolution of shrimp exports and its local value (in AR)



Source: DOEP/MAEP – Data processing: ONE

Table 65: Economic data on industrial shrimp fishery

The direct value added created is 20% of the total. 8% goes to the administration as taxes and levies. The total contribution of the industrial shrimp fishing sector to State revenue was US$ 2,884,785. Between 2005 and 2018, this value dropped to 392,107 USD in 2018.

The industrial shrimp fishery provides employment to the Malagasy, and contributes to the improvement of the standard of living of the population. In 2001 and 2002, approximately 5,000 direct jobs in full-time equivalent were created. Since the crisis of the sector in 2005, this contribution has decreased, and only about 1,500 direct jobs have been created in the last ten years.

Industrial shrimp fishing contributes effectively to the balance of trade of Madagascar.

INDUSTRIAL SHRIMP FISHING	2017	2018	2019	2020
Shrimp catch from industrial fishing (in tons)	4,035	3,808	4,014	3,862
Quantity of shrimp exported (in tons eqc*)	3,430	3,237	3,412	3,090
Export value (in MUSD)	21.,81	21.,85	24.47	23.61
Direct Value Added (in MUSD)	4.,59	5.80	4.99	6.04
Export price FOB eqc*(€ / kg)	6.50	6.13	6.40	6.38
Number of jobs (full-time equivalent)	1,492	1,504	1,575	1,524
Number of active vessels	41	41	43	43

Source: Economic Observatory of Fishing and Aquaculture

Table 66: Summary of economic data for the fishing and aquaculture sector (2016-2020)

According to data from the Economic Observatory of Fisheries and Aquaculture (OEPA), the share of the fisheries sector in the formation of Madagascar's gross domestic product (GDP) was around 5.5% in 2020. It is one of the first contributors to the country's GDP with agriculture, forestry and hunting (34.6%), followed by trade and tourism (16.3%), and transport, storage and communications (13.1%). The fishing sector is also the main provider of foreign exchange, animal protein and employment for vulnerable populations. It employs around 470,000 people and provides a living for almost 1,500,000 Malagasy (OEPA, 2021). Since the outbreak of the COVID-19 pandemic, which put a stop to four years of economic growth in Madagascar and led to a substantial decline in the tourism sector, the contribution of the fisheries sector to the balance of payments, of the order of US$148 million or 5.7% in value of overall exports in 2020 compared to 3.3% in 2019, is considered more strategic. It constitutes an important manna for the Malagasy economy with regard to the structure and financing needs of the country.

Despite its numerous potentialities and favorable natural factors, the production of fisheries and aquaculture in Madagascar, all types of activity combined, is slightly less than 140,000 tons (t) per year on average over the period 2016-2020 (source: Service Statistique de la Pêche et de l'Economie Bleue, 2021), i.e., at a lower level than the potential catches, estimated at 230,000 t by the MEPB.

Macroeconomic Indicators	2016	2017	2018	2019	2020
Contribution of the sector to the GDP (Estimate)	6.7%	7.1%	6.6%	6.2%	5.5%
Production of the Fishing and Aquaculture sector	139,966 tonnes	163,491.95 tonnes	131,550 tonnes	130,725 tonnes	124,537.64 tonnes
Contribution to the balance of payments: Value of exports of fishery products	139,197,875 USD	159,643,439 USD	141,998,637 USD	161,043,820 USD	147,880,238 USD
Contribution to the non-tax revenues of the State: Fishing royalties	3,671,799 USD	3,811,837 USD	4,329,978 USD	2,722,341 USD	2,825,969 USD

Source: OEPA, August 2021

7.2.1.2. Case study: Cost-benefit analysis of fisheries production services based on the EU – Madagascar tuna fishing partnership

Advanced evaluation of provisioning services is limited by the inaccessibility of data. These partial evaluations have been drawn from the analyses of some projects. This case study was drawn from the Fisheries Partnership.

The EEZ of Madagascar is located in the migratory pathways of large pelagics. Since 1986, a fishing agreement grants access to Malagasy waters to European Union tuna vessels. Renewed as a Fisheries Partnership Agreement (FPA) in January 2007 for a period of six years and tacitly renewed from 2012 to 2018, the protocol sets out the fishing possibilities and the annual financial contribution of the FPA, one third of which is intended to support and implement Madagascar's maritime and fisheries policy. A cost-benefit evaluation of the partnership was conducted in 2014 to assess its impact in relation to the scope of the investment. From this analysis, a one-year case study in 2013 was used to estimate the benefits to Madagascar, and to propose conditions for the success of the partnership in the future (COFREPECHE, MRAG, NFDS and POSEIDON, 2014)[63]. On average, the European investment per ton is around 143 Euro; the relatively low unit access cost and the high value of the catches contribute to a ratio (access rights/turnover) that is advantageous for European fleets and has been for several years. For Madagascar, although in 2013, the turnover from the marketing of catches made by EU vessels in Malagasy waters is estimated to be around €17 million: According to the protocol, Madagascar received approximately €2 million, consisting mainly of access fees, income paid to embarked

[63] COFREPECHE, MRAG, NFDS and POSEIDON, 2014. Retrospective and prospective protocol of the partnership agreement in the fishery sector between EU and the Republic of Madagascar. Contract framework MARE / 2011/01 – Lot 3, specific contract No. 10, Brussels, 175 p.

personnel residing in Madagascar, and taxes and levies related to the use of Malagasy port facilities. The direct beneficiaries of the sectoral support funds paid by the EU under the FPA are the fisheries health authority (ASH) and the fisheries monitoring center (CSP). The analysis of the impacts of these revenues on the two beneficiary institutions shows a low rate of achievement of the activities that were carried out. CSP has completed almost 64% while AHS has difficulty in carrying out activities. As a result, the impacts of partnerships on fisheries in Madagascar are not yet optimal. However, the partnership offers an opportunity to generate income from migrant stocks in its EEZ, through sectoral support. It is, for the moment, the most viable way to benefit from the existence of tuna resources for Madagascar.

7.2.2. Agriculture and coastal forestry

Madagascar's population being mainly rural, the coastal regions present important opportunities for agriculture, both for subsistence and cash crops such as litchis, vanilla, coconuts, bananas, sugar cane, cloves, cocoa, etc. However, all agricultural and forestry products are not coast-dependent even though they have an impact on the coastal zone and watersheds.

Although a large number of the coastal population is involved in agriculture, its value cannot be solely linked to the coast since subsistence products can be grown both on the coast and on the mainland.

The evolution of subsistence production is presented in the table below and they have become over the years the main causes of erosion and clearing of coastal forests.

For specifically coastal agriculture, the evolution of production from 2011 to 2016 is given in the following table:

Table 67: Exports of coastal products, f.o.b. (Costs in millions of SDR, volume in thousands of tons, unit cost in SDR/kg except in specific mention)

		2014	2015	2016	2017	2018
Clove oil	Value	17,6	10,0	15,1	17,6	19,5
	Volume	2,0	1,1	1,5	1,8	2,0
	Unit price	8,9	8,9	9,9	10,1	9,7
Coffee	Value	10,1	3,6	5,2	2,3	2,6
	Volume	8,9	3,2	4,3	1,9	2,2
	Unit price	1,1	1,1	1,2	1,2	1,2
Vanilla	Value	74,4	141,8	283,9	488,9	377,4
	Volume	6,0	11,5	22,8	38,8	31,1
	Unit price	12,4	12,3	12,5	12,6	12,1
Clove	Value	72,5	114,3	106,4	159,0	169,7
	Volume	12,6	20,0	18,4	27,2	30,1
	Unit price	5,7	5,7	5,8	5,9	5,6

		2014	2015	2016	2017	2018
Pepper	Value	6,8	7,7	6,7	4,4	5,2
	Volume	2,2	2,6	2,2	1,4	1,8
	Unit price	3,0	3,0	3,0	3,1	3,0

Source: REF 2018

7.2.3. Forestry products

With regards to the export of wood products, an increase of 26.3% was noted in incomes from the export of pinewood. As for other types of woods, a very small increase of 1.02% was recorded. Finished products which include furniture, handicrafts, ship models and musical instruments have, during the year 2017, declined by 7.19% in their exports value.

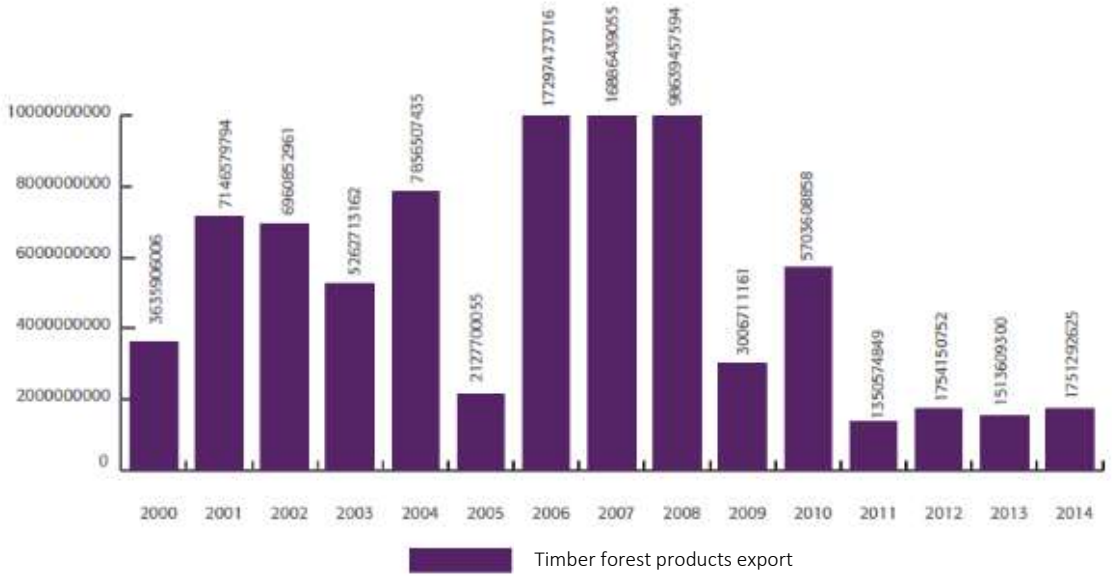
Regarding the royalties collected on exported products, almost all of the values were collected from essential oils and medicinal plants, a sum of USD 167,444 on the USD 178,013 received (RAEM, 2017)

Table 68: Evolution of the exports incomes from forestry products (TFP, CITES and non CITES NTFP), (en Ar)

Type of products	Value				Variation (2017/2016)		
					en valeur		
	2014	2015	2016	2017		in %	Collected royalties in 2017
Pinewood	12,127	79,947	19,409	24,512	5,103	26.30%	684
Other types of wood	45,578	81,845	54,606	55,162	557	1.02%	1,012
Finished products	477,426	283,197	360,572	334,652	-25,921	-7.19%	5,020
Accessory products	1,547	5,059	22,444	84,489	62,045	276.44%	3,853
Essential oils and medicinal plants	4,028,720	4,878,630	6,665,093	9,887,625	3,222,532	48.30%	167,444
Fauna et Flora	175,468	275,775	219,486				
TOTAL	4,740,867	5,604,454	7,341,611	10,386,441	3,264,316	41.50%	178,013

Source: Directorate General of the Natural Resources valorization, MEDD, (RAEM, REF 2017)

Figure 52: Evolution of national exports on timber forest products (MGA)



Source: Directorate General of the Natural Resources valorization, MEDD

As for coastal forests, it is important to state that Madagascar has coastal forest formations in the regions of Vatovavy Fitovinany, Atsimo Atsinanana and Anosy. These are specific forests that can only be found on coastal soils.

In total, these forests cover an area of 56,731 ha (Expanding and Consolidating the Network of Marine Protected Areas of Madagascar, MEDD 2019) and contain ecosystems as well as a unique and rich biodiversity.

The economic value of these forests relates mainly to their use as a source of medicinal plants, fishing gear for fishermen and timber for construction, as well as grazing areas for cattle.

7.2.4. Wood production capacity of mangroves

7 families, 9 genera and 9 species were inventoried with a dominance of the Rhizophoraceae and Verbenaceae families.

The DPH of the mangroves is between 8.6 and 13.82 cm with a total height of 5.5 m and an exploitable height of 2.89 m. Four species Tangandahy, Afiafy, Tangambavy and Tangampoly are the most distinguished mangroves of Madagascar while the diameter classes between 5 and 15cm of DBH are the most abundant. On dominance, the mangroves of the Boeny and Melaky regions have a basal area of 3.18m2 and 3.78m². On the potentiality, the value in Melaky (Total Volume = 11.58m³ and Container Volume = 9.28m³) and Boeny Regions (Total Volume = 10.19m³ and Container Volume = 8.70m³) are important.

The coverage is about 60% in the Atsimo Andrefana, Boeny, DIANA regions.

The regeneration rate of mangroves is 1,281% according to the analysis of the different vegetation strata and natural regeneration.

7.2.5. Marine aquaculture

L'aquaculture Marine aquaculture such as shrimp farming, algaculture and holothuriculture create well-paid jobs and generate foreign currency, thus contributing to improving the country's balance of trade. (SNDAM 2021)

Algaculture has been growing steadily for several years. Today, the production could reach 2,300 t of dry algae, mainly on two species of red algae: Cotonii (Kappaphycus sp.), also commercially called Iota carrageenan. The strains of these algae were introduced from Zanzibar. Algal farming currently employs about 1,250 families (SNDAM 2021)

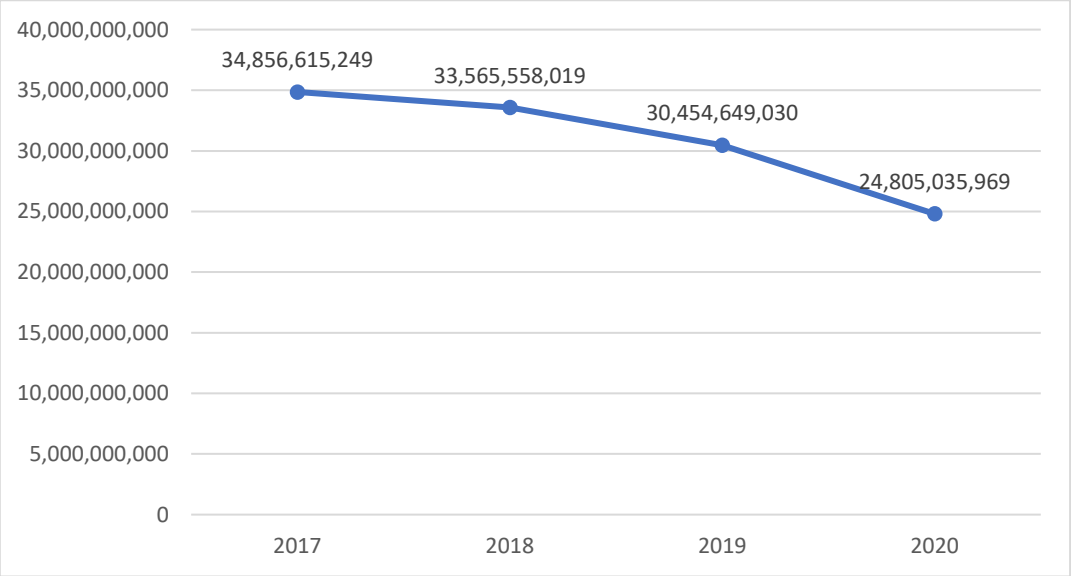
Sea cucumber aquaculture, which started at the end of the 2000s, seems to have experienced a certain stagnation in its production level for several years. The current production could be around 10t/year of trepangs, which is the equivalent of about 250t in fresh products. This sector is based on only one species, namely *Holothuria scabra* (SNDAM 2021).

