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Sustainable Management of Northeastern Madagascar Halieutic Resources

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Abstract This present study analyses the management of fishery resources to ensure their sustainability and rational exploitation in fishing villages of the Loky-Manambato marine protected area (LM-MPA), which are located in Vohemar district and SAVA region of the northeastern coast of Madagascar. Based on local surveys and research in rural villages of LM-MPA, this research reveals a strong potential for fishery resources in this area. The artisanal fishing plays a vital role as main source of income for the surrounding fishermen community rural area village residents and contributes to poverty reduction. The number of fishermen is increasing and fishing techniques continue to evolve over time in the LM-MPA villages. Different types of fishery resources, fishing gear and catching methods are exploited within the LM-MPA. However, the practice of new, destructive fishing techniques is accentuating the reduction in fishery products and threatening the local mangrove environment. It is therefore important to educate fishermen to stop using this detrimental fishing technique to ensure the sustainability of fishery resource. The sustainable management and closure as solution to ensure an increase in fishermen's catch yields and to protect the environmental resource are investigated. Effective improvement measures are recommended.
Keywords Sustainable management; Fishery resources; Loky-Manambato (LM) marine protected area (MPA); Northeastern Madagascar

1 Introduction

The fishing sector is one of Malagasy economy pillars like in many African coasts. The fishing remains a main economic activity (Henderson et al., 2008; Akhilesh et al., 2011; Ontomwa et al., 2019) thanks to the continental shelf rich in marine biodiversity. The fishing activity constitutes an important income source to Figureht against poverty and to supply population of animal origin proteins (Henderson et al., 2008; MPRH, 2012; Gerami and Dastbaz, 2013; Beedessee et al., 2015; Gore et al., 2019; Obiero MO et al., 2019). However, under demographic pressure on coastal zones, withdrawals from resources have exceeded the capacity to renew stocks. Therefore, most of marine natural resources (Akhilesh et al., 2011; Fischer et al., 2012; Davis, 2022) are threatened by overexploitation and deterioration of environmental conditions (Badjeck et al, 2011). Thus, the fishery products are reduced and one finds certain species scarcity (Jaquemet, 2024). The main reasons of that economic issue are insufficient resources for coastal surveillance and the climate change (Badjeck et al., 2011; Wu, 2024). Protection directive closures (MPRH, 2012; IUCN, 2014; National Assembly, 2015; Kaaya, 2019; Chauveau, 2024) are needed to preserve environmental halieutic resources (FAO, 2009) notably to help Madagascar coastal regions to meet their needs through fishing, processing and the sale of fishery products. Hence, relevant halieutic resource management closes and directives justified by the existence of protected areas (FAPBM, 2014) are required for certain types of fisheries. The present research work objective is to ensure the sustainable and rational exploitation of fishery resources by ensuring an increase in catch yields of fishermen in the Loky-Manambato marine protected area (LM-MPA) (FAPBM, 2014). The artisanal passive engine-based fishing has existed for a long time in the LM-MPA villages. The local authority administrator is facing up to problems relating to the difficulty of respecting the regulations in force and the overexploitation of fishery resources. Therefore, the fishing products quality and quantity are reduced. With the aim of safeguarding the marine environment and managing existing aquatic halieutic resources, this work provides analyzes on the current management mode while subsequently

putting forward proposals for the fishing technique improvement. The research specific objectives consist of fishing product identification, gear and capture fishing technique understanding, noticing problems related to the way aquatic resources and determination of current state of fishing resources as the insufficiencies of data necessary to act effectively in order to improve the fishery sustainable management existing type.

2 Artisanal Fishing Techniques in LM-MPA Villages

Like several countries in the African continent and in the southern hemisphere countries, Madagascar is surrounded by sea and ocean. It is separated from African continent by Mozambique channel in west side and limited by Indian Ocean on east side. Madagascar is crossed in its southern part by the Tropic of Capricorn and has approximately 5,600 km of coastline, 17,000 km2 of continental shelf and an Exclusive Economic Zone (EEZ) of 1,140,000 km^2. The fishing zone understudy belongs LM-MPA particularly in the FokontanyAntsampilay marine coastal part, Vohémar district and Madagascar SAVA northeastern region (MAEP, 2024). The considered villages are Antafiamivony, Ambanifony, Ambanifilao, Ambavarano, Ampasimadera as well as Nosy-Ankao, all located in the rural municipality of Ampisikinana. The present section describes the artisanal fishing techniques and materials in the LM- MPA villages.

2.1 Destructive fishing gear

Throughout all study sites, fishermen are faced with the use of small mesh nets less than 25 mm mesh size. In 2018, the villages of Antafiamivony, Ambanifony and Ambavarano no longer respected this minimum mesh size of 25 mm. On the other hand, the villages of Ambanifilao, Ampasimadera and Nosy- Ankao respect this minimum size 100% (Figure 1(a)). In addition, during the first six months of 2019 the majority of these villages respected this minimum size, the compliance rate of which was 100% for the Ambanifilao, Ambavarano, Ampasimadera as well as Nosy-Ankao villages and it reached 80% for the Antafiamivony and Ambanifony villages (Figure 1(b)).

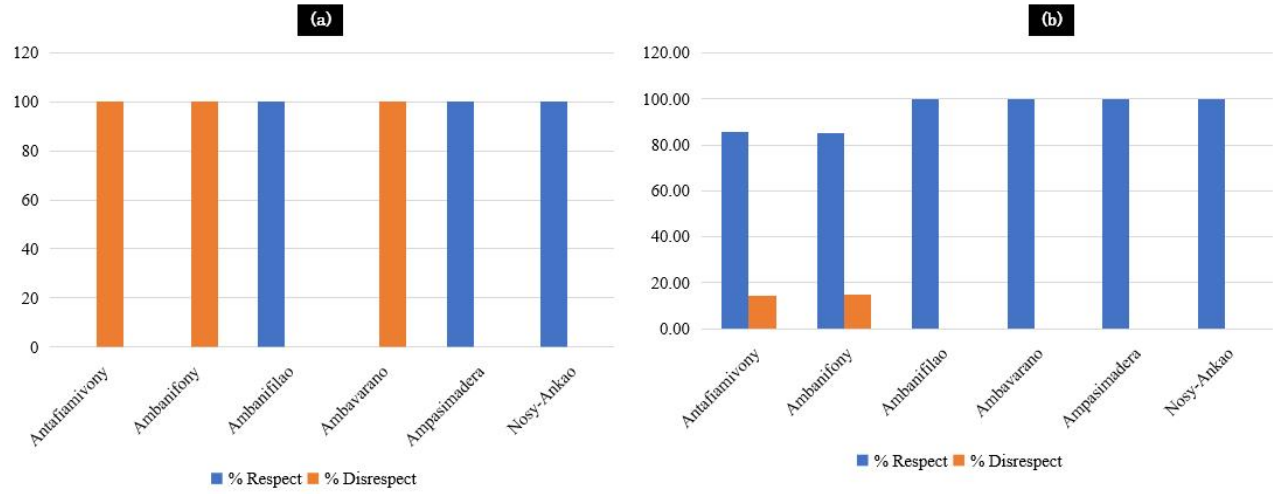

Figure 1 Use of minimum mesh size 25 mm in (a) 2018 and (b) 2019

The Correspondence Factor Analysis (CFA) (Lugen, 2015; Dufour et al., 2017; Paudyal et al., 2018) facilitates the identification of compliance rates by each village, that is to say during the year 2018 only the three villages of Ambanifilao, Ampasimadera and Nosy Ankao which respect (Figure 2(a)) the minimum size usage.

In addition, in 2019, the Ambavarano fishermen are aware (Figure 2(b)) of the risk for using this technique explaining the compliance rate which reached 100%. Likewise for the fishermen of Antafiamivony and Ambanifony, the fishermen majority are trained to respect it if we compare year 2018 and 2019, let us hope that next year they will reach the maximum rate of respect.

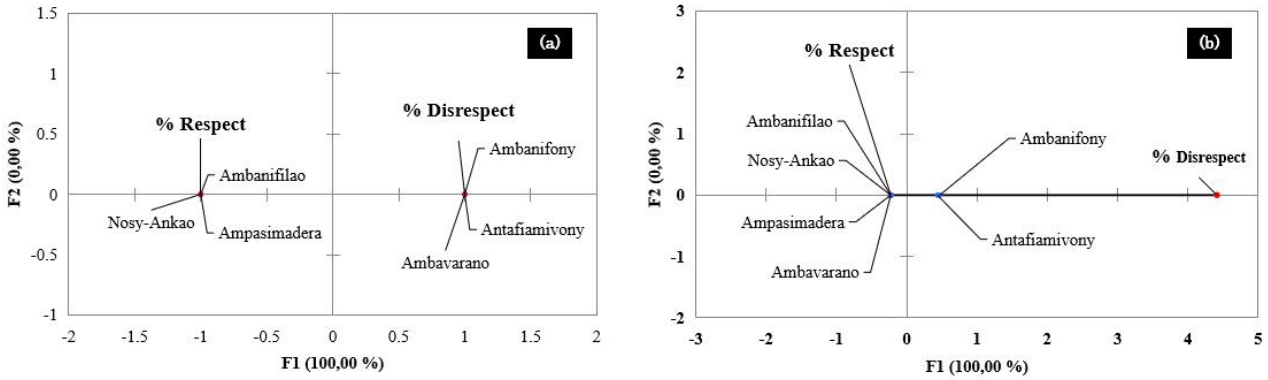

Figure 2 Asymmetric graph of the CFA of the minimum size for (a) 2018 and (b) 2019

2.2 Destructive fishing techniques

Throughout our LM-MPA study area, the most destructive fishing technique currently detected is “serisery”. This technique is classified as destructive because of the period of use as well as the materials. That is to say, it is practiced at the edge of the “dengy” during the neap by depositing the large mesh nets during the open sea then closed and tightened with small mesh nets by diving with the fishing equipment. diving as well as rifles. As a result, all the fish inside these nets are caught. In our study site the rate of compliance with this technique varies depending on the fishing villages (Figure 3(a)). They are grouped according to use (Figure 3(b)). The compliance rate with the serisery usage in the Ambanifony and Ampasimadera villages are higher (100%) compared to the other villages. On the other hand, Ambanifilao is a village most using this technique whose compliance rate was 58.33% in 2018 and decreased to 50% in 2019. These are confirmed by the CFA graph (Figure 3(a)) whose Classification Ascending Hierarchical (CAH) dendrogram is presented (Figure 3(b)).

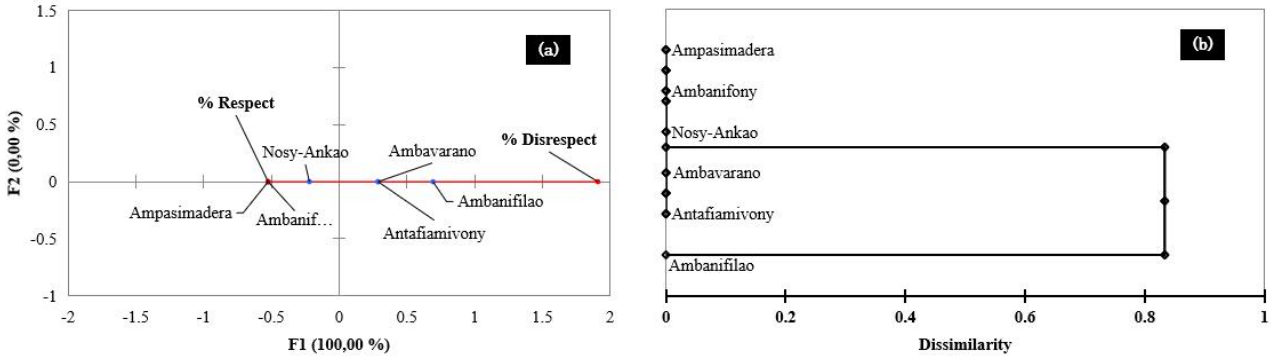

Figure 3 (a) Asymmetric plot and (b) CAH Dendrogram of serisery usage

The latter groups the villages according to the use of serisery. That is to say, the Ambanifony and Ampasimadera villages form the same group that most respect the use of this destructive fishing technique by transforming another group with the Nosy-Ankao village. On the contrary for the other group, the Antafiamivony and Ambavarano villages combine with Ambanifilao (Figure 3(a)).

3 Seasonal Fishing Closures

3.1 Opening and closing season for crab fishing

According to the calendar listed by MIHARI (Figure 4(a)), the crab seasonal closure is between July 1st and August 31st. The females can spawn and juveniles can breed. Despite the non-existence of mangrove forests in all study areas, some villages such as Ambanifilao and Nosy Ankao are not affected by the seasonal closure of crabs. On the other hand, for the other villages, the rate of compliance with the seasonal closure of crabs is almost zero except Ampasimadera (Figure 4(b)). This situation is confirmed by the CFA (Figure 4(b)) of three villages Antafiamivony, Ambanifony and Ambavarano which are all in the non- compliance point with the seasonal

closure of crabs in 2018. But it is not the case of the Ampasimadera village which respects this period. This leads to the CAH grouping (Figure 4(c)) showing three villages do not respect the seasonal closure constituted in the same group.