Aquaculture of mangrove crab, which is currently based on only part of the biological cycle of the species, i.e. the fattening of individuals caught by fishing, concerns the species *Scylla serrata*. (SNDAM 2021)

It should also be noted that there is an aquaculture production of spirulina, estimated at around 5t of dry products. This sector is part of public policies to fight malnutrition among children, particularly in rural areas.

The aquaculture potential of Madagascar can be considered as important considering the natural potentialities that the country offers, both in continental areas and on the coast. As an indication, with a current production of about 30,000 t/year, Madagascar represents about 1% of Africa's production (2,196 million t) and 0.03% of the world's production (82.1 million t) of aquaculture (Source: SNDAM/World Bank and FAO).

Figure 53: Evolution of shrimps exports with local value (in AR)



Source: DOEP/MAEP – Data processing: ONE

7.2.6. Energy

The oil and gas deposits in Madagascar's territorial waters are quite considerable. However, to date, no exploitation of marine energy sources has taken place. We can therefore say that no positive economic value has been derived from these energy sources. It is mainly oil research that has been developed in recent years.

7.2.7. Ports and coastal transport

Madagascar being an island country, a large percentage of the country's international trade is carried out by sea. Madagascar has 17 ports, including two large ports (Toamasina and Ehoala), four medium-sized ports, and other coastal ports.

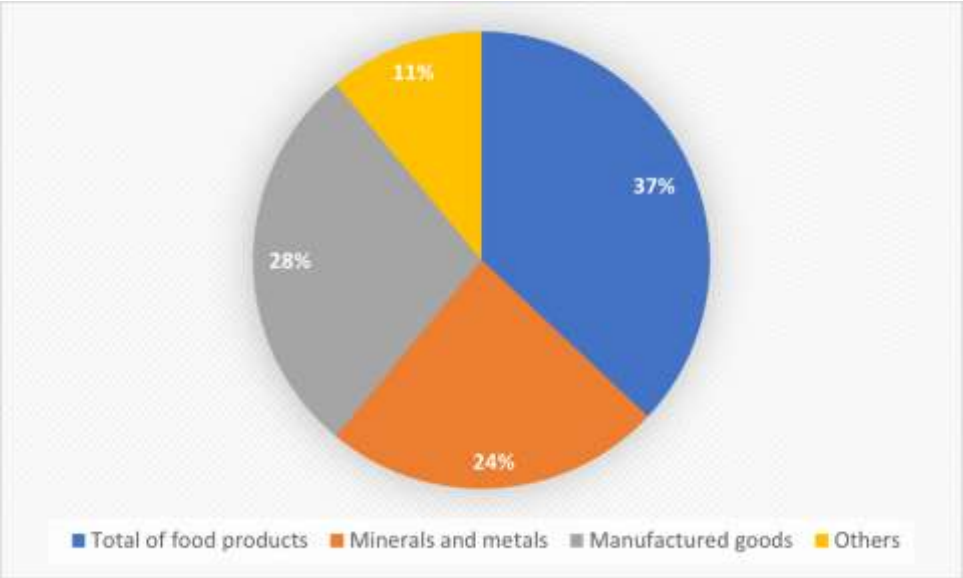
In 2019, the recorded annual traffic was 753 ship calls with 28 vessels flying the national flag, and 14 thousand DWT. The port throughput of containers is 199,713 TEU and the country counted 1187 seafarers in 2019.

Table 69: The value of the goods that transit in the ports (in MUSD)

Total sale of goods (MUSD)	2005	2010	2015	2019
Exports of goods	855	1,149	2,048	2,640
Imports of goods	1,706	2,584	2,795	3,927
Balance of trade of goods	-852	-1,434	-746	-1,286

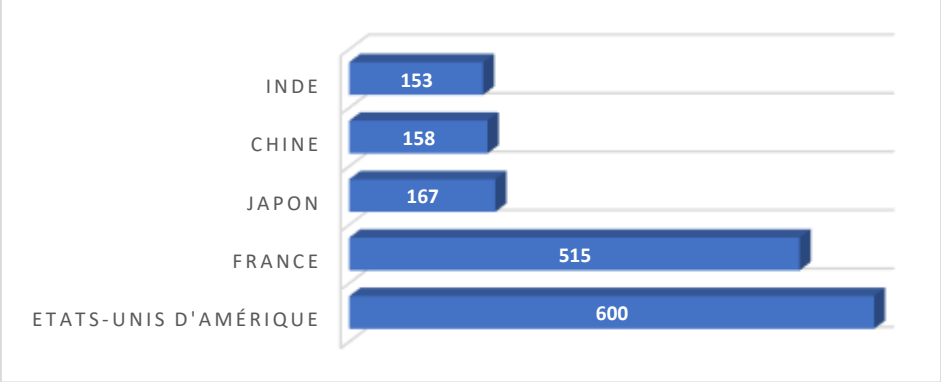
Source: CNUCED stat, 2019

Figure 54: Structure of exports per category of goods in 2019



Source: CNUCED stat, 2019

Figure 55: Top 5 partners 2019 (exports MUSD)



Source: CNUCED stat, 2019

Table 70: International trade of transport services

Exports of services per main category (in % du total des services)				
	2005	2010	2015	2019
Transport	23,8	30,6	22,4	-
Trip	37,0	31,9	58,6	-
Other services	39,0	36,2	19,0	-
Total sale in the transport services sector (in MUSD)				
Exports of transport services	118	297	238	-
Imports of transport services	250	420	620	-
Balance of trade of transport services	-132	-123	-382	-

7.2.8. Coastal mines

The heavy metals titanium and zirconium contained in the mineralized sand are mined in the South-east coast of Madagascar by QMM.SA which is based in Tolagnaro.

Table 71: The amount and the value of the minerals exploited in 2018

Basic material	Extracted / produced amount	Value of extracted / produced resources (USD)
Ilmenite	381,924 t	45,704,845.08
Zircon	22,757 t	6,085,221.8
Monazite	15,870 t	364,057.8

Source: EITI, 2018

Besides, Madagascar produces salt from the sea. Depending on the seasons, the producers can produce between 100 to 150,000 tons of salt every year.

7.2.9. Coastal tourism

Tourism has increasingly and significantly contributed to the Malagasy economy over the past 10 years (Ministry of Tourism Report, 2019). Cultural diversity, biodiversity, natural beauty, and unique location all add up to its attractiveness and make it a leading tourist destination. The Malagasy coastline represents an important attraction and contributes significantly to the overall tourism value. Leisure has been the main reason for travel in the country, representing 57% of total arrivals. The Malagasy coast is characterized by beautiful beaches with warm waters and a number of different ecotourism activities, such as scuba diving and whale watching. Recreational activities such as surfing also attract a large number of tourists and vacationers to the coasts of the big island.

Table 72: Evolution of incomes from tourism

Recettes	2013	2014	2015	2016	2017	2018	2019
Millions of SDR	256,86	428,05	437,89	540,51	482,017	489,296	511,691
Billion ARIARY	861,63	1574,37	1718,35	2386,70	2077,93	2306,991	2558,436
Million USDs	390,42	649,62	585,38	748,297	668,262	693,664	707,097
Million Euros	294,93	490,97	527,29	681,42	592,811	586,493	632,045

Source: MTTM-SG-DSIC-STAT-SIIT; Central Bank of Madagascar ;
Directorate of Studies and International Relations

Table 73: Evolution of investments in the tourism sector in USD

	2013	2014	2015	2016	2017	2018	2019
Hôtels and / or Restaurants	5,968,144	4,116,840	5,903,446	10,148,281	27,849,658	10,804,780	200,427,576
Tourism business and travel services	227,422	69,459	199,974	1,803,411	2,454,868	1,945,689	1,120,865
TOTAL	**6,195,566**	**4,186,299**	**6,103,421**	**11,951,692**	**30,304,526**	**12,750,469**	**201,548,441**

Source: MTTM- SG- DSIC– STAT- SITT

Tourism contributed 7.49% to GDP in 2019, with approximately USD 309 Million in income and 719,620 tourist numbers. Tourism directly supported 47,493 jobs in 2019. This includes employment in hotels, travel agents, airlines and other passenger transportation services.

Touristic activities which focus on the nature significantly contribute to the attractiveness of the coast as a touristic destination.

7.3. Economic evaluation of regulatory services

7.3.1. Coastal protection

Les Coral reefs, which cover an area of more than 2,000 km² and run along about 1,400 km of coastline from Toliara to Antsiranana and from Cap d'Ambre to Toamasina, are inhabited by various classes of marine animals (madreporaria, cnidaria, molluscs, echinoderms, marine mammals...) and plants. In addition to acting as a protection for the coast against the actions of the swell and waves, these areas of high biological potential, provide living resources to the population. Besides, the uneven structure of the reef barrier constitutes a strong obstacle for the schools of pelagic fish, thus reducing the risk of predation from the prey reef species. Marine phanerogams, abundant in the seagrass beds, also play an important role in photosynthesis, which is the origin of the cycle of living matter and the production of organic matter in the ocean environment.

In order to evaluate the protection of the shoreline, Caesar values will once again be used, as was done in 2012, as a reference for benefit transfer. The benefit transfer rate is 0.04 and the agricultural use of the coastline is assumed to be 10-30% while the human settlement use is assumed to be 20-30%. The length of Madagascar's coral reefs is 2,700 km. Based on these data, the value of benefits for agricultural protection is 0.045 to 0.135 MUSD, and the value of benefits for human settlement

protection is 5.51 to 8.26MUSD. The total value of coastal protection is therefore between $5.55 and $8.40 million.

Mangroves stabilize the coastline and serve as a barrier against erosion from swells, storms, and cyclones (Furukawa et al, 1997, Wolenski et al, 2013). Mangroves act as physical barriers and play the role of screen while protecting the mainland.

Thanks to mangroves, the force of waves as well as the damage caused by wind can be reduced, provided that they are in good condition (Bacar, 2008; Indritiana, 2009).

Mangroves have been shown to have a significant impact on the magnitude of coastal flooding and the damage caused (The Nature conservancy 2016).

Mangroves prevent significant damage from catastrophic events. As an illustration, without mangroves, the number of people experiencing flooding each year worldwide would increase by 18 million, an increase of more than 39%. In addition, annual property damage would increase by more than 16% (The Nature Conservancy, IH Cantabria, BundnisEntwicklungHilft, 2017).

7.3.2. Climate regulation / Disturbance regulation

Deux Two ecosystems provide climate regulation services: coral reefs and mangroves. As for the Comoros, the benefits of coral reef regulation will be estimated based on the benefit transfer method whereas the benefits of mangrove regulation are based on market prices.

Climate regulation by coral reefs has a value of 648 USD/ha/year (Sukhdev, 2009). This value can be transferred without requiring any adjustment, given the nature of the benefit. Madagascar has 2,230 km² of coral reef area. Thus, the total annual benefit for climate regulation is 144.5 MUSD, and the net present value for a thirty-year period at 3% discount rate is about 2,772.81 MUSD.

For disturbance regulation, we will refer to Costanza's reference value for benefits (USD 1,839/year/ha) and the transfer rate is 0.04. The annual benefit value for disturbance control is about 28, 935 MUSD and the net present value for thirty years with a 3% reduction is about 463.48 MUSD.

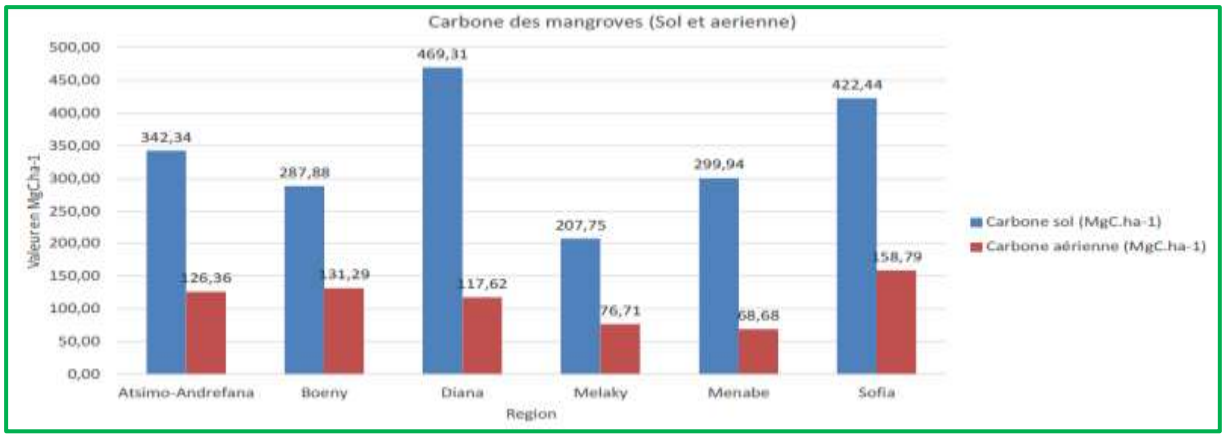
Between 2000 to 2019, the area occupied by mangroves has increased by more than 80,000 hectares, from 310,452 ha to 393,353 ha. For carbon sequestration through avoided deforestation and mangrove restoration, 393,353 km² of mangroves area has been saved, and the average biomass rate according to the inventory conducted in 2019 is 436.86 t/ha. The total volume of CO_2 not emitted is 17.185 MteCO2. The market price is 10 USD/teCO_2, and the cost of avoided deforestation is 2.51 USD/teCO2. Based on these data, the net value for climate regulation by mangroves (carbon sequestration) is 214.984 MUSD.

In addition, the absorption of solar radiation by mangroves protects adjacent ecosystems such as coral reefs and seagrass beds. Mangroves thus reduce direct UV-B exposure on corals and reduce the risk of coral bleaching (Anderson et al., 2001).

Figure 56: Average carbon capture by the mangroves in every region

Like all forests, mangroves capture carbon dioxide (CO_2) from the air which is then stored by the plant, root systems and substrate to form a carbon sink. They contribute to air purification and can therefore play a role in managing greenhouse gases and buffering the effects of climate change. It is estimated, that mangroves would sequester 25.5 million tons of carbon per year (CRNCDB, 2014).