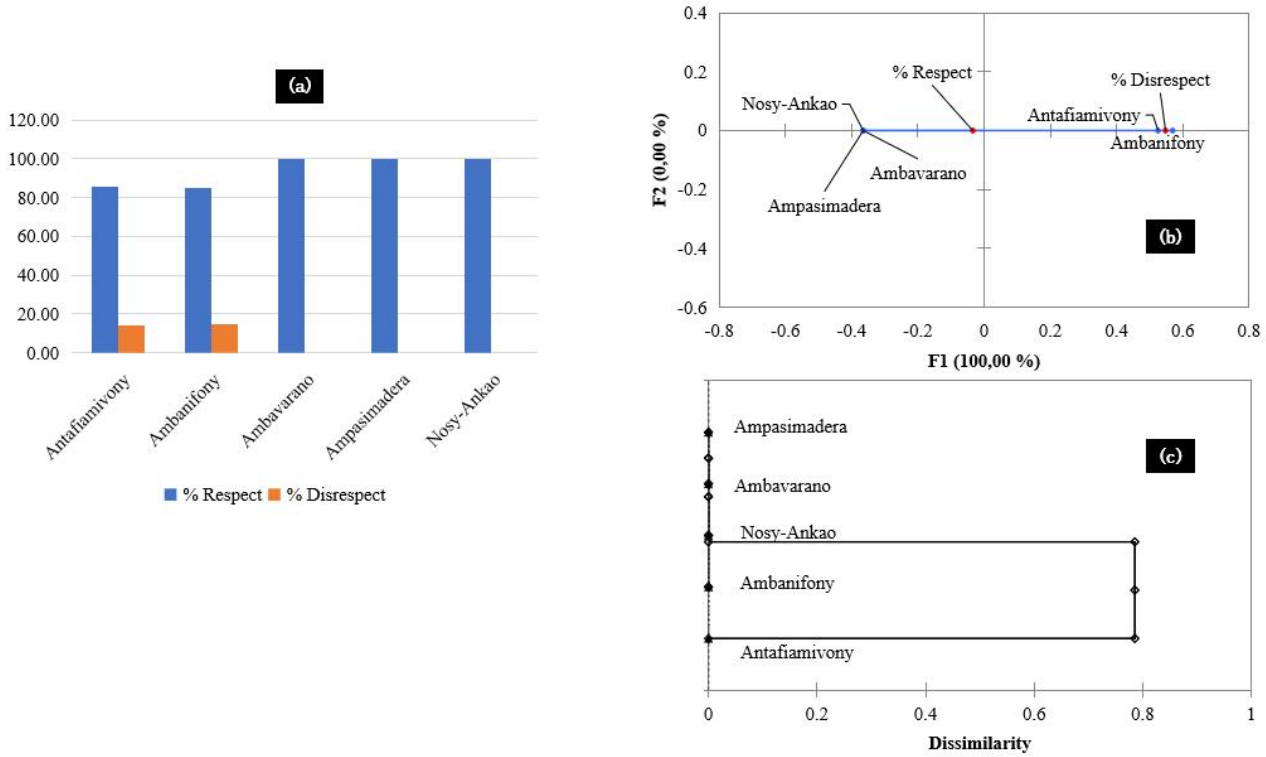

Figure 4 (a) Rate of compliance with the seasonal period of crabs, (b) asymmetric plot of CFA and (c) CAH Dendrogram for seasonal crab closure

3.2 Opening and closing season foroctopus fishing

According to the annual artisanal fishing in the Madagascar northeastern region, the LM-MPA has a specific seasonal closure for octopuses which begins from January 1 to March 15 in 2018 and January 1 to March 1 in 2019. These variations are caused by the lack of scientific studies. Because previously this closure follows Order No. 16.376/2005, regulating octopus fishing which extends from June 1 until July 15, date during which the FPZN certifies that no octopus is only in its juvenile state in its fishing areas. However, they saw the juveniles from January until March, hence the integration of this period into the MIAHARI seasonal calendar of the Madagascar eastern region. Thus, two closures are applied by the FPZN in the LM-MPA, the first of which is the original closure of local management from January to March and the second is a ministerial closure from June to July with compliance rates in two successive years (2018~2019) (Figure 5).

3.3 Opening and closing season for shrimp fishing

Failure to respect seasonal shrimp closures is among the major problems linked to the way aquatic resources are exploited in the LM-MPA. Because it leads to a reduction in natural stocks in this environment. According to the calendar of annual fishing closures in the Eastern Region of Madagascar listed by MIHARI, the seasonal closure of shrimp should be between December 1stand March 1st. Despite the unawareness of fishermen, the majority do not respect these closure dates before 2019 (Figure 6(a)). There is no difference in distance to the origin between Antafiamivony, Ambanifony, Ambavarano and Ampasimadera (Table 1).

This means that these villages no longer respect the seasonal closure of shrimp in 2018. Thus, they have grouped in the non-compliance rate same point (Figure 6(b)) approved by the CAH grouping (Figure 6(c)). The Ambanifilao village has compliance single group with this closure.

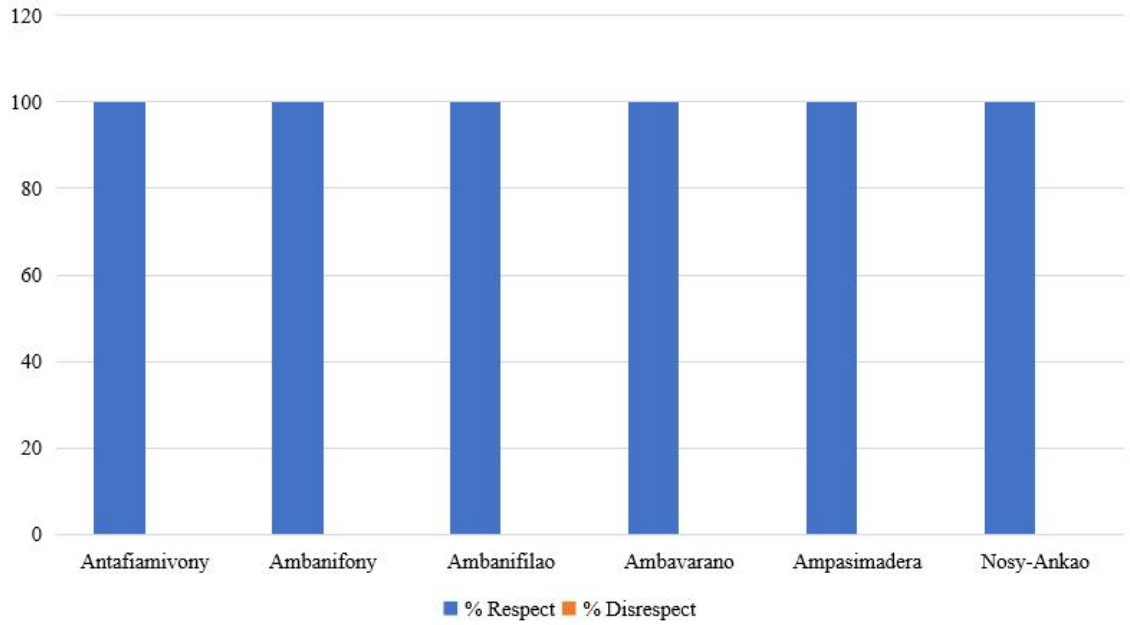

Figure 5 Rate of compliance with seasonal octopus closures in 2018-2019

Table 1 Weights, distances and quadratic distances to the origin, inertias and relative inertias of the seasonal closure of shrimp year 2018