Mangroves have the capacity to sequester CO2 captured in organic form in biomass and substrates. They have a rapid and long-lasting carbon storage capacity. The rate of carbon sequestered by species varies according to the different ecological conditions at each survey site that influence the biology of each species. The ability of each species to retain carbon also depends on the tissue of which they are composed and how it functions (Rakotovao, 2013). Estimation of carbon stocks is typically done by combining satellite and inventory data.



Source: Inventaire des mangroves REDD+, 2018

Carbon stocks are relatively high in the soil compared to aboveground biomass. Biomass refers to live wood, dead standing wood, and debris. Canopy cover was also considered. Soil sediments were collected to a depth of 2 m.

Table 74: Results from a study on carbon stocks in different sites of Madagascar

Mangrove zones	Carbon stocks MgC/Ha	Observations	Authors
Maintirano	124,63	Soil Organic Carbon (SOC)	Rajoelina, 2012
Baie d'Ambaro-Ambanja	146,8	Closed canopy mangrove (Above-ground biomass)	Blue Ventures, 2014-2015
Baie d'Ambaro-Ambanja	446,2	Soil Organic Carbon (SOC)	Blue Ventures, 2014-2015
Helodrano Fagnemotse	454,92	Closed canopy mangroves and soil organic carbon (SOC)	Blue Ventures, 2017
Baie d'Ambaro Ambanja	134,57	Soil Organic Carbon (SOC)	Ratefinjanahary, 2015
Baie d'Ambanja	101,9	Closed canopy mangroves (Above-ground biomass)	Zafindramiadana, 2016
Baie de Mahajamba	127,32 to 154,61	Closed canopy mangroves (Above-ground biomass)	Zafindramiadana, 2016
Baie des Assassins	55,68	Closed canopy mangroves (Above-ground biomass)	Zafindramiadana, 2016
NAP Antrema	175,33	Closed canopy mangroves (Above-ground biomass)	Totoharisoa, 2016
Baie d'Ambaro-Ambanja	267,83	Soil Organic Carbon (SOC)	Randriambololona, 2017
Baie de Mahajamba	196,24	Soil Organic Carbon (SOC)	Randriambololona, 2017
Baie des Assassins	358,02	Soil Organic Carbon (SOC)	Randriambololona, 2017

Sources: Situational ananlysis of the mangroves of Madagascar 2019

For the eastern part of Madagascar, a study was conducted and it showed that the epigeous biomass by facies can go up to 47 T/ha, or even more, at the level of the large homogeneous mangroves of Mananara and Rigny (>70t/ha), while it does not exceed 10-20T/ha in the sporadic mangroves of Foulpointe and Manompana. According to RAKOTOMAVO, the carbon sequestration capacity at the level of the epigeous biomass is evaluated at more than 5-20 T/ha, based on a South-North gradient, that is to say the equivalent of a minimum sequestration potential of 21,300 to 85,200T for the whole East.

7.3.3. Therapeutic value of mangroves

Mangroves are used as medicinal plants by local populations, with apparent therapeutic virtues depending on the species. Avicennia marina is the most commonly used species.

Table 75: Therapeutic virtues of mangrove species

Species	Part of the plant that is used	Treated diseases
Avicennia marina	Leaves	Bellyache, jaundice, diarrhea
	Resin	Toothache

Species	Part of the plant that is used	Treated diseases
	Branch	Against mosquitoes
Xylocarpus granatum	Leaves	Backache
Rhizophora mucronata	Young plant, seedling	Muscle fatigue for men
Sonneratia alba	Leaves	Bellyache
Lumnitzera racemosa	Bark	Abdominal pain

Source: Situational ananlysis of the mangroves of Madagascar 2019

7.3.4. Water purification

Mangroves protect adjacent ecosystems (seagrass beds, lagoons, coral reefs) from downstream sediments by forming biological filters through the retention and export of sediments and nutrients. Large quantities of nutrients such as phosphorus and nitrogen, mainly from agricultural runoff upstream, are effectively removed by mangroves. They thus prevent the downstream process of eutrophication that can promote rapid plant and algal growth and lead to a depletion of oxygen levels in the marine environment.

Due to their primarily ecological status and functions, mangrove ecosystems represent invaluable values for the marine and coastal environment. The values of mangrove areas can be defined or classified into different categories:

- direct use values resulting from the benefits obtained through direct use of the mangrove ecosystem;
- indirect use values resulting from the environmental functions of mangroves if we only mention their role in maintaining the ecological balance of the coastal and marine environment;
- an option value that can also be attributed to mangroves for the conservation of the current quality of mangrove ecosystems for future use;
- other values which are not related to use can also be attributed to mangroves such as heritage values and existence values insofar as mangroves represent privileged habitats of several endemic and/or threatened species (State of mangroves in Madagascar)

The total economic value of the regulation services (reefs and mangroves) is the sum of the three previous services: protection of the coastline, regulation of disturbances and climate regulation, water purification. The total amount of this service is between 3,369.21 and 3,451.274 MUSD

7.3.5. Forest ecosystems

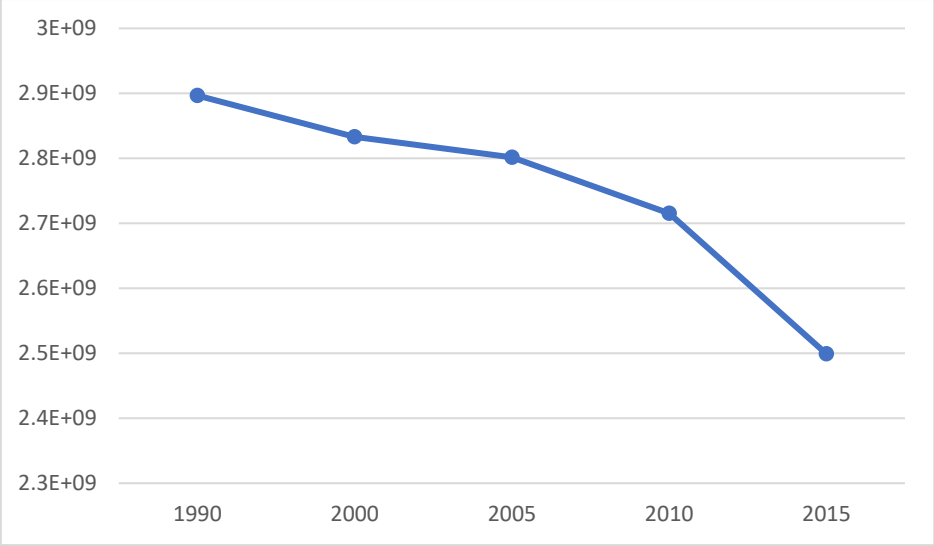
Table 76: Evolution of standing timber stock in coastal zones (in m^3)

Regions	1990	2000	2005	2010	2015
Analanjirofo	869,311,000	864,475,000	861,097,000	839,062,000	786,957,000
Androy	47,799,300	45,235,500	43,954,900	43,719,900	41,376,800
Anosy	160,481,000	155,311,000	152,402,000	149,528,000	143,706,000
Atsimo Andrefana	228,025,000	210,144,000	204,159,000	196,717,000	168,202,000

Regions	1990	2000	2005	2010	2015
Atsimo Antsinanana	190,705,000	185,003,000	180,777,000	176,630,000	166,544,000
Atsinanana	404,973,000	393,199,000	387,288,000	375,019,000	345,819,000
Boeny	106,592,000	103,422,000	102,560,000	95,176,300	79,940,000
DIANA	295,851,000	291,548,000	288,845,000	284,539,000	276,162,000
Melaky	148,894,000	147,032,000	145,924,000	137,426,000	117,282,000
Sofia	443,997,000	437,588,000	434,490,000	417,597,000	373,161,000
Vatovavy Fitovinany	199,809,000	193,568,000	185,550,000	177,289,000	160,085,000
TOTAL	**3,096,437,300**	**3,026,525,500**	**2,987,046,900**	**2,892,703,200**	**2,659,234,800**

Source: Image processing: ONE

Figure 57: Evolution of standing timber in coastal zones (m^3)



Source: Image processing: ONE

7.3.5.1. Evolution of the value of standing timber in coastal zones (m^3)

Referring to the indicative value of the price of standing timber on the international market recorded in September 2018, we consider as the price of the cubic meter of standing timber, for all types of trees combined, equal to 100 Euros (about 110 Dollars).

Table 77: Estimated value of standing timber (en USD)

Regions	1990	2000	2005	2010	2015
Analanjirofo	95,624,210,000	95,092,250,000	94,720,670,000	92,296,820,000	86,565,270,000
Androy	5,257,923,000	4,975,905,000	4,835,039,000	4,809,189,000	4,551,448,000

Regions	1990	2000	2005	2010	2015
Anosy	17,652,910,000	17,084,210,000	16,764,220,000	16,448,080,000	15,807,660,000
Atsimo Andrefana	25,082,750,000	23,115,840,000	22,457,490,000	21,638,870,000	18,502,220,000
Atsimo Antsinanana	20,977,550,000	20,350,330,000	19,885,470,000	19,429,300,000	18,319,840,000
Atsinanana	44,547,030,000	43,251,890,000	42,601,680,000	41,252,090,000	38,040,090,000
Boeny	11,725,120,000	11,376,420,000	11,281,600,000	10,469,393,000	8,793,400,000
DIANA	32,543,610,000	32,070,280,000	31,772,950,000	31,299,290,000	30,377,820,000
Melaky	16,378,340,000	16,173,520,000	16,051,640,000	15,116,860,000	12,901,020,000
Sofia	48,839,670,000	48,134,680,000	47,793,900,000	45,935,670,000	41,047,710,000
Vatovavy Fitovinany	21,978,990,000	21,292,480,000	20,410,500,000	19,501,790,000	17,609,350,000
TOTAL	**340,608,103,000**	**332,917,805,000**	**328,575,159,000**	**318,197,352,000**	**292,515,828,000**

Source: Data processing: ONE

7.3.5.2. Costs of forest ecosystem degradation

Therefore, the historical costs of degradation of our forest ecosystems are as follows:

Table 78: Estimate of the costs of degradation of the forest ecosystems (in MUSD)

Regions	Between 1990-2000	Between 2000-2005	Between 2005-2010	Between 2010-2015
Analanjirofo	532	372	2,424	5,732
Androy	282	141	26	258
Anosy	569	320	316	640
Atsimo Andrefana	1,967	658	819	3,137
Atsimo Antsinanana	627	465	456	1,109
Atsinanana	1,295	650	1,350	3,212
Boeny	349	95	812	1,676
DIANA	473	297	474	921
Melaky	205	122	935	2,216
Sofia	705	341	1,858	4,888

Regions	Between 1990-2000	Between 2000-2005	Between 2005-2010	Between 2010-2015
Vatovavy Fitovinany	687	882	909	1,892
TOTAL	**7,691**	**4,343**	**10,379**	**25,681**

Source: Data processing: ONE

For forest ecosystems, the following benefits can be cited:

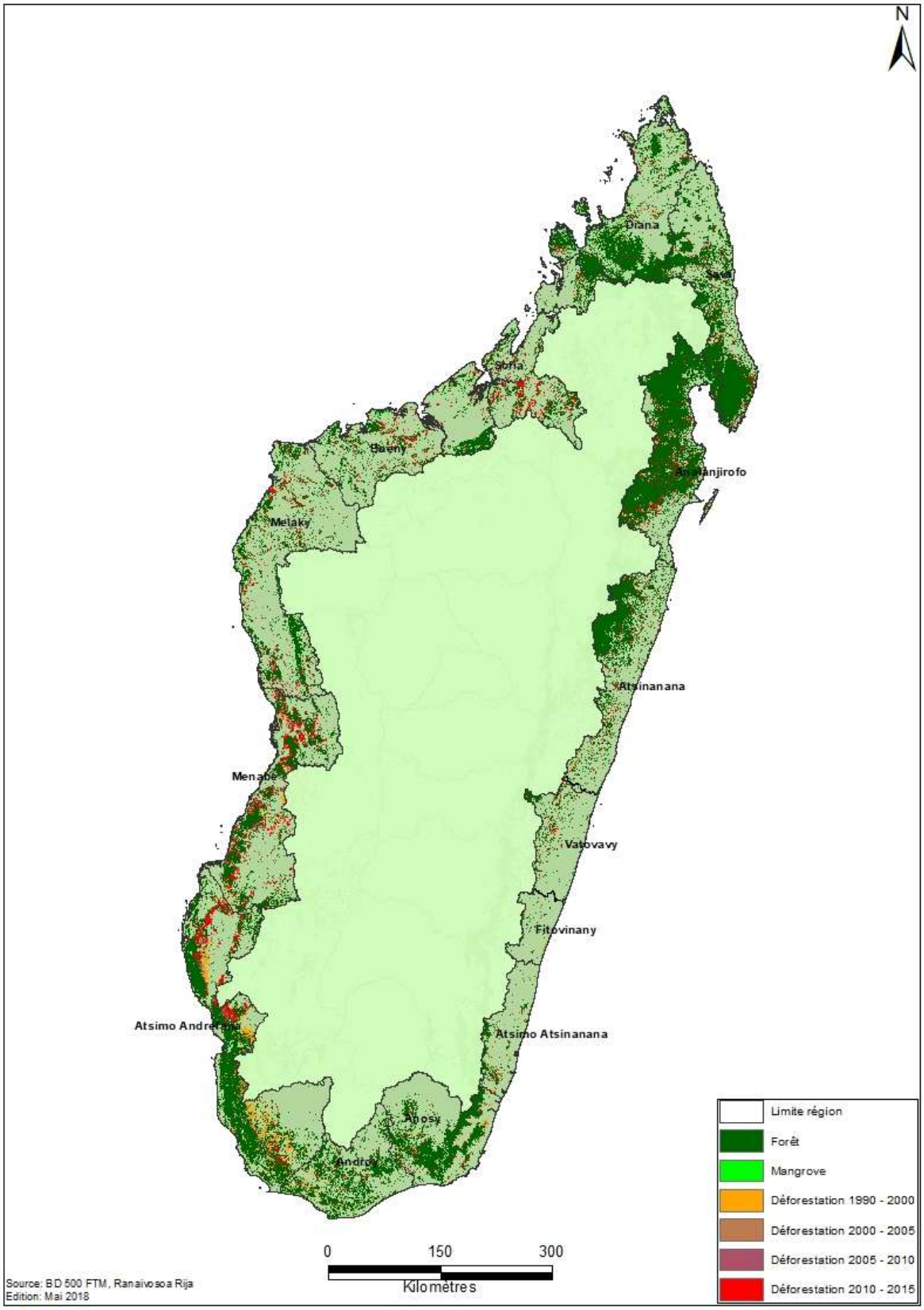
- Contribution to the reduction of erosion
- Impacts on water resources
- Impacts on water quality
- Carbon sequestration
- Contribution to biodiversity

The benefit related to water and soil conservation can be very high, especially in plantations that fix the banks of ravines protecting downstream water reservoirs.

The local population is the main beneficiary of the goods and services provided by the forests, and suffers a loss of income if access to the resources is denied or if the resources are severely degraded.

The costs of degradation are also considered in order to take into account the losses suffered by the society in general.

Map 33: Forest ecosystem degradation



7.3.6. Measurement Setup value

Capacity building of stakeholders involved in regulating the services provided by marine ecosystems constitutes a significant benefit even if it has no market value as such. Indeed, the awareness and involvement of communities in the preservation of mangroves and coral reefs contribute in some way to the increase of the surface areas and by ricochet, contribute to the increase of the total economic value of the latter.

Similarly, it should be noted that infrastructure projects which aim to protect the coastline have been implemented, namely:

- The beach nourishment project in Andilana Nosy Be (ANDILANA BEACH- SMTH);
- The implementation of a coastal protection dike in Toamasina (MEEF/BNCCC Toamasina):
- The coastal infrastructure project in Manakarabe (MEEF/BNCCC Manakara);
- The project of filling the right bank of the mouth of Sambava Centre and protection of the banks (RAZANADRANORO Brillante Lynda);
- The Morondava Coastal Development Project (AGETIPA-PALM)

It is necessary to underline that the above-mentioned infrastructures have gone through an environmental assessment which was dealt with at the ONE level and represent a total value of more than 3,6 MUSD.

Finally, actions to reinforce the interventions for the protection of the coastline have also been undertaken, namely:

- The Center for Fisheries Surveillance (CSP) reinforces the maritime surveillance by air and satellite and by the establishment of new surveillance brigades which is equipped with fast boat
- In 2019, 16 community surveillance units were implemented and operational for the fishing communities.
- Developing Maritime Spatial Planning in the Analanjirofo, Atsimo-Andrefana, DIANA and SAVA Regions, in partnership with the MAHTP
- Developing maps of the maritime and coastal space integrating the themes of climate change and disaster risks

Planting reef cuttings so as to restore the marine ecosystems.

7.4. Economic evaluation of cultural services

7.4.1. Cultural and cultual sites / tourism

Malagasy people firmly hold onto lines of practice inherited from their ancestors. They act as rules and lines of conduct dictated by the ancestors and they are very important in the lives of the population. The populations highly respect their ancestors: they venerate them and evoke them in difficult times as well as in better days. Malagasy cultural practices are strongly linked to its natural heritage, namely the forest, water, land and sea. Therefore, there are multitudes of cultural and cultual sites along the coasts and in the coastal regions of Madagascar. For the sacred places, we can quote as an example the islets of Sainte-Luce and Nosimboronona in the Anosy Region, the sacred site of Anjaloky in the District of Manja in the Menabe Region, the mouth of the river Mananjary in the South-East Region, etc. For rituals related to the sea, we can mention the Donia festival in Nosy-Be, the Whale festival in Sainte-Marie, the Savatry in Mananjary, the Fitampoha in Morondava, etc.

The total economic value of these cultural sites and rituals is evaluated according to the number of people who come to visit them or to attend the rituals. As a matter of fact, these cultures generate travel, lodging, restaurants, and sales of souvenirs and local handicrafts that can be valued economically.

In addition, the cultural value of these sites generates a voluntary protection from the riparian communities who consider them as sacred and this brings a certain plus in the conservation of the genetic and natural heritage of these sites.

Finally, the organization of festivals and cultural rites implies the reception of many local and international tourists, which entails the setting up of hotel and restaurant infrastructures.

7.4.2. Value of thermal and thalassotherapy sites

A great number of thalassotherapy centers exist in Madagascar and one of them is the Hélio-Marin center in Mahajanga. It can involve for instance algotherapy which is about lying warmed up marine algae over the whole body. It can also be a type of aqua-gym in a sea water filled swimming pool or a water jet massage.

7.4.3. Existence and legacy value

Existence value is a value for which biodiversity must be protected for its own sake. It is justified by intangible aspects, including in a humanistic approach that considers that all biodiversity deserves to be conserved as a source of wonder beneficial to man, for the aesthetic, spiritual or cultural values it brings, or as a heritage to be transmitted to future generations, any loss of species being irreversible. Biodiversity is here an ecosystem service rendered to man.

The inheritance value corresponds to the benefit we derive from the transmission of an intact nature to future generations.

For example, in the Mahavavy Kinkony Complex Protected Area in the Boeny Region, in addition to the value of the fauna that gives the site exceptional ecotourism potential, Mahavavy-Kinkony also has immense cultural importance as the heart of the Sakalava ethnic group that inhabits much of western Madagascar. In fact, members of the Sakalava royal family are among the leading supporters of the site's conservation. All this makes it a very promising prospect for sustainable ecotourism. (Situational analysis of mangroves of Madagascar, 2019).

7.4.4. Spiritual value

A study conducted by Robin M. et al. in 2008 on the perceptions, practices, traditional and modern management of mangroves in the Northwest of Madagascar, showed that ¾ of the respondents claim that there are fady or sacred areas in the mangrove massifs and its surroundings, which are mainly:

- Non-working days: i.e., it is forbidden to fish on Thursdays in the Bay of Boeny;
- The belief on the protective power of the mangrove forest and the sea, considered as genies against which one can protect oneself from possible risks;
- The sacralization and protection of the totem tree such as the Madiro (*Tamarindus indica*, FABACEAE), the vato or stone, the Doany or sacred places.

This "system of fady", which are regulations and prohibitions, contribute a lot in the conservation and protection of mangrove forests and natural resources in the concerned areas. (Situational analysis of the mangroves of Madagascar, 2019)

7.4.5. Education

Various education and awareness programs are currently implemented in the island so as to make the local population fully aware of the value of coastal and marine ecosystems.

Several projects and NGO such as the SWIOFISH 2 project or NGOs such as AQUATIC SERVICE, Blue venture, WWF, etc. are working on this field.

Moreover, there are also scientific researches training centers which essentially focus on marine ecosystems such as the IHSM of the University of Toliara.

7.5. Economic evaluation of support / back up services

7.5.1. Maintaining genetic diversity

7.5.1.1. Value of back up and genetic maintenance of coral reefs

Coral reefs are the main coastal marine habitats besides mangroves and marine phanerogam meadows. The distribution of the different geomorphological types of western Indian Ocean (Quod et al., 2004) states that Madagascar has a barrier reef, the Big Reef of Toliara (about 18km long and 3km wide); numerous fringing reefs along the south western, north-eastern and south-eastern coast; coral benches (Bench of Leven and Bench of Castor in the north-western part, and the numerous small benches on the western coast like the Bench of Parcel, the Bench of Bayfield, the Bench of Milieu…); there are also the cay reefs in the south-western part (Nosy Fasy, Nosy Ve) and the north-western part (Nosy Hao).

The biogeography of the marine organisms in shallow areas of western Indian Ocean is not very well known but scientific studies have shown a biodiversity peak (distribution of species and genera) in the zone located at the north end of the Mozambique Channel which includes the north of Madagascar, the northern part of Mozambique and South of Tanzania (North of Channel of Mozambique) (McKenna & Allen, 2003 ; Obura et al., 2008 ; Obura et al., 2011 ; Maharavo et al., 2011 ; Obura, 2012 ; Obura et al., 2019). This high marine biodiversity hotspot in West of Indian Ocean could be the second coral biodiversity center after the coral triangle of the Pacific.

Among the numerous threats on these habitats are: use of harmful fishing engines, on-foot fishing, physical impacts of ship anchors, implementation of coastal infrastructures, sedimentation due to deforestation, pollution, over exploitation of the fish located on reefs by the local population which led to an ecological misbalance etc. However, the impacts of the phenomena due to climate changes can also be seen in coral bleaching due to the increase of the sea surface temperature and the important physical damages that occur during extreme climate events such as cyclones and storms.

It is all about a global service that is induced by the coral reefs, which means that the profit transfer can be directly used without requiring any adjustment (13,541USD/ha/year, Sukhdev). Madagascar has a total coral reef area of 2,230 km², which means that the yearly value of the profits equals approximately to 3,019.64 MUSD. The net real value for thirty years at the discount rate of 3% is 57,942.22 millions of dollars.

7.5.1.2. Value of back up and genetic maintenance of mangroves

The main surfaces of mangroves are located along the western coast of Madagascar at the level of the estuaries of large rivers such as Mahavavy du Nord, Narindra (Loza), Mahajamba Betsiboka, Bombetoka, Mahavavy du Sud, Besalampy, Maintirano, Tsiribihina et Mangoky (Lebigre, 1990). There are very few mangrove areas in the east coast because there are only 5,000 ha of them and they are located in Manompana (Sainte Marie), Rodo, Lokaro and Baie de Sainte Luce (Taolagnaro). Madagascar has got eight species of mangroves which are also visible in the Indopacific region: *Avicennia marina, Xylocarpus granatum, Ceriops tagal, Rhizophora mucronata, Bruguiera gymnorhiza, and Sonneratia alba.* They are mostly distributed at a very large scale from the north to the south. *Lumnitzera racemosa* and *Heritiera littoralis* are more or less distributed mainly locally and can also be seen in the western region (Bosire et al., 2015). Mangroves are also nesting zones and habitats for several animals (fish, seafood, reptiles and mollusks). They are either permanent or temporary homes for a great number of fauna species. At the same time, several endemic species of birds like the herons of Madagascar (*Ardea humbloti)*, Madagascar teals (*Anas bernieri)*, Plovers (*Charadrius thoracicus)*, and ospreys (*Haliaeetus vociferoides)* live in these areas. Since 2000, an annual loss rate of about 1 to 1.5% has been observed, with the district of Mahajanga having the most important destroyed surface area (Shapiro et al, 2019), and this is mostly due to the transforming of the land and the collect of wood for heating and cooking.

7.5.1.3. Value of back up and genetic maintenance of marine phanerogam meadows

Among marine ecosystems, marine phanerogam meadows play a major ecologic and socioeconomic role even if the researches are not well documented for Madagascar. These seagrass beds play a crucial role in their interaction with adjacent marine ecosystems such as mangroves and coral reefs (Green et Short, 2003). Madagascar is home to seven species of seaweeds (UNEP-Nairobi Convention, WIOMSA, 2015) namely, *Cymodocea rotundata, C. serrulata, Halodule uninervis, Thalassodendron ciliatum, Halophila ovalis, H. stipulacea, and Thalassia hemprichii.* Most of the marine phanerogam meadows are dominated by two species which are the *Thalassodendron ciliatum* and *Thalassia hemprichii*. Seagrass beds habitat is very critical for a number of endangered species like the dugongs *(Dugong dugon)*, marine turtles (especially the green *Chelonia mydas* turtles) and hippocampus. Human activities are among the main threats to the marine phanerogam meadows (use of harmful fishing engines, implementation of coastal infrastructures, a strong deforestation in the mouths of rivers, etc…). However, natural factors due to the climate also play a major role in the destruction of these habitats.

7.5.1.4. Value of marine PA

Madagascar has today 16 protected marine zones of a total surface of 822,000 ha and a potential marine conservation of about 9 million ha.

It is important to note two most important nesting places for sea birds in Madagascar: (i) Nosy Manampaho (east coast, 60 km south east of Antsiranana) which is home to a large colony of *Onychoprion fuscata*, with 21,800 couples ; and (ii) Nosy Foty (west coast, at 30 km west of Antsiranana, central zone of the marine national park of Nosy Hara), home to a large colony of *Thalasseus bergii*, less 1,000 couples in July 1997 compared to 10,840 in July 2008. This colony of *Thalasseus bergii* is currently the most important in Madagascar and in the whole western Indian Ocean (Le Corre et Bemanaja, 2009). Moreover, on the basis of their being feeding zones and their being close to nesting sites, five zones have been identified as priority regions for sea birds in the West Indian Ocean, in the North eastern part of Madagascar.

7.5.1.5. Cycle of nutrients

The cycle of nutrients performed by oceans is another global service. The Costanza (118 USD/ha/year) is the reference value. Madagascar has got 124,900 km² of sea. Therefore, the annual service value of the nutrients cycle is approximately equal to 1,473.82 MUSD and the net real value for a thirty year period at a discount rate of 3% is 28,887.52 MUSD.

7.6. Cost-benefit of marine protected areas

In 2020, the marine protected areas in place and in progress cover approximately 2,561,440 hectares of coastal and marine habitats, corresponding to about 20% of the continental shelf[2]. With the addition of the 1,380,000 ha of LMMAs[3] (locally managed marine areas), the marine coverage under management amounts to 3,935,284 hectares.

Based on two current growth sectors in the marine domain, including sustainable fisheries and ecotourism related to park visits, marine protected areas contribute an estimated US$ 190 million to US$ 314 million per year, or US$ 122-138/ha/year[64].

In 2012, the World Bank, through the ICP Program, estimated that the cost of managing one hectare of protected area in Madagascar would be US$ 6.06 ha/year. A review of the costs of managing new protected areas by FAPBM found the cost to average 16.32 ha/year in the years following their establishment. Conservative estimates indicate that the minimum management costs for a hectare of protected area in Madagascar is US$10 per hectare for protected areas. Thus, the minimum management costs for MPAs are around US$ 25,614,399.70 per year. The ratios between the economic contributions of MPAs and the management costs are 8% to 13%. Since the framework and mechanism for Paying for Ecosystem Services from fisheries production to MPAs is not yet in place, MPAs receive only a small portion of these benefits, sometimes in-kind (training, provision of equipment, technical support). Over the past 30 years, the average annual investment in conservation of US$ 33.4 million has come from donations and grants.

Some marine protected areas, however, manage to finance themselves from tourism revenues, such as Nosy Tanihely in the northwest of Madagascar, in the DIANA region. Madagascar National Park as an operator has developed a management agreement with the Urban Commune of Nosy Be and the Regional Office of Tourism for about ten years. This convention has allowed to amplify tourism and to generate financial resources through the entrance fee to the park and other related revenues through the sale of ecoshop items, research rights and other rights. Nosy Tanihely has been able to cover 100% of the management costs of Nosy Tanihely for 10 years, including management activities, operations and staff salaries. During the last 5 years, despite the pandemic and the total halt of tourism, Nosy Tanihely through an exemplary adaptive management, manages to meet these needs. The following table shows the self-financing index.