Villages	Weight (relative)	Distance	Distance^2	Inertia	Relative inertia
Antafiamivony	0.202	0.472	0.223	0.04498	0.048
Ambanifony	0.202	0.472	0.223	0.04498	0.048
Ambanifilao	0.194	1.968	3.874	0.74973	0.806
Ambavarano	0.202	0.472	0.223	0.04498	0.048
Ampasimadera	0.202	0.472	0.223	0.04498	0.048

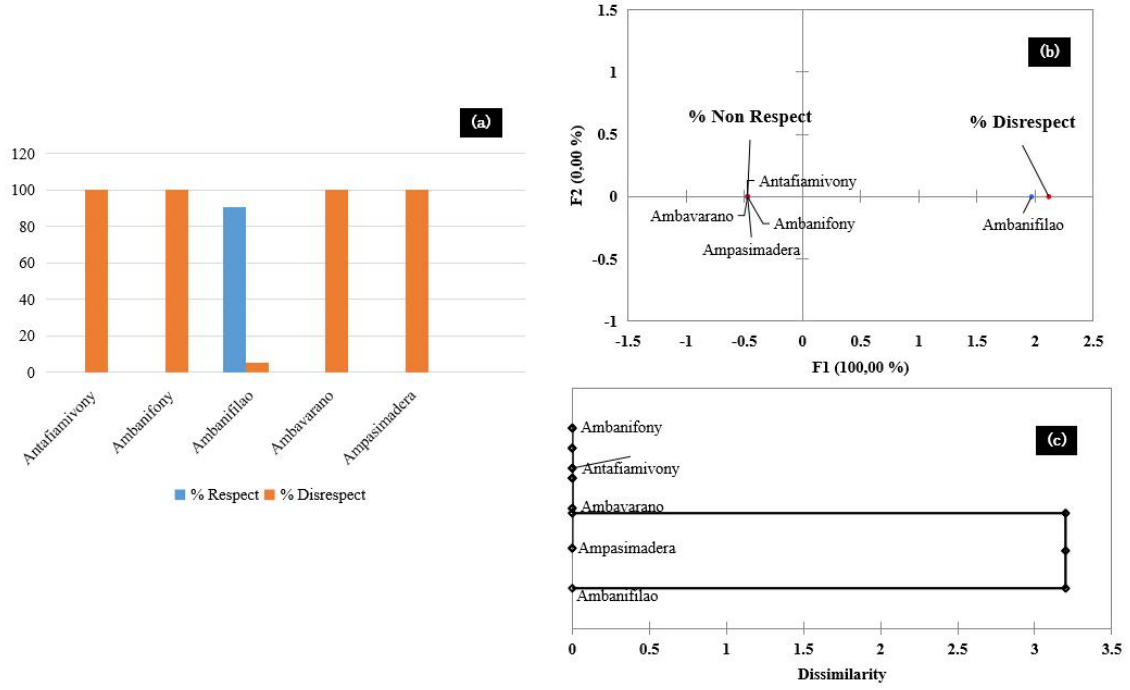

Figure 6 Rate of (a) compliance, (b) asymmetric graph and (c) CAH Dendrogram for seasonal shrimp closure year 2018

As a result, there is a qualitative and quantitative decrease in shrimp in these villages. Fortunately, the presence of manager Fanamby and the training of fishermen which was organized by the Time + Tide Nosy Ankao Foundation during 2018. The result is that fishermen are aware of the existence of the seasonal shrimp closure. Thus, they all subsequently respected this closure until today except the fishermen in the villages of Ampasimadera (Figure 7(a)). The existence of the distances between these villages indicates that they evolved in 2019 (Table 2).

Table 2 Weights, distances and square distances to the origin, inertias and relative inertias of the seasonal closure of shrimp year 2019

Villages	Weight (relative)	Distance	Distance²	Inertia	Relative inertia
Antafiamivony	0.2	0.488	0.238	0.04768	0.053
Ambanifony	0.2	0.394	0.155	0.03108	0.035
Ambanifilao	0.2	0.529	0.280	0.05590	0.062
Ambavarano	0.2	0.480	0.231	0.04613	0.051
Ampasimadera	0.2	1.891	3.578	0.71554	0.798

However, the rate of respect differs according to the villages (Figure 7(b)). The Ambanifilao village followed by the Antafiamivony and Ambavarano villages more respect the seasonal shrimp closure. On the other hand, the Ampasimadera fishing village does not always respect the seasonal closure. These villages are grouped by the CAH according to the rate of compliance with the seasonal closure (Figure 7(c)).

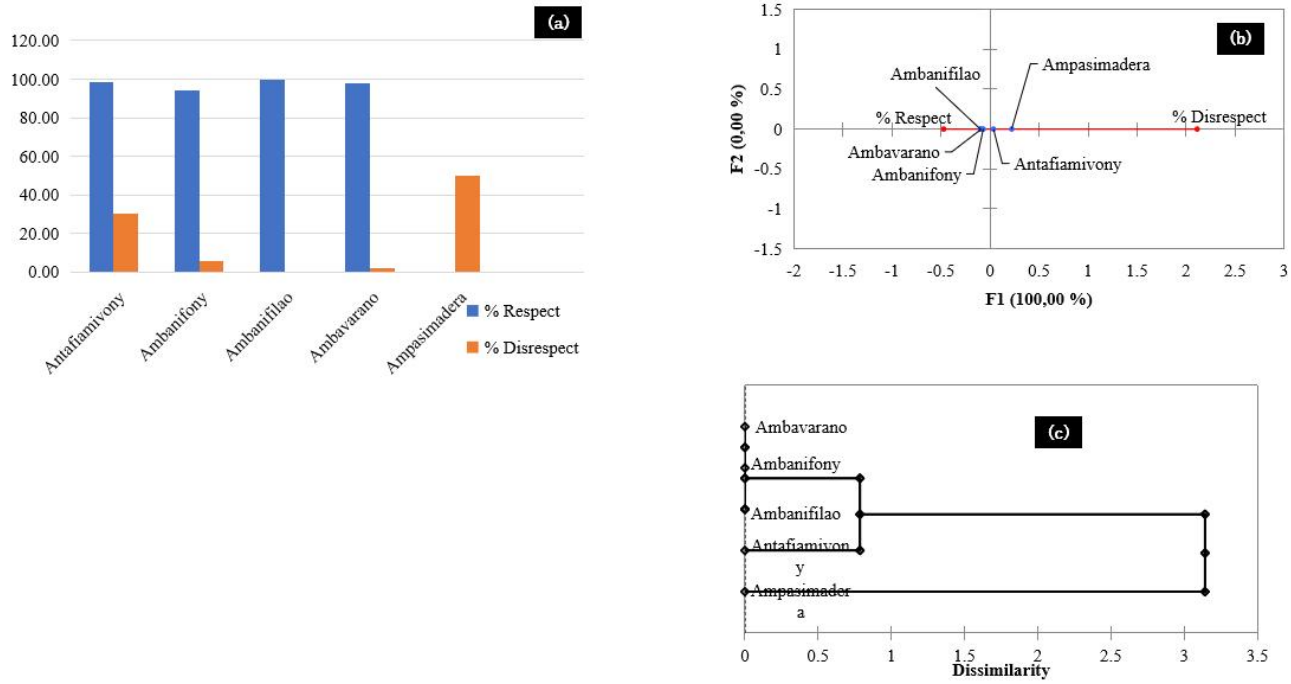

Figure 7 (a) Rate of compliance, (b) asymmetric graph closure year of (c) CAH Dendrogram for seasonal shrimp 2019

4 Regulation of Catches

4.1 Fishing target species

With a view to this law application on the minimum authorized size (Table 3) for fishing with which the Ministry of Fisheries Resources and Fisheries (MAEP 2003; MPRH 2012) has developed fisheries development and management plans in order to ensure the sustainability of resources.

Fishermen have an interest in respecting the catch regulations listed by the Ministries in force in order to have sustainable and rational management of fishing resources while ensuring the future of generations. LM-MPA fishermen have never caught sea turtles. Indeed, during the survey and field observation, the fishermen majority from Antsampilay fokontany do not respect the authorized sizes, hence the importance of recycling training or strengthening sustainable management capacities for all LM-MPA fishermen.

Table 3 Minimum size in centimeters (cm) of fished species (Source: Circumscription of Fisheries Resources and Fishing Vohemar 2017)

N°	Species	Minimal length	Laws
1	Large fish	12 cm	Order 62-2013 Art3
2	Pyrazus palustris (Voronana)	5 cm	Order 05/06/1922
3	Fresh sea cucumber	14 cm	Order 05/06/1922
4	Dry sea cucumber	8 cm	Order 0525 du 05/12/75 Art1
5	Lobsters	20 cm	Order 16365/2006 in 22/09/06
6	Crabs	10 cm	Order 16365/2006 in 22/09/06
7	Octopuses	40 cm (350 g)	Order 16365/2006 in 22/09/06

4.2 Current state of resources

Among the villages in the Madagascar northeastern coast, the Fokontany Antsampilay, in particular the villages of Antafiamivony, Ambanifony, Ambanifilao, Ambavarano, Ampasimadera and Nosy Ankao, are still rich in fishery resources illustrated by the presence of various species of fish, crustaceans, Cephalopods, Gastropods, echinoderms etc. However, given the problems listed above, these resources suffer a sudden qualitative and quantitative decrease caused by: Overexploitation using destructive fishing equipment and techniques; The increase in the number of non-native and indigenous fishermen caused by population growth and drought; Failure to respect the closure period so that juveniles can grow; The deficiency of the biological study for the seasonal closure; Neglect of the minimum catch size according to fishing regulations; The insufficiency of the natural stock assessment study; The absence of the local Fisheries Surveillance Center (CSP) to ensure security.

5 Techniques of Managing Fishing And Marine Resources

5.1 Mode of governance within the MPA

According to the 2014 PAG of the NGO Fanamby, Protected Areas can be managed and administered in various ways. IUCN provides typologies of management objectives and governance types for Protected Areas to help describe Protected Area systems and to advise governments and other managers developing individual protected areas and management systems (IUCN 2014). With this in mind, the scoring system used was designed to help managers, among other things, assign the appropriate IUCN management category and the right type of governance to a protected area. Based on the IUCN categories and their compatibility with the management objectives of Loky-Manambato, IUCN Category V is the most appropriate. This is confirmed for the following reasons: (i) the protected area includes terrestrial and coastal landscapes which host a multitude of faunal species with very high endemicity, (ii) existence of traditional modes of used space and social organization, (iii) the area offers leisure and tourism opportunities compatible with the lifestyle and usual economic activities of its inhabitants and (iv) sustainable use of resources for purposes other than subsistence is permitted, under certain conditions, And the management objectives go in the direction of: Maintaining harmonious interactions between nature and culture, by protecting the terrestrial and coastal landscape and guaranteeing the maintenance of traditional forms of land use, as well as the expression of socio-cultural facts; Encouragement of lifestyles and economic activities in harmony with nature; Maintaining the diversity of the landscape, habitat, as well as associated species and ecosystems; Provide benefits to the local community and contribute to its well-being.

Shared governance is considered the most appropriate for the sustainable management of the LM territory, given that the territory is affected by several sectors and actors.

5.2 Modes of management of fishing and fishery resources

5.2.1 Regulations and management by Fanamby

Since its creation in 1987, NGO FANAMBY has distinguished itself in the conservation of natural resources (https://association-fanamby.org/). The Malagasy territory, with its endemic fauna and flora, is a victim of the extent of degradation. It is in the face of this urgency of biodiversity conservation and the figure against poverty in Madagascar that FANAMBY has been committed for 20 years to granting Protected Area status, following the conservation gradients which include preservation activities. and local and regional development through the

mobilization and participation of all the entities concerned. The LM-MPA is part of the New Protected Areas created within the framework of the Madagascar PA system. It is located in the SAVA Region, District of Vohemar and includes 4 rural municipalities whose 19 fokontany land is included in the NAP. The Protected Area, with an area of 250,000 ha, is delimited to the North and North-West: by the Loky River, to the South and South-West: by the Manambato River and to the East: by the Indian Ocean, including the Ankao archipelago. The LM-MPA presents a unique concentration of areas representative of various habitats and species of the SAVA Region. It presents exceptional biodiversity with its various types of ecosystems, namely: forest ecosystems including dense dry forest, humid forest and coastal forest, aquatic ecosystems composed of permanent and temporary continental lakes, and marine and mangrove ecosystems where the study of fisheries resource management is focused. A protected area is "A geographical space clearly defined, recognized, dedicated and managed, by any effective means, legal or otherwise, in order to ensure in the long term, the conservation of nature as well as the ecosystem services and cultural values which are inherent to it" (IUCN, 2014). All Protected Areas in Madagascar are governed by Law No. 2001/05 of February 11, 2003 on the Code of Protected Areas (CoAP) and its implementing decrees, Decree No. 2005-013 of January 11, 2005 and Decree No 2005-848 of December 12, 2005 (PAG Fanamby, 2014). According to this PAG, the implementation of regulations in the management of the Protected Area aims to preserve natural resources with strict conservation measures in the hard cores on the one hand, and rational exploitation in controlled use zones on the other hand. It also aims not to deteriorate the living standards of the population, and monitors the principles of equity with a fair distribution of the costs and benefits of the PA establishment, between the different parties concerned and between the generations. This includes reducing anthropogenic pressure on natural resources. All regulations in force, more particularly concerning Protected Areas, fishery resources and tourism, are applicable throughout the territory of the LM-MPA. The rules which are applied by activities and by zone but also the responsible entities and their respective attributions (Tables 4), which are defined in consultation with the stakeholders. The regulations and management listed by the NGO Fanamby will allow us to draw up the CAH dendrograms for the grouping of these regulations as well as the CFA graphs for the rate of respect of fishermen in each village in two years. In 2018, the capture of sea turtles, the period of closing and opening of octopuses as well as the use of toxic products locally called "Fagnamo" are grouped into the same group (Figure 8(a)). Because all study site villages fully respect these regulations. This statement is confirmed (Figure 8(b)). That is to say, the more the regulations are concentrated in the middle of the horizontal and vertical axis, the more the regulations are well respected. On the other hand, for the period of closure and opening of shrimps and crabs, they are grouped in the same group (Figure 8(a)) of which the majority of fishermen in all the villages do not respect them except those in the villages of Ambanifilao and Nosy-Ankao (Figure 8(b)). The non-compliance of these last two villages is caused by the non-existence of mangrove forests in these environments. Same as for the year 2019, the three regulations are again brought together in the same affiliation (Figure 9(a)). Because they are the most respected regulations for all fishermen in all villages (Figure 9(b)). In addition, the closing and opening period of shrimps is placed in a single group (Figure 9(a)). Because some fishermen like in the villages of Antafiamivony and Ambavarano already respect. This is not the case for fishermen from the Ambanifony and Ampasimadera villages (Figure 9(b)). Because the further the villages move away from the regulations, the more the fishermen do not respect these regulations. In addition, for the use of the "serisery" fishing technique and compliance with the minimum mesh size of 25 mm, the majority of fishermen have been trained to respect them since 2019 (Figure 9 (b)) because of the fishermen formation which was carried out in 2018.