[64] Source PA data base /DAPRNE/ MEDD 2020

[3] Source Mihari Network https://mihari-network.org/base-de-donnees/lmma-a-madagascar/

[4] USAID Hay Tao, FAPBM, MNP 2020 White Paper on added value of protected areas system

[5] USAID Hay Tao, FAPBM, MNP 2020 White Paper added value of protected areas system

Table 79: Self-financing index of Nosy Tanihely

YEAR	Number of visitors	Income in Ar	% covered management fee	IAF
2017	38,319	~ 500,000,000	100%	0.79
2018	44,098	~ 600,000,000	100%	0.58
2019	51,285	~ 700,000,000	100%	0.79
2020	7,646	~ 100,000,000	100%	2.83
2021	6,671	~ 30,000,000	100%	9.03

7.7. Analysis and conclusion

Comme As outlined in the introduction to this chapter, conducting a cost-benefit analysis of Madagascar's marine ecosystem means putting economic values not only on the benefits but also on the various costs. Therefore, it would have been necessary to have values for the efforts made to enable coastal and marine ecosystems to provide:

- **Supply goods and services such as, among others**, the value of the area deforested/cleared to have crop land, habitat losses (mangroves, coral reefs) to have fisheries products, the total cost of fishing efforts, the costs of fisheries administration: monitoring of reserves, control and surveillance, etc, the cost of watershed and coastal erosion, the real value of waste management and pollution control, the value of energy production, the value of water production for food and agriculture, the costs of research and mining, the costs of setting up and operating salt marshes, the total value of IGAs implemented by projects and partners to improve incomes and reduce pressures on ecosystems

- **Regulatory goods and services** such as the cost of coastal and upstream watershed protection infrastructure, the costs of reforestation, restoration, tree planting, the value of mangrove restoration, the costs of capacity building actions for stakeholders

- **Cultural goods and services**, such as the costs of maintaining and protecting sites, the costs of waste treatment, the costs of combating sex tourism, the costs of building infrastructures, the costs of scientific research

- **Support/back up goods and services**, including the costs of protecting coral reefs, the costs of restoring mangroves, the costs of protecting genetic areas, the costs of cleaning up the sea and coasts, the costs of repairing critical ecosystems, the costs of maintaining and cleaning up ports and harbors

However, since few areas have formal programs for the protection of coastal and marine ecosystems, the valorization of these parameters requires an in-depth study of several months. Thus, the analysis can only be limited to the quantification of benefits against a qualitative analysis of costs.

Fishing and exploitation of marine resources, coastal agriculture, urbanization, exploitation of coastal forests, degradation of coral reefs, uncontrolled removal of mangroves, even if they generate revenues and added values, accelerate erosion, degrade both the soil and biodiversity.

Supra, the benefits induced by the exploitation of marine fishing resources in Madagascar with its contribution to the national GDP have also been outlined. It is however obvious that costs are necessary to harvest the products presented here. First, there are direct costs such as fishing efforts, then come the indirect costs, namely, avoidance and prevention costs such as management actions, fisheries surveillance and control, and finally the costs of monitoring and information combined with research and expertise.

The relationship between poverty of local populations and establishing conditions for sustainable development of coastal areas is ambivalent and often contradictory in nature. In fact, the hypothesis of a convergence between the objective of reducing poverty and that of enhancing the value and sustainable management of ecosystems is sometimes invalidated by the socio-economic and environmental dynamics observed. In Madagascar, faced with the deterioration of their material living conditions, rural populations may respond by increasing pressure on terrestrial and marine natural resources. This contradiction is taken into account in the strategies implemented by the actors involved, at the local, regional and national levels, in the implementation of public policies, but these strategies are far from being effectively implemented due to a lack of means and especially due to the lack of conscious involvement of the communities involved in the project.

For Madagascar, which is an island territory, the impact is considerable, both in terms of **sustainable development and economic development**. The seas are reserves of food and commercial resources, the beaches are a tourist attraction that can help in the economic development of the regions, the agricultural lands are vital as sources of food and income. However, the coasts and the seas, threatened, are becoming more and more vulnerable and the soils, exhausted, are becoming more and more fragile and impoverished.

80% of coral reefs are threatened and/or degraded. Mangroves are being harvested and are disappearing. Urbanization and beach development, as well as agriculture, threaten coastal areas. It is therefore necessary, more than ever, to integrate the costs of **sustainable management of soils and ecosystems in the costs of sustainability of marine and coastal ecosystems**. Even more so in a context of climate change increasing the intensity and frequency of natural disasters and climatic phenomena, such as cyclones.

In conclusion, although the resources are under pressure and the management and preservation requires costs, the territorial waters of the country have certain reserve of sedentary and migratory resources that should be evaluated more closely to plan its rational exploitation. And, the coastal areas which brings a considerable added value to the economy require more concrete efforts for them to be enhanced in the development strategies.

Research for establishing a mechanism for the valorization of costs induced by the economic benefits derived from coastal areas has also to be funded.

Appendix

Chapter 3 appendix

Table 80: Evolution of the number of population in coastal areas

Regions	Districts	1993	2018
Analanjirofo	Fenoarivo Atsinanana	185,147	294,036
	Mananara Avaratra	81,713	240,352
	Maroantsetra	128,832	251,878
	Sainte Marie	12,563	26,457
	Soanierana Ivongo	76,471	143,365
Total Analanjirofo		**484,726**	**956,088**
Androy	Ambovombe Androy	146,078	362,309
	Beloha	50,652	154,652
	Tsihombe	51,596	149,700
Total Androy		**248,326**	**666,661**
Anosy	Amboasary Atsimo	120,248	256,977
	Taolagnaro	169,561	341,482
Total Anosy		**289,809**	**598,459**
Atsimo Andrefana	Ampanihy Andrefana	163,210	398,374
	Morombe	76,933	218,190
	Toliary I	80,826	169,760
	Toliary II	146,493	369,485
Total Atsimo Andrefana		**467,462**	**1,155,809**
Atsimo Atsinanana	Farafangana	156,943	406,174
	Vangaindrano	159,110	355,329
Total Atsimo Atsinanana		**316,053**	**761,503**
Atsinanana	Brickaville	122,588	212,572
	Mahanoro	163,233	284,812

Regions	Districts	1993	2018
	Toamasina I	137,782	326,286
	Toamasina II	129,581	261,516
	Vatomandry	99,383	170,148
Total Atsinanana		**652,567**	**1,255,334**
Boeny	Mahajanga I	106,780	244,722
	Mahajanga II	36,829	95,192
	Mitsinjo	42,036	86,719
	Soalala	21,594	41,727
Total Boeny		**207,239**	**468,360**
DIANA	Ambanja	100,465	238,114
	Ambilobe	112,917	280,089
	Antsiranana I	59,040	131,165
	Antsiranana II	57,373	130,903
	Nosy Be	29,432	109,465
Total DIANA		**359,227**	**889,736**
Melaky	Antsalova	23,662	57,662
	Besalampy	29,739	58,916
	Maintirano	41,481	115,192
Total Melaky		**94,882**	**231,770**
Menabe	Belo Sur Tsiribihina	41,879	132,141
	Manja	44,946	106,378
	Morondava	64,070	151,028
Total Menabe		**150,895**	**389,547**
SAVA	Antalaha	149,684	268,902
	Sambava	190,788	395,680

Regions	Districts	1993	2018
	Vohemar	136,320	239,034
Total SAVA		**476,792**	**903,616**
SOFIA	Analalava	70,775	163,968
	Port Bergé	81,599	228,972
Total Sofia		**152,374**	**392,940**
Fitovinany	Manakara	178,607	380,538
	Vohipeno	74,773	143,935
Total Fitovinany		**253,380**	**524,473**
Vatovavy	Nosy Varika	134,708	254,735
	Mananjary	177,041	278,736
Total Vatovavy		**565,129**	**1,057,944**
Total Population côtière		**4,465,481**	**9,727,767**
MADAGASCAR		12,238,917	25,680,342

Soure: INSTAT Madagascar

Table 81: Population density in coastal areas in 2018

Regions	Population density (inhab./km²)
Melaky	8,1
Menabe	17,1
Sofia	24,8
Boeny	27,3
Atsimo Andrefana	37
Anosy	37,8
DIANA	44,5
SAVA	45,8
Androy	48,2
Analanjirofo	50,3
Atsinanana	73,2
Vatovavy Fitovinany	77,7
Atsimo Atsinanana	99,7

Source: INSTAT Madagascar (Traitement de données: ONE)

Table 82: Number of public health facilities in 2020

Regions	Districts	CSB1	CSB2	CHRD	CHRR	CHU
Analanjirofo	Fénérive Est	17	11	0	1	0
	Mananara Avaratra	**5**	17	**1**	**0**	**0**
	Maroantsetra	**11**	20	**1**	**0**	**0**
	Sainte Marie	4	6	1	0	0
	Soanierana Ivongo	11	9	1	0	0
Total Analanjirofo		**48**	**63**	**4**	**1**	**0**
Androy	Ambovombe	4	19	0	1	0
	Beloha	8	6	1	0	0
	Tsihombe	6	8	1	0	0
Total Androy		**18**	**33**	**2**	**1**	**0**
Anosy	Amboasary	17	18	1	0	0
	Tolagnaro	14	28	0	1	
Total Anosy		**31**	**46**	**1**	**1**	**0**
Atsimo Andrefana	Ampanihy	9	17	1	0	0
	Betioky	8	25	1	0	0
	Morombe	13	10	1	0	0

Regions	Districts	CSB1	CSB2	CHRD	CHRR	CHU
	Toliary I	1	7	0	0	2
	Toliary II	17	**25**	0	0	0
Total Atsimo Andrefana		**48**	**84**	**3**	**0**	**2**
Atsimo Atsinanana	Farafangana	8	30	0	1	0
	Vangaindrano	19	30	1	0	0
Total Atsimo Atsinanana		**27**	**60**	**1**	**1**	**0**
Atsinanana	Brickaville	13	18	1	0	0
	Mahanoro	20	13	1	0	0
	Toamasina I	0	6	0	0	2
	Toamasina II	18	19	0	0	0
	Vatomandry	5	19	1	0	0
Total Atsinanana		**56**	**75**	**3**	**0**	**2**
Boeny	Mahajanga I	0	8	0	0	2
	Mahajanga II	12	9	0	0	0
	Mitsinjo	10	7	1	0	0
	Soalala	12	4	1	0	0
Total Boeny		**34**	**28**	**2**	**0**	**2**
DIANA	Ambanja	10	23	1	0	0
	Ambilobe	14	16	1	0	0
	Antsiranana I	2	1	0	1	1
	Antsiranana II	10	20	0	0	0
	Nosy Be	7	**5**	1	0	0
Total DIANA		**43**	**65**	**3**	**1**	**1**
Melaky	Antsalova	8	5	1	0	0
	Besalampy	1	8	1	0	0
	Maintirano	3	16	0	1	0
Total Melaky		**12**	**29**	**2**	**1**	**0**
Menabe	Belo sur Tsiribihina	5	14	1	0	0
	Manja	9	6	1	0	0
	Morondava	10	8	0	1	1
Total Menabe		**24**	**28**	**2**	**1**	**1**
SAVA	Antalaha	14	18	1	0	0
	Sambava	15	25	0	1	0
	Vohémar	15	20	1	0	0

Regions	Districts	CSB1	CSB2	CHRD	CHRR	CHU
Total SAVA		**44**	**63**	**2**	**1**	**0**
Sofia	Analalava	15	12	1	0	0
	Port Bergé (Boriziny)	8	15	1	0	0
Total SOFIA		**23**	**27**	**2**	**0**	**0**
Vatovavy Fitovinany	Manakara	5	47	0	1	0
	Mananjary	11	27	1	0	0
	Nosy Varika	**8**	18	1	0	0
	Vohipeno	**7**	19	1	0	0
Total Vatovavy Fitovinany		**31**	**111**	**3**	**1**	**0**
TOTAL GENERAL		**439**	**712**	**30**	**9**	**8**

Source: MSANP, 2020

Table 83: Road infrastructures in coastal areas

Regions	Districts	Axis	Lenght (in km)
Analanjirofo	Fenoarivo Atsinanana Mananara Avaratra Maroantsetra Sainte Marie Soanierana Ivongo	RNP 5	185
		RNT 22	55
Androy	Ambovombe Androy Beloha Tsihombe	RNS 10	205
Anosy	Amboasary Atsimo Taolagnaro	RNS 13	266
			138
		RNT 12	101
Atsimo Andrefana	Ampanihy Andrefana Morombe Toliary I Toliary II	RNT 9	205
			9,2
		RNS 10	291
		RNP 7	168,4
Atsimo Atsinanana	Farafangana	RNS 27	129
	Vangaindrano	RNS 12	247

Regions	Districts	Axis	Lenght (in km)
Atsinanana	Brickaville Mahanoro Vatomandry Toamasina I Toamasina II	RNP 2	159,5
		RNT 11	136,2
		RNS 11	67
		RNS 5	91,9
Boeny	Mahajanga I Mahajanga II Mitsinjo Soalala	RNT 19	162
		RNT 8B	
		RNP 4	111
		RNP 6	35,5
DIANA	Ambanja Ambilobe Antsiranana I Antsiranana II Nosy Be	RNP 6	242,3
		RNS 5A	46,9
Melaky	Antsalova Besalampy Maintirano	RNT 8A	122,9
Menabe	Belo Sur Tsiribihina Manja Morondava	RNS 34	169,5
		RNS 35	154,5
		RNT 9	172
		RNT 8	136,8
SAVA	Antalaha Sambava Vohémar	RNS 5A	332
		RNT 23	49,2
		RNT 3B	107
Sofia	Analalava Port Bergé	RNP 6	355
		RNS 32	187
		RNT 31	102
	Manakara	RNS 25	100

Regions	Districts	Axis	Lenght (in km)
Vatovavy Fitovinany	Mananjary Nosy Varika	RNS 25	216
		RNS 11	117
		RNT24	42

Source: MTM

Chapter 5 appendix

Table 84: Summary table of coastal and marine governance

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
PRIME MINISTER'S OFFICE: **<u>Entity in charge of the integrated management of coastal zones:</u>** National committee for the integrated management of coastal zones (CNGIZC)	-After the government communication on December 15, 2021 which approved the dissolution of the CNGIZC, no official act of repealing the CNGIZC or revising the 2010 GIZC decree in order to adapt it to the context of the new state policies (concept of Blue economy, sustainable development, maritime spatial planning etc) has been taken by the Government to date. -The coordination of the governance of the oceans and maritime spaces is still rather vague despite the existence of the Department in charge of fisheries and the Blue Economy. -The CNGIZC is the body responsible for consultation, policy-making and coordination of all the interventions and the stakeholders in the coastal areas of Madagascar. It is attached to the *Prime Minister's office* and has a number of offshoots at regional and communal level through the setting up of regional and local committees at the decentralized territorial collectivities level. It is composed of multisectoral and multidisciplinary members from different Ministries as well as national and international organizations, ….	All the ratified international conventions dealing with coastal and marine governance.	-All environmental and sectoral texts related to marine and coastal governance; -Decree no. 2010-137 of March 23, 2010 regulating the integrated management of coastal and marine areas in Madagascar. -Order no. 22473-2012 of August 21, 2012 establishing the organization and functioning of the national committee for the integrated management of coastal zones (CNGIZC).