5.2.2 Community management mode

To manage fishery resources in an efficient and sustainable manner, it is important to integrate community management techniques into the Management Development Plan for the manager. In our study area their management concerns the seasonal closure of octopuses from January to March so that the broodstock can reproduce and the juveniles can increase as well as the cultivation of mangroves (Figure 10) in order to increase the forest surface of the mangrove ecosystem as initiated in (Spalding and Leal 2021; Ntibona et al., 2023). This serves as a spawning ground for several faunal species. For compliance with the local seasonal octopus closure, we saw maximum efficiency within all study villages (Figure 11). However, the cultivation of mangroves evolves

according to the year and villages. That is to say during the year 2018 only the villages of Ambavarano and Ambanifilao carried out the cultivation of mangroves (Figure 12(a)) the maximum rate of which is found in the village of Ambavarano. From 2019 the community participation rate increased except in the villages of Antafiamivony and Nosy Ankao (Figure 12(b)) with a zero-participation rate.

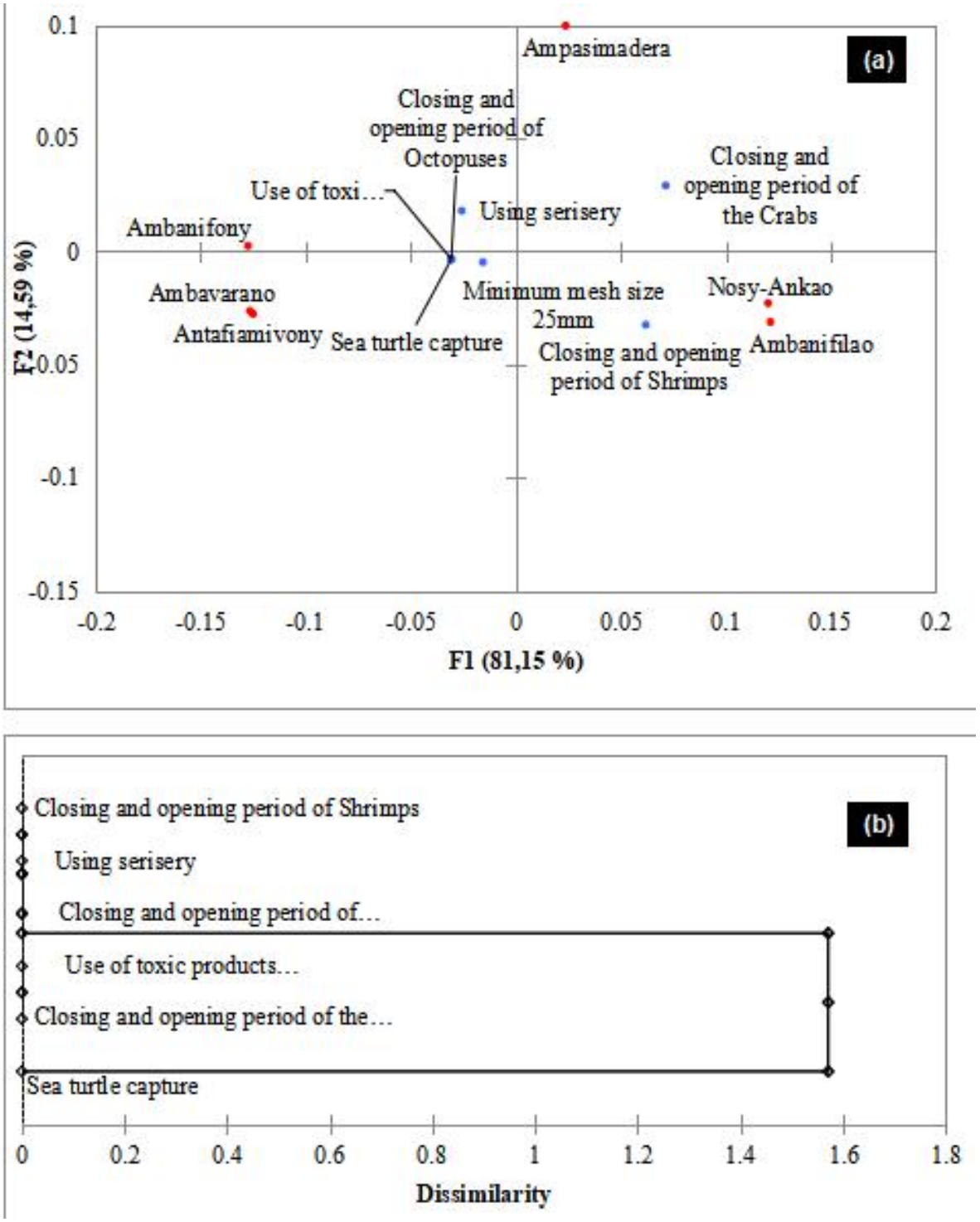

Figure 8 (a) Dendrogram of grouping of management regulations and (b) CFA graph showing compliance with regulations by Fanamby year 2018