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
Ministry in charge of Fisheries: Ministry of Fisheries and Blue Economy (MPEB)	-In accordance with the provisions of the article 21 of the law No. 2018-025 of December 25, 2018 regarding the maritime zones of the maritime space under the jurisdiction of the Republic of Madagascar "(…), the ministerial department in charge of the Sea ensures the coordination of the State activities at sea (…)". -The decree that sets the responsibilities of the Minister of Fisheries and Blue Economy stipulates that any mission related to the coordination of all actions at sea falls under the responsibility of the MPEB. -The Ministry has the management and planning support Directorate which is responsible for governing the sea and the ocean, as well as coordinating all related activities, in collaboration with all the stakeholders of the Blue Economy. Among other things, it is also in charge of the Marine Spatial Planning. - Any activity affecting the maritime space under the jurisdiction of the Malagasy State and the use of marine, coastal and aquatic ecosystems, whether for conservation or exploitation, must involve the Ministry in charge of the Governance of the sea, the ocean and the development of the Blue Economy.	**International conventions ratified in the fishing sector** - United Nations convention on the Law of the Sea -Code of Conduct for a responsible fishery, 1995 -Agreement on port State measures to prevent, deter and eliminate illegal, unreported and unregulated fishing, 2009 Relevant international conventions to be ratified: -Agreement so as to apply the provisions of the United Nations convention on the law of the sea related to the conservation and the management of fish stocks whose movements take place both inland and beyond Exclusive Economic Zones (Straddling stocks) and highly migratory fish stocks, 1995	-Law No. 2015-053 of February 03, 2016 on the Fisheries and Aquaculture Code; -Law No. 2001-020 of December 12, 2001 on the creation of responsible and sustainable shrimp aquaculture; - Law No. 2001-004 of October 25, 2001 on the general regulation of Dina in terms of public security; -Decree No. 2017-936 of October 11, 2017 creating the national framework for the implementation of the Blue Economy; -MECIE Decree No. 99-954 of December 15, 1999 about the compatibility of investments with the environment modified by Decree No. 2004-167 of 02/03/04; - Decree No. 2016-1352 of November 08, 2017 on the organization of activities for the preservation of fishery resources and aquatic ecosystems; -Inter-ministerial Order No. 29211-2017 of November 28, 2017 setting the terms and conditions for the management transfer of fisheries resources and aquatic ecosystems; -Order No. 16646/2008 of August 19, 2008 regulating the practice of cage

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
			farming and its installation in the public aquaculture and brackish domain

Ministry in charge of the environment: Ministry of Environment and Sustainable Development (MEDD)	-The MEDD is responsible for designing, coordinating, implementing, monitoring and evaluating the State policy on environment and sustainable development.[33] -Within the framework of ocean governance, there are internal and external cross -cutting structures ensuring the integration of the environmental dimension and sustainable development. **For internal structures:** -The Body for the Coordination of Strategic Actions for Green Diplomacy and Related Organizations (OC-DVOR) which is responsible for monitoring international conventions on the environment that were ratified by Madagascar; -The General Directorate of Environmental Governance (DGGE) whose mission is to protect, enhance and take care of the environment of the protected areas system; -The Directorate of Protected Areas, a structure attached to the DGGE, which is responsible for ensuring the management of renewable natural resources and biodiversity, particularly at the level of the protected areas system -The Support Directorate for the Promotion of Green and Blue Economy, a structure attached to the DGDD. With regard to the blue economy, it is in charge of contributing to the promotion and enhancement of research as well as the use of marine ecosystems including its biodiversity, for sustainable development purposes.	**Ratified International conventions relating to environment** -United Nations Convention on the Law of the Sea -Nairobi Convention for the Protection, Management and Development of the Marine Environment and Coastal Zones of East Africa, 1985; -Protocol on Protected Areas and Wild Fauna and Flora in the East African Region, -African Convention on the Conservation of Nature and Natural Resources -Convention on Biological Diversity (CDB), 1992 -Cartagena Protocol on Biosafety relating to the Convention on Biological Diversity, 2000 -Convention on International Trade of Wild Fauna and Flora Species, 1973 (CITES) -Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their use related to the Convention on Biological Diversity -United Nations Framework Convention on Climate Change, 1992 -Kyoto Protocol, 1997	-Law No. 2015-003 of February 19, 2015 on the Updated Environment charter; -Law No. 2001-004 of October 25, 2001 on the general regulation of Dina in terms of public security; -Law No. 2015-005 of February 26, 2015 revising the Protected Areas Management Code; -Decree No. 2017-415 of May 30, 2017 setting the terms and conditions for the application of Law No. 2015-005 of February 26, 2015 recasting the Protected Areas Management Code; -Law No. 96-025 of September 30, 1996 relating to the local management of renewable natural resources (GELOSE); -Decree No. 2000-027 of January 13, 2000 relating to grassroots communities responsible for the local management of renewable natural resources; -Decree No. 2000-028 of January 13, 2000 relating to environmental mediators; -Decree No. 2017-066 of January 31, 2017 regulating access and sharing of benefits arising from the use of genetic resources;

	For independent external structures but attached to the MEDD: - *The Body responsible for combating marine oil pollution (OLEP)* which is responsible for managing oil pollution situations (preventive and curative) at sea. -*The National Office for the Environment (ONE*) which is responsible for ensuring the compatibility of investments for creating Marine Parks with the environment -*Madagascar National Parks (MNP)* which is responsible for the operational management of the Marine Parks created **For all structures outside the MEDD:** -*The SAPM Commission* which is responsible for the technical aspects of the creation of land, lake, marine and coastal parks -*The COPIL for the fulfillment of the Promise of Sydney* which is responsible for the technical, legal and strategic aspects in creating Marine and Coastal Parks and other similar forms (LMMAs, OECM).	-Vienna Convention on the Protection of the Ozone Layer, 1985 -Montreal Protocol on Substances that deplete the Ozone Layer, 1987 -Paris Climate Agreement, 2015 -Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989 -Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, 1998 -Stockholm Convention on Persistent organic pollutants -RAMSAR Convention, 1971	-MECIE Decree No. 99-954 of December 15, 1999 relating to the compatibility of investments with the environment modified by Decree No. 2004-167 of February 03, 2004; -Decree No. 2003-439 of March 27, 2003 establishing an environmental unit within each Ministry; -Decree No. 2017-566 of July 11, 2017 setting the control and inspection missions of environmental technicians as well as the terms of transaction.

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
Ministry in charge of maritime transport: Ministry of Transport and Meteorology (MTM)	-The MTM[65] is responsible for defining and developing policies and strategic focus in the areas of transport and meteorology, in accordance with the General State Policy (PGE) and the Sustainable Development Goals (SDGs). -More specifically, it is responsible for implementing State policy in the field of maritime and river transport, executing, monitoring and evaluating activities and studies within the framework of the development program for the maritime and river sub-sector. **Among its responsibilities:** -Ensure compliance with obligations arising from international and national conventions and agreements; -Establish a legal environment conducive to the development of the transport sector; -Promote the integrated, harmonious and orderly development of transport; -Set up standards for good governance in the transport and meteorology sector;	**Ratified international conventions in maritime transport** -United Nations Convention on the Law of the Sea; - International Convention for the Prevention of Pollution from Ships of November 2, 1973 completed by the 1978 Protocol (MARPOL 73/78), Annexes I to VI; - International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC 1990); -1992 International Convention on Civil Liability for Oil Pollution Damage (CLC 92); -1992 International Convention establishing an International fund for damage compensation due to Oil Pollution (IOPC Funds 92); -2000 Protocol on preparedness, response and cooperation against pollution Incidents by Harmful and	-Law No. 99-028 of February 03, 2000 recasting the Maritime Code; -Law No. 2018-025 of November 21, 2018 relating to the maritime zones of the maritime space under the jurisdiction of the Republic of Madagascar;

[65] Decree no. 2021-863 defining the responsibilities of the Ministry of transport and meteorology as well as the general organization of the ministry.

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
	-Ensure the inter-ministerial coordination of transport and meteorology development policies with the decentralized territorial entities; -Develop and ensure the application of program contracts and means for structures intervening in its field of competence; -Put in place an incentive framework facilitating the activities of investors and operators in the perspective of Public-Private Partnership (PPP); -Ensure better circulation of goods and people; -Develop and implement strategies relating to transport safety and security; -Anticipate the harmful effects of climatic and meteorological hazards with a view to protecting property and people; -Contribute to scientific and technical exchanges in the field of transport and meteorology; The Ministry is supported in its missions by the Port, Maritime and River Authority (APMF).	potentially hazardous substances (OPRC-HNS Protocol); -2001 International Convention on civil liability for pollution damage caused by bunker oil (BUNKERS 2001); -2001 International convention on the control of harmful anti-fouling systems on ships (AFS 2001); - International convention on control and management of the ballast water and sediments of ships, 2004 (BWM 2004); -Nairobi Wrecks Removal Convention, 2007 (NWRC 2007); -1996 Protocol to the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes	
Ministry in charge of land use planning Ministry in charge of land use planning and land services (MATSF)	-MATSF is in charge of the design, the implementation and the monitoring of the state policy with regards to land development, housing and land. -The Ministry includes a *Department responsible for the Coordination, Planning and Valorization of the Maritime Territory* whose mission is to develop and implement the planning scheme and the valorization of the Malagasy maritime territory, as well as the Maritime Spatial Planning	**All ratified international conventions with regards to coastal and marine governance.**	- Law No. 2015-051 of February 03, 2016 on land use planning; -Decree no. 2017-646 of August 01, 2017 setting the terms and conditions for implementing land use planning policy and the terms and conditions for applying the penal provisions of the law relating to urban planning and housing.

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
	(PSM) ; to initiate reflections and studies on the development of the Malagasy maritime territory; ensure the regularization of the Malagasy continental shelf; harmonize the actions of the ministerial departments concerned with the development of the maritime territory. - Other organizations and institutions support the Ministry in charge of land use planning, notably the National Council for land use Planning (CNAT), the provincial, regional and communal Committees for land use planning at the Decentralized Territorial Collectivities[66] level, the CNGIZC and the ICZM Committees at regional and local level.		
Ministry in charge of the decentralization: Ministry of interior and Decentralization	The general mission of the MID[67] is to draw up and implement the general policy of the State, which is led by the Government on the subjects that fall under its responsibilities and competences. **Among its responsibilities:**	All ratified international conventions with regards to coastal and marine governance.	-Organic Law No. 2014-018 of September 12, 2014 governing the powers, establishing the structure and operating methods of Decentralized Territorial Collectivities, as well as those of the management of their own affairs (supplemented by Organic Law No.

[66] Decree no. 2019-1933 defining the composition, the structure and the operating methods of the communal, regional and provincial committees.

-Decree no. 2019-1935 defining the composition, the operating methods and the responsibilities of the CNAT

[67] Decree no. 2020-156 on February 19, 2020 setting the responsibilities of the Ministry of Interior and Decentralization as well as the general organization of its Ministry

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
(MID)	-Develop and implement government policy on decentralization and deconcentration; -Work for the effectiveness and efficiency of the administration of the territory; -Promote effective decentralization and good local governance; -Exercise the powers relating to the State sovereignty mission which are assigned to it by the legislation in force; -Manage the organizations and the groups; -Ensure civil protection, coordination of emergency relief activities, risk and disaster reduction and management of aid in the event of cataclysms; -Promote and strengthen the free administration of the Decentralized Territorial Collectivities and ensure respect for legality of their acts; -Promote democracy and support towards citizen participation in this area; -Contribute to the preservation and maintenance of public order and security;		2016-030 of August 23, 2016 concerning the “national equalization fund”, intended to reduce inequalities between CTDs (DTCs); -Decree No. 2015 – 957 of June 16, 2015 relating to the Local Consultation Structure of Decentralized Territorial Collectivities; -Law n° 2014-020 of September 27, 2014 relating to the resources of the Decentralized Territorial Collectivities, the election procedure as well as the organization, the functioning and the responsibilities of the different bodies within them (modified by the law n° 2015-008 of April 01, 2015 concerning the respect for the democratic foundations of the list-based system, and equal access to functions in the field of political, economic and social life); -Decree No. 2015 – 960 of June 16, 2015 setting the responsibilities of the Chief Executive of the Decentralized Territorial Collectivities; -Law n° 2014-021 of September 12, 2014 relating to the representation of the State;

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
			-Decree No. 2014 – 1929 of December 23, 2014 setting the terms of application of some provisions of the Law No. 2014-021 on September 12, 2014 relating to State representation.
Ministry in charge of tourism: Ministry of Tourism	- The Minister of Tourism is responsible for designing, coordinating, monitoring and evaluating the implementation of State policy in the area of tourism development. - His/her mission is to promote a harmonized, orderly and integrated development of tourism so as to stimulate growth of the sector by improving the offers through a training policy on tourism-related jobs.	**All ratified international conventions related to the biodiversity and to the natural resources:** -African Convention on the Conservation of Nature and Natural Resources. -Convention on Biological Diversity (CBD) -Nairobi Convention for the Protection, Management and Development of the Marine Environment and Coastal Zones of East Africa, 1985; -Protocol on Protected Areas and wild fauna and flora in the East African Region; -Convention on International Trade of Wild Fauna and Flora Species (CITES) -Nairobi Convention for the Protection, Management and Development of the Marine	-Law no. 95-017 of August 25,1995 on the tourism code -MECIE decree no. 99-954 of December 15, 1999 relating to the compatibility of investments with the environment, modified by Decree No. 2004-167 of February 03, 2004;

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
		Environment and Coastal Zones of East Africa, 1985; -United Nations Framework Convention on Climate Change, 1992 -Kyoto Protocol, 1997 -Paris Climate Agreement, 2015	
Ministry in charge of strategic resources: Ministry of Mines and Strategic Resources (MMRS)	-The MMRS[68], through the General Directorate of Strategic Resources, is responsible for implementing State policy in the development and exploitation of resources in the Upstream Petroleum sector. -The maritime zones are equivalent to the international system required by the United Nations Convention on the Law of the Sea, ratified on August 20, 2001 by Madagascar. -The National Hydrocarbons Mining Domain is defined as all the areas where prospecting, research, exploration, exploitation, processing and transport of hydrocarbons are carried out. -The extent of the continental shelf meets the requirements of the United Nations Convention on the Law of the Sea: low slope, depth less than or equal to 2500m.	**All ratified international conventions on marine pollution (maritime transport)** -United Nations Convention on the Law of the Sea; -International Convention for the Prevention of Pollution from Ships of November 2, 1973 supplemented by the 1978 Protocol (MARPOL 73/78), Annexes I to VI; -International Convention on Oil Pollution preparedness, Response and Cooperation, 1990 (OPRC 1990); -1992 International Convention on Civil Liability for Oil Pollution Damage (CLC 92);	-Law No. 96-018 of September 04, 1996 on the Petroleum Code -MECIE Decree No. 99-954 of December 12, 1999 relating to the compatibility of investments with the environment, modified by Decree No. 2004-167 of February 03, 2004;

[68] Decree no. 2020-078 on February 04, 2020 setting the responsibilities of the Ministry of Mines and Strategic resources as well as the general organization of the Ministry

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
	-Institutions and organizations support the MMRS in the preservation of the marine environment, notably the Office of National Mines and Strategic Industries (OMNIS) which is responsible for the management of the national hydrocarbon mining domain.	-1992 International Convention establishing an International Fund for damage compensation due to Oil Pollution (IOPC Funds 92); -2000 Protocol on preparedness, response and cooperation against pollution incidents by harmful and potentially hazardous substances (OPRC-HNS Protocol); -2001 International Convention on civil liability for pollution damage caused by bunker oil (BUNKERS 2001); -Protocol for the fight against telluric pollution in East Africa; -Protocol on Cooperation in the fight against accidental marine pollution in the East African Region.	
Ministry in charge of national defense: Ministry of National Defense (MDN)	-The MDN[69] executes the national defense policy, and uses all the resources at its disposal to preserve national sovereignty, territorial integrity and national security.	**All ratified international conventions on coastal and marine governance**	-Law No. 99-028 of February 03, 2000 recasting the Maritime Code. -Law n° 2018-025 of November 21, 2018 relating to the maritime areas of the maritime space under the

[69] Decree no. 2019-061 on 01/02/2019 setting the attributions of the Ministry of National Defense as well as the general organization of the ministry

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
	-Institutions and organizations support the Ministry of National Defense **in the preserving the marine environment, notably the General Staff of the Navy**[70.] -We can also mention the Naval Base of Antsiranana, the Marine Detachments (Mahajanga, Nosy Be, Sainte-Marie, Fort-Dauphin), the Commanders of the Patrol Boats and Coastal Surveillance Boats of the Malagasy National Navy who are authorized to detect offences at sea. -10 Defense and Security zones with their respective Commanders and 22 regional military delegates at the Regional level are also planned to be set up. -The decree establishing the Defense and Security Zones and setting the principles governing them was adopted by the Council of Ministers on December 09, 2020. -A Memorandum of Understanding between the Ministry of National Defense and the Ministry of the Environment and Sustainable Development in the fight against pollution at sea was concluded on December 23, 2016.		jurisdiction of the Republic of Madagascar.

[70] The Navy was created by the decree no. 2020-318 on 11/03/2020

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
	<u>The General staff of the Navy</u>: -The General Staff of the Navy is the central body in charge of the design, the leadership, the command and the preparation of the Navy. It is headed by the Chief of Staff of the Navy. *-Defense mission:* Guarantee national sovereignty in waters under Malagasy jurisdiction; Defend the maritime approaches to the territory ; Participate in joint missions; *-Coastguard missions within the framework of State action at sea:* Ensure sovereignty and protection of national interests ; Ensuring maritime safety ; Participate in maritime security ; Participate in customs, tax and economic police at sea ; Fight against illicit activities at sea ; Participate in safeguarding people and property ; Support the protection of protected areas ; Participate in the protection of the environment ; Support health control and working conditions at sea ; Support the management of marine heritage and marine public resources		
<u>Ministry in charge of scientific research:</u>	The MESRS implements the general State policy in terms of higher education and research. **Among its responsibilities:**	**All ratified international conventions on coastal and marine governance**	

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
Miniistry of Higher Education and Scientific research (MESRS)	-Make higher education and scientific research a real engine of development in Madagascar; - Promote professionally-oriented course, within faculties, schools, institutes, and various sites with high economic potential; - Ensure a better environment for studies, training and research; - Prioritize research and innovation themes; - Enhance scientific research outcomes by establishing an entrepreneurial strategy (promotion of the economy) in order to achieve the best possible exploitation of the products resulting from the research; - Systematize this investment option for research outcomes so that it becomes a real generating source of financial resources; - Coordinate and control the activities of the organizations and institutions attached to his/her Ministry. In terms of marine ecosystems, the Ministry responsible for Scientific Research is supported by the National Center for Oceanographic Research (CNRO), the National Center for Environmental Research (CNRE),		

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
Entity in charge of maritime and river transports: Port, maritime and river agency (APMF)	-The APMF[71] is the maritime authority responsible for regulating the port, maritime and river sub-sector. -It coordinates the implementation of national policy in the field of this sub-sector by ensuring the administration of port, maritime and river affairs, maritime and river "security and safety", the concessioning authority for ports, supervision and control of self-managed ports, regulation and management of port, maritime and fluvial public domains, protection of the coastline, as well as the marine environment, development and promotion of the sub-sector. -APMF is under the technical supervision of the Ministry of Transport.	**All ratified international conventions regarding maritime transports:** -United Nations Convention on the Law of the Sea; - International Convention for the Prevention of Pollution from Ships of November 2, 1973 completed by the 1978 Protocol (MARPOL 73/78), Annexes I to VI; -International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC 1990); -1992 International Convention on Civil Liability for Oil Pollution Damage (CLC 92); -1992 International Convention establishing an International fund for damage compensation due to Oil Pollution (IOPC Funds 92); -2000 Protocol on preparedness, response and cooperation against	Law No. 99-028 of February 03, 2000 recasting the Maritime Code; Law n° 2018-025 of November 21, 2018 relating to the maritime areas of the maritime space under the jurisdiction of the Republic of Madagascar.

[71] Decree no. 2012-391 of March 20, 2012 deals with the restructuring of the Port, Maritime and River Agency (APMF); modified and completed by the decree no. 2017-325 on May 20, 2017, defines its statute, funding modes and creates the ports, maritime and river transports Council as well as the Maritime operations and Support Center.

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
		pollution Incidents by Harmful and potentially hazardous substances (OPRC-HNS Protocol); -2001 International Convention on civil liability for pollution damage caused by bunker oil (BUNKERS 2001); -2001 International convention on the control of harmful anti-fouling systems on ships (AFS 2001); - International convention on control and management of the ballast water and sediments of ships, 2004 (BWM 2004); -Nairobi Wrecks Removal Convention, 2007 (NWRC 2007); -1996 Protocol to the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes	

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
Entity in charge of combating marine oil pollution: Body responsible for combating marine oil pollution events (OLEP)	OLEP's[72] mission to prepare and coordinate response operations against pollution events in the marine and coastal environment, namely accidental spills of hydrocarbons and noxious and potentially hazardous substances (all cargoes combined within the meaning of the OPRC-HNS Protocol). -Upstream, it is responsible for emergency planning (the emergency response plans to which vulnerability maps are annexed are the outputs), prevention, preparation and pre-positioning of response equipment on the coast. -Downstream, it is responsible for crisis management, remediation, compensation (application of the polluter pays principle), and its restoration. -OLEP is under the technical supervision of the Ministry in charge of the Environment.	**Ratified international conventions on marine oil pollution (maritime transport)** - International Convention for the Prevention of Pollution from Ships of November 2, 1973 completed by the 1978 Protocol (MARPOL 73/78), Annexes I to VI; -International Convention on Oil Pollution Preparedness, Response and Cooperation, 1990 (OPRC 1990); -1992 International Convention on Civil Liability for Oil Pollution Damage (CLC 92); -1992 International Convention establishing an International fund for damage compensation due to Oil Pollution (IOPC Funds 92);	Law No. 2004 - 019 of August 19, 2004 implementing international conventions relating to the protection of the marine and coastal environment against oil spill pollution.

[72] Decree no. 2004-994 on October 26, 2004 sets the creation, the structure and the functioning of the Body responsible for combating marine oil pollution events (OLEP)

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
		-2000 Protocol on preparedness, response and cooperation against pollution Incidents by Harmful and potentially hazardous substances (OPRC-HNS Protocol); 2001 International Convention on civil liability for pollution damage caused by bunker oil (BUNKERS 2001); -2001 International convention on the control of harmful anti-fouling systems on ships (AFS 2001); - International convention on control and management of the ballast water and sediments of ships, 2004 (BWM 2004); -Nairobi Wrecks Removal Convention, 2007 (NWRC 2007);	
Entity in charge of managing Marine Protected Areas: Madagascar National Parks (MNP)	-Madagascar National Parks or MNP, was created in 1990 under its first name "ANGAP", or National Association for the Management of Protected Areas, association of private law recognized of public utility by the decree n ° 91-592 of December 4, 1991. -The new name "MNP" of the Association is given following the decision of the EGM on October 29, 2008.	**Ratified international conventions relating to biodiversity and natural resources:** -Nairobi Convention for the Protection, Management and Development of the Marine Environment and Coastal Zones of East Africa, 1985;	-Law No. 2015-003 of February 19, 2015 on the updated Environmental Charter; -Law No. 2015-005 of February 26, 2015 recasting the Protected Areas Management Code; -Decree No. 2017-415 of May 30, 2017 setting the terms and conditions for the application of the

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS
	-Currently, Madagascar National Parks benefits from a new Statute adopted on May 04, 2021. -MNP is responsible for establishing, conserving and sustainably managing Madagascar's national parks. In 2020, it managed 43 Protected Areas including 5 RAMSAR Sites, 5 Biosphere Reserves and 7 UNESCO World Heritage sites. -The MNP is under the supervision of the Ministry in charge of the Environment and Sustainable Development.	-Protocol on Protected Areas and wild fauna and flora in the East African Region; -African Convention on the Conservation of Nature and Natural Resources; -Convention on Biological Diversity (CBD); -Convention on International Trade of Wild Fauna and Flora Species (CITES) -Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their use related to the Convention on Biological Diversity NB: The implementation of the Convention on Biological Diversity through the Aichi target (11) concerning marine protected areas is in progress. -United Nations Framework Convention on Climate Change, 1992 -Kyoto Protocol, 1997 -RAMSAR Convention, 1971	Law No. 2015-005 of February 26, 2015 recasting the Protected Areas Management Code; -Law No. 2001-004 of October 25, 2001 on the general regulation of Dina in terms of public security; -Law No. 2015-053 of February 03, 2016 on the Fisheries and Aquaculture Code; -Law No. 96-025 of September 30, 1996 relating to the local management of renewable natural resources (GELOSE); -Decree No. 2000-027 of January 13, 2000 relating to grassroots communities responsible for the local management of renewable natural resources; -Decree No. 2000-028 of January 13, 2000 relating to environmental mediators; -Decree No. 2017-066 of January 31, 2017 regulating access and sharing of benefits arising from the use of genetic resources; -MECIE Decree No. 99-954 of December 15, 1999 relating to the compatibility of investments with the environment modified by Decree No. 2004-167 of February 03, 2004;

ENTITY	RESPONSIBILITIES	INTERNATIONAL CONVENTIONS	NATIONAL LAWS

Chapter 6 appendix

Table 85: List of Protected Areas in Coastal Regions - Madagascar

	Manager	Site name	Legal status	UICN Cat	Creation date	Regions	Surface area (ha)
1	ASITY	Complexe Zones Humides Mahavavy Kinkony	PHP	V	Décret N°2015 -718 du 21 avril 2015	Boeny	302 000
2	ASITY	Complexe Zones Humides Mangoky Ihotry	PHP	V	Décret N°2015 -719 du 21 avril 2015	Atsimo andrefana, Menabe	426 146
3	ASITY	Tsitongambarika	RRN	VI	Décret N°2015 -720 du 21 avril 2015	Anosy	58 597
4	BCM	Beanka	PHP	V	Décret N°2015-727 du 21 avril 2015	Melaky	17 000
5	BCM	Sahafina	RRN	VI	Décret N°2015-728 du 21 avril 2015	Atsinanana	2 400
6	Blue Ventures	Velondriake	PHP	V	Décret N°2015-752 du 28 avril 2015	Atsimo andrefana, Menabe	63 985
7	CI	Ambodivahibe	PHP	V	Décret N°2015-753 du 28 avril 2015	DIANA	39 794
8	CI	Corridor Ambositra Vondrozo	PHP	V	Décret N°2015-755 du 28 avril 2015	Haute Matsiatra, Vatovavy Fitovinany, Ihorombe Amoron'Mania, Atsimo atsinanana	314 186
9	DELC	Bombetoka Beloboka			Décret N°2015-808 du 5 mai 2015	Boeny	71 943
10	DURRELL	Complexe Lac Forêt Ambondrobe	PHP	V	Décret N°2015-758 du 28 avril 2015	Menabe	6 133
11	DURRELL	Rivière Nosivolo	PHP	V	Décret N°2015-757 du 28 avril 2015	Atsinanana	9 657
12	ESSA Forêt	Réserve de Tampolo	PHP	V	Décret N°2015-789 du 28 avril 2015	Analanjirofo	675
13	FANAMBY	Allée des Baobabs	MN	III	Décret N°2015-760 du 28 avril 2015	Menabe	320
14	FANAMBY	Andrafiamena Andavakoera	PHP	V	Décret N°2015-761 du 28 avril 2015	DIANA	73 319
15	FANAMBY	Loky Manambato	PHP	V	Décret N°2015-759 du 28 avril 2015	SAVA	250 000
16	FANAMBY	Menabe Antimena	PHP	V	Décret N°2015-762 du 28 avril 2015	Menabe	210 312
17	Association TAMIA	Tsinjoriake	PHP	V	Décret N°2015-781 du 28 avril 2015	Atsimo andrefana	5 484
18	Lemuria Land	Nosy Antsoha	PHP	V	Décret N°2015-764 du 28 avril 2015	DIANA	28
19	MBG	Agnakatrika	RRN	VI	Décret N°2015-794 du 28 avril 2015	Atsimo atsinanana	780
20	MBG	Agnalazaha	RRN	VI	Décret N°2015-795 du 28 avril 2015	Atsimo atsinanana	2 745
21	MBG	Ampasindava	PHP	V	Décret N°2015-769 du 28	DIANA	91 790