Table 4 Regulations and management by Fanamby

Rules	Details	Responsible	Entities Responsibilities
It is prohibited to use fixed nets whose smallest mesh size is less than 25 mm square and trailing nets whose smallest mesh size is less than 25 mm square. Floating nets are not subject to any mesh size	Type of fishing gear recommended depending on the target and area (1) Gill nets, commonly used in traditional western fishing, which vary between 25 mm to 40 mm mesh (2) The ZDZD net (used offshore), large mesh of 8-10 cm, is designed to target large fish species and sharks (3) the JARIFA net is a specific type of gillnet used both offshore, in areas close to the shore and in brackish waters, mesh size between 12 and 25 cm, target: large fish, sharks, gogo, lamatra	Chief Fokontany and Fisherman's Association	Control and monitoring
		DAEP	Information and awareness
		DREF	Information on texts and verbalization
It is prohibited to use toxic substances intended to stun, weaken or kill fish	Product prepared from a species of plant origin known as "fagnamo"	Chief Fokontany and Fisherman's Association	Control and monitoring
		DAEP	Information and awareness
		DREF	Information on texts and verbalization
It is prohibited to hunt protected marine species	Marine protected species such as sea turtles, terns, "lambohara"	Chief Fokontany, KMT, Fishermen's Association, municipality	Control, Monitoring and information to the manager and the fishing service
		Fisheries and Aquaculture Service	Information, awareness, verbalization and repression
It is prohibited to exploit ovate crabs, soft crabs or crabs less than 10 cm in cephalothoracic width	-	-	-
It is prohibited to dump garbage and other waste into marine or lake waters	This concerns all villages located by the sea, around lakes and in islets	-	-
All new constructions and/or establishment of new villages and/or hamlets must respect the rule governing the geometric pitch zone all along the Loky-Manambato coastline	This measure makes it possible to limit pollution of coastal ecosystems	Chief fokontany, municipality	Monitoring, control and information from the manager, the CEF and land services
		CEF and land services	Land, Awareness, control, verbalization and repression
Fishing activities and/or the collection of fishery products must first be subject to authorization	Any natural or legal person wishing to fish and/or collect fishery products: lobsters, crabs, sea cucumbers, shrimp, camarons, squid, shark fin, fish, eels, may only do so with authorization from the Ministry responsible for fishing. fishing and fishery resources, after advice from the Regional Directorate of Fisheries and Fisheries Resources	Chief Fokontany, KMT, municipality	Monitoring and control of fishing licenses
		DRPRH	Authorization, control and monitoring

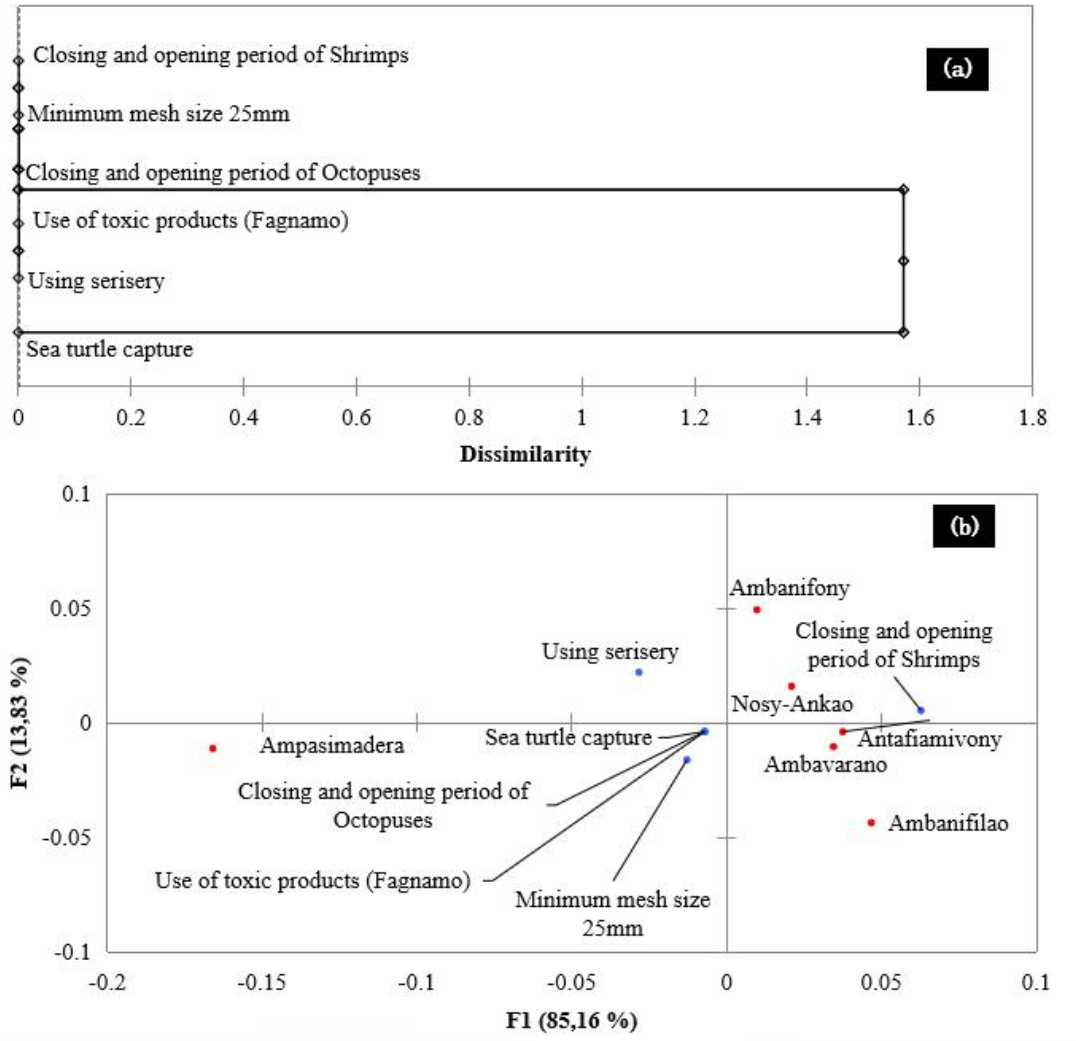

Figure 9 (a) Dendrogram of grouping of management and (b) CFA graph showing compliance with regulations by Fanamby year 2019

Figure 10 Mangrove cultivation with the communities of Ambavarano and Ambanifilao