	Manager	Site name	Legal status	UICN Cat	Creation date	Regions	Surface area (ha)
					avril 2015		
22	MBG	Analalava	RS	IV	Décret N°2015-765 du 28 avril 2015	Atsinanana	229
23	MBG	Ankarabolava	RRN	VI	Décret N°2015-793 du 28 avril 2015	Atsimo atsinanana	773
24	MBG	Forêt Sacrée Alandraza Analavelo	MN	III	Décret N°2015-766 du 28 avril 2015	Atsimo andrefana	4 487
25	MBG	Galoko Kalabinono	PHP	V	Décret N°2015-770 du 28 avril 2015	DIANA	74 205
26	MBG	Makirovana Tsihomanaomby	RRN	VI	Décret N°2015-768 du 28 avril 2015	SAVA	3 398
27	MBG	Oronjia	PHP	V	Décret N°2015-771 du 28 avril 2015	DIANA	1 648
28	MBG	Pointe à Larrée	RS	IV	Décret N°2015-773 du 28 avril 2015	Analanjirofo	770
29	MBG	Vohidava - Betsimalaho	RRN	V	Décret N°2015-774 du 28 avril 2015	Anosy	18 169
30	MEEF	Ambararata Londa			Décret N°2015-808 du 5 mai 2015	Androy	10 284
31	MEEF	Ambatotsirongorongo			Décret N°2015-792 du 28 avril 2015	Anosy	1 033
32	MEEF	Angavo			Décret N°2015-808 du 5 mai 2015	Anosy	42 760
33	MEEF	Behara Tranomaro			Décret N°2015-808 du 5 mai 2015	Androy	95 588
34	MEEF	Bemarivo	RS	IV	Décret N°2425 AP/4 du 20 / 02 / 56	Melaky	11 570
35	MEEF	Maningoza	RS	IV	Décret N°56-208 d 20 / 02 / 56	Melaky	7 900
36	MEEF	Ranobe Bay			Décret N°2015-808 du 5 mai 2015	Atsimo andrefana	42 404
37	MEEF	Ranobe PK32			Décret N°2015-808 du 5 mai 2015	Atsimo andrefana	168 500
38	MEEF	Sud-Ouest Ifotaky			Décret N°2015-808 du 5 mai 2015	Atsimo andrefana	57 062
39	MEEF	Vohidefo			Décret N°2015-808 du 5 mai 2015	Atsimo andrefana	5 056
40	MNHN	Site Bioculturel d'Antrema	RRN	VI	Décret N°2015-712 du 21 avril 2015	Boeny	20 620
41	MNP	Ambatovaky	RS	IV	Décret N°58-10 du 28/10/58 ; Changement de limite par décret N°2015-731 du 21/4/2015	Analanjirofo	78 139
42	MNP	Analamerana	RS	IV	Décret 56-208 du 20/2/56 ; Changement de limite par décret N°2015-785 du 28/4/2015	DIANA	34 700
43	MNP	Andohahela	PN	II	Décret N°97-1043 du 07/8/97 ; Changement de limite par décret N°2015-785 du 28/4/2015	Anosy	76 140

	Manager	Site name	Legal status	UICN Cat	Creation date	Regions	Surface area (ha)
44	MNP	Andranomena	RS	IV	Décret N°58-13 du 28/10/58	Menabe	6 420
45	MNP	Anjanaharibe Sud	RS	IV	Décret N°58-12 du 28/10/58	SAVA	26 903
46	MNP	Ankarafantsika	PN	II	RNI depuis 1927, Changement de limite par décret N° 2015-730 du 21/4/2015	Boeny	136 513
47	MNP	Ankarana	RS	IV	Décret N°56-208 du 20/2/56 ; Changement de limite par décret N° 2015-729 du 21/4/2015	DIANA	18 225
48	MNP	Baie de Baly	PN	II	Décret N°97-1452 du 18/12/97	Boeny	57 418
49	MNP	Bemaraha	PN	II	RNI par décret N°66-242 du 01/6/66, PN par décret N°97-1045 du 07/8/97 ; Changement de statut en 2011	Melaky	157 710
50	MNP	Betampona	RNI	I	Créée le 31/12/1927 complétée par décret N°66-242 du 01/6/66	Atsinanana	2 228
51	MNP	Beza Mahafaly	RS	IV	Créée le 04/6/86	Atsimo andrefana	4 200
52	MNP	Cap Sainte Marie	RS	IV	Créée le 24/10/62 par décret N°62-527 ; Changement de limite par décret N°2015-733 du 21/4/2015	Androy	3 610
53	MNP	Iles Radama / Sahamalaza	PN	II	Décret N°2007/247 du 19/3/07	Sofia	26 035
54	MNP	Kirindy - Mitea	PN	II	Décret N°97-1453 du 18/8/97 ; Changement de limite par décret N°2015-735 du 21/4/2015	Menabe	156 350
55	MNP	Lokobe	PN	II	Décret N°2011-499 du 06/7/2011 ; anciennement RNI	DIANA	862
56	MNP	Mananara - Nord	PN	II	Décret N°89-216 du 25/7/89	Analanjirofo	24 000
57	MNP	Mangerivola	RS	IV	Décret N°58-10 du 28/10/58	Atsinanana	11 900
58	MNP	Manombo	RS	IV	Décret N°62-637 du 05/12/62	Atsimo atsinanana	5 320
59	MNP	Manongarivo	RS	IV	Décret N°56-208 du 20/2/56	DIANA	568
60	MNP	Marojejy	PN	II	Décret N°98-375 du 19/5/98	SAVA	60 050
61	MNP	Marolambo	PN	II	Décret N°2015-716 du 21/4/2015	Atsinanana, Vatovavy Fitovinany, Vakinankaratra, Amoron'i Mania	95 063
62	MNP	Masoala	PN	II	Décret N°97-141 du	Analanjirofo,	230 000

	Manager	Site name	Legal status	UICN Cat	Creation date	Regions	Surface area (ha)
					02/3/97	SAVA	
63	MNP	Midongy du sud	PN	II	Décret N°97-1451 du 18/12/97	Atsimo atsinanana	192 198
64	MNP	Mikea	PN	II	Décret N°2011-499 du 06/7/2011	Atsimo andrefana	184 630
65	MNP	Montagne d'Ambre / Forêt d'Ambre	PN	II	RS par décret N°58-15 du 28/10/58 ; Changement de statut par décret N°2015-776 du 28/4/2015	DIANA	30 538
66	MNP	Nosy Hara	PN	II	Décret N°2011-499 du 06/7/2011	DIANA	471
67	MNP	Nosy Mangabe	RS	IV	Décret N°65-795 du 14/12/65	Analanjirofo	729
68	MNP	Nosy Tanikely	PN	II	Décret N°2011-499 du 06/7/2011	DIANA	180
69	MNP	Nosy Ve Androka	PN	II	Décret N°2015-717 du 21/4/2015	Atsimo andrefana	91 445
70	MNP	Pic d'Ivohibe	RS	IV	Décret N°64-380 du 16/9/64 ; Changement de statut et de limite par décret N°2015-775 du 21/4/2015	Ihorombe	3 453
71	MNP	Ranomafana	PN	II	Décret N°91-250 du 27/5/1991	Vatovavy Fitovinany	43 550
72	MNP	Tsaratanàna	PN	II	31/12/97 ; Complétée par décret N°66-242 du 01/6/66 ; Changement de limite par décret N°2015-782 du 28/4/2015	DIANA	108 610
73	MNP	Tsimanampesotse	PN	II	Créée le 07/8/2003 ; Changement de limite par décret N°2015-736 du 21/4/2015	Atsimo andrefana	202 525
74	MNP	Tsingy de Namoroka	PN	II	RNI depuis 1927 ; Changement en PN le 07/8/2004	Boeny	22 227
75	MNP	Zahamena	PN	II	RNI par décret N°66-242 du 01/6/66 et PN par décret N°97-1044 du 07/8/97 ; Changement de statut par décret N°2015-737 du 21/4/2015	Analanjirofo, Atsinanana	65 935
76	MNP	Zombitse Vohibasia	PN	II	Décret N°97-1454 du 18/12/97	Atsimo andrefana	36 803
77	QMM	Ambatoatsinanana	PHP	V	Décret N°2015-778 du 28/4/2015	Anosy	1 365
78	QMM	Forêt naturelle de Petriky	PHP	V	Décret N°2015-777 du 28/4/2015	Anosy	300
79	QMM	Mandena	PHP	V	Décret N°2015-779 du 28/4/2015	Anosy	430
80	SAGE	Ambohitr'Antsingy Montagne des Français	PHP	V	Décret N°2015-780 du 28/4/2015	DIANA	6 049

	Manager	Site name	Legal status	UICN Cat	Creation date	Regions	Surface area (ha)
81	SEDIM	Ambohijanahary	RS	IV	Créée le 28/10/58	Melaky, Menabe	24 750
82	TPF	Complexe Tsimembo Manambolomaty	PHP	V	Décret N°2015-75 du 21/4/2015	Melaky	62 745
83	TPF	Mandrozo	PHP	V	Décret N°2015-714 du 21/4/2015	Melaky	15 145
84	WCS	Andreba	PHP	V	Décret N°2015-791 du 28/4/2015	Analanjirofo	39
85	WCS	Ankarea	PHP	V	Décret N°2015-721 du 21/4/2015	DIANA	135 556
86	WCS	Ankivonjy	PHP	V	Décret N°2015-722 du 21/4/2015	DIANA	139 140
87	WCS	Makira	PN	II	Décret N°2012-641 du 19/6/2012	SAVA, Analanjirofo, Sofia	372 470
88	WCS	Soariake	RRN	VI	Décret N°2015-723 du 21/4/2015	Atsimo andrefana	38 293
89	WWF	Amoron'Onilahy	PHP	V	Décret N°2015-788 du 28/4/2015	Atsimo andrefana	100 482
90	WWF	Ankodida	PHP	V	Décret N°2015-787 du 28/4/2015	Anosy	11 048
91	WWF	COMATSA Nord	RRN	VI	Décret N°2015-782 du 28/4/2015	SAVA, DIANA	237 083
92	WWF	COMATSA Sud	PHP	V	Décret N°2015-782 du 28/4/2015	SAVA, DIANA	80 204
93	WWF	Nord Ifotaky	PHP	V	Décret N°2015-786 du 28/4/2015	Androy	22 288
94	FBM	Corridor forestier Bongolava			Décret N°2015-790 du 28 avril 2015	Sofia	60 589
95	MEEF	Bora	RS	IV	Décret N°56-208 AP/4 du 20 / 02 / 56	Sofia	4 481
96	MEEF	Tampoketsa Analamaitso	RS	IV	Décret N°58-14 du 28 / 10 / 58	Sofia	17 150
97	MNP	Iles Radama / Sahamalaza	PN	II	Décret N°2007/247 du 19/3/07	Sofia	26 035
98	MNP	Marotandrano	RS	IV	Décret N°56-208 du 20/02/56 ; Changement de limite par le décret N° 2015-784 du 28/4/2015	Sofia	42 200
99	TPF	Bemanevika	PHP	V	Décret N°2015-782 du 28/4/2015	Sofia	35 605
100	TPF	Mahimborondro	RRN	VI	Décret N°2015-782 du 28/4/2015	Sofia	75 163

PHP: Paysage Harmonieux Protégé, RRN: Réserve de Ressources Naurelles, MN: Monument Naturel, RS: Réserve Spéciale, RNI: Réserve Naturelle Intégrale, PN: Parc National ;

Table 86: Protected Areas under temporary protection in coastal areas

	Manager	Site name	Legal status	UICN Cat	Creation date	Regions	Surface area (ha)
101	Blue Ventures	Iles Barren	PT		Arrêté N°30441/2014 de mise en protection temporaire	Melaky	
102	Groupe Anjajavy Lodge	Anjajavy	PT		Arrêté N° /2017 de mise en protection temporaire	Sofia	
103	SEAR	Sakara				Anosy	

PT: Protection Temporaire

Source: MEDD/DSAP/SCGAP, 2018

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Banque Mondiale	https://www.banquemondiale.org/fr/news/feature/2021/07/07/reducing-child-stunting-in-madagascar#:~:text=Avec%20un%20taux%20de%20retard,mesures%20pour%20inverser%20la%20tendance
Centre de Fusion d'Informations Maritimes	http://cfimmadagascar.org/
CNGIZC	https://www.primature.gov.mg/cngizc/
CNLEGIS	http://www.cnlegis.gov.mg/
Communauté du Pacifique	https://www.spc.int/fr (Fiche d'information sur les herbiers de la communauté pacifique)
Groupement des Aquaculteurs et Pêcheurs de crevettes de Madagascar	https://www.gapcm.org/aquaculture/
Groupement des Aquaculteurs et Pêcheurs de crevettes de Madagascar	https://www.gapcm.org/peche/
Institut National de la Statistique	https://www.instat.mg/
KNOEMA	https://knoema.fr/atlas/Madagascar/topics/Tourisme/Contribution-directe-du-tourisme-et-voyage-au-PIB/Travel-and-tourism-direct-contribution-to-GDP
L'Express de Madagascar	https://lexpress.mg/07/10/2020/
L'INFO Réunion	http://www.linfo.re/ocean-indien/madagascar/canal-du-mozambique-un-cargo-sombre-avec-8-000-litres-de-fuel-au-large-de-madagascar
L'INFO Réunion	http://www.linfo.re/oceanindien/madagascar/688958-madagascar-risque-de-pollution-marine-a-faux-cap
L'INFO Réunion	https://www.linfo.re/ocean-indien/madagascar/un-faible-taux-d-acces-a-l-eau-potable-a-madagascar

Liste des sites et monuments culturels de Madagascar, Wikipedia	https://fr.wikipedia.org/wiki/Liste_des_sites_et_monuments_culturels_de_Madagascar
Madarail	http://www.madarail.mg/
MEAH	http://bdeah-sesam.mg:8080/seam/index.php/bpor/bporv2etat/afficetatindicateur/6
MEN	https://www.education.gov.mg/
MEN	https://www.education.gov.mg/journee-internationale-de-lalphabetisation-2018-strategie-nationale-de-lalphabetisation-sna-a-madagascar-actualisee/
MIHARI	https://mihari-network.org/base-de-donnees/lmma-a-madagascar/
Ministère chargé des Travaux Publics	http://www.mahtp.gov.mg/la-direction-generale-des-travaux-publics-dgtp/
Ministère de l'Education Nationale	https://www.education.gov.mg/
MTTM	http://www.mahtp.gov.mg/la-direction-generale-des-travaux-publics-dgtp/
Okzone Madagascar	https: //okzonemadagascar.com/fibre-optique
Profil maritime de Madagascar, UNCTAD STAT	http://unctadstat.unctad.org/countryprofile/MaritimeProfile/fr-FR/450/index.html
Ramsar	http://www.ramsar.org
SESAM	http://bdeah-sesam.mg:8080/seam/index.php/bpor/bporv2etat/afficetatindicateur/6
TBE National	https://www.pnae.mg/tbe/national.html
UNESCO	https://www.unesco.org/fr/articles/lexclusion-scolaire-madagascar-pendant-la-covid-19#:~:text=Pourcentage%20des%20enfants%20non%2Dscolaris%C3%A9s,et%201%20million%20d'enfants
UNESCO	http://uis.unesco.org/fr/country/mg
UNICEF	https://www.unicef.org/madagascar/
	https://doi.org/10.3390/f5010177
	http://dx.doi.org/10.3390/land10060597
	http://dx.doi.org/10.1016/jocecoaman.2019.03.014
	http://doi.org/10.1080.19480881.2019.1625209