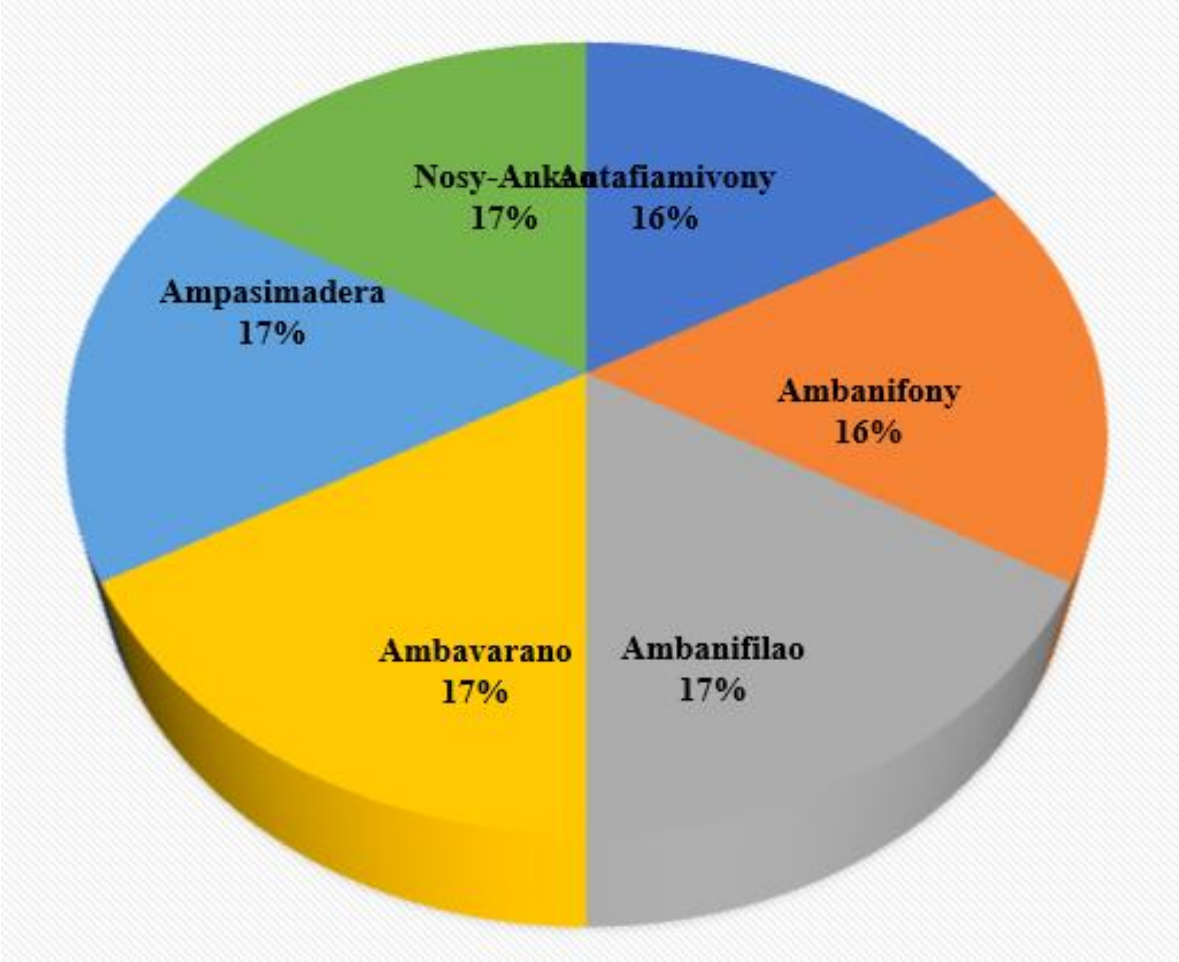

Figure 11 Local management respect percentage rate for seasonal octopus closure

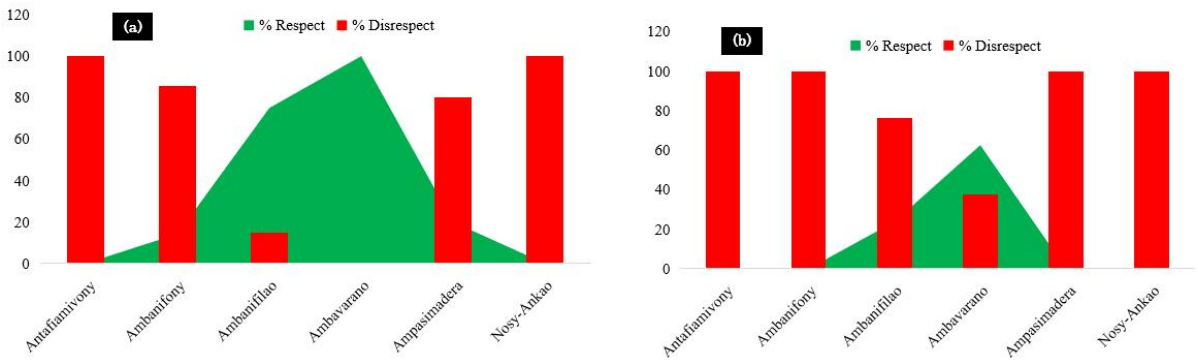

Figure 12 Participation rate for mangrove cultivation in (a) 2018 and (b) 2019

It is also the communities of Ambavarano accompanied by the communities of Ambanifilao who have the maximum rate for the cultivation of mangroves including 1,700 plants of propagules planted in order to manage and improve the life of mangrove species.

5.2.3 Completion of community management and FANAMBY NGO

In this paragraph, we will focus on the outcome of fishery resources management and fishing in the AP Loky-Manambato by the variances analysis with two factors without repetitions which was verified by the Bartlett and Levene Test. The line factor is the management regulations and the column factor is the fishing villages, the results of which arepresented (Table 5).

Table 5 Analysis of variance

Source of variations	Year	Sum of squares	Ddl	Mean of squares	F Observed	Critical value for F
Raw	2018	32037.1572	6	5339.5262	5.3519	2.4205
Column		8192,2743	5	1638.4549	1.6423	2.5336
Error		29930.4465	30	997.6816	-	-
Total		70159.8780	41	-	-	-
Raw	2019	18697.1402	6	3116.1900	5.2153	2.4205
Column		1919.8903	5	383.9780	0.6426	2.53358
Error		17925.0829	30	597.5027	-	-
Total		38542.1135	41	-	-	-

Given these results, the two tables comeback to the same result, including rejecting the hypothesis H0 for the line factors by accepting the hypothesis H1 of these factors, that is to say the regulations for the management of fishery resources have effects on the economic potential of fishermen in coastal villages within the LM-MPA. However, they accept hypothesis H0 for the column factors and reject hypothesis H1 for these factors. That is to say, no fishermen in all the villages had any economic effects on the regulations governing the management of fishery resources in the LM-MPA. All this means that thanks to the management of fishery resources in these areas, fishermen can improve their sources of income through fishing products because their existence does not prevent the sustainable and rational management of resources by ensuring the increase of stocks. natural in the aquatic environment.

6 Conclusion

Madagascar has a significant number of coastal communities which depend on the fishing sector to meet their food needs and as a source of income. This is also the case for the rural municipality of Ampisikinana and the village of Antsampilay. The fishing sector plays an important role for the economy of fishermen in the coastal villages within the LM-MPA. Providing them with considerable foreign income to live on. Despite of this situation, the current production trend is towards a decrease in terms of both quantity and quality for fish, cephalopods, crabs, shrimps, lobsters. The sea is still open access for all Malagasy citizens, so anyone can go fishing. The lack of suitable means to go fishing out of usual fishing zone such as motorized canoe equipped with refrigeration and the inability to buy non-destructive fishing gears were the main the problems raised by the fishermen. They fish and exploit the shallower zone within a restricted radius. Indeed, signs of overexploitation of fishing products have been noted. However, for the development of the sector to be sustainable and rational, it is halt the clandestine exploitation of fishery resources by revising the regulatory texts relating to these resources such as the revision of the minimum catch size and the setting of periods closures for laying. In addition, stock assessment studies should be carried out during a certain fishing closure period and must be accompanied by awareness raising among fishermen about sustainable management.

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