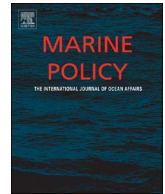




Contents lists available at ScienceDirect

## Marine Policy

journal homepage: [www.elsevier.com/locate/marpol](http://www.elsevier.com/locate/marpol)

## Governance analysis of a community managed small-scale crab fishery in Madagascar: novel use of an empirical framework

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## ARTICLE INFO

## Keywords:

Small-scale fishery  
Governance  
Madagascar  
Locally managed marine area  
Mangrove  
*Scylla serrata*

## ABSTRACT

The Marine Protected Area Governance (MPAG) framework was developed to offer a structured, empirical approach for analysing governance and has been applied to marine protected areas (MPAs) around the world. This study sees the novel application of the MPAG framework to a small-scale mangrove crab fishery in northwest Madagascar. The country typifies developing country environmental governance challenges, due to its poverty, political instability and lack of state capacity, with bottom-up approaches often identified as a potential solution. In this context, small-scale fisheries (SSF) play a vital role in food security and poverty alleviation but are vulnerable to over-exploitation. The case study examines community-based management, including the role of three nascent fishing association managing portions of the fishery, within a mangrove ecosystem. Despite issues with underrepresentation of fishers in local resource management organizations that have partial responsibility for the mangrove habitats, some management measures and incentives have been applied, including the re-plantation of mangroves and fishery-wide gear restrictions. However, the analysis highlights market forces and migration are drivers with negative synergistic effects that cannot be controlled by bottom-up management. Incentives identified as needed or in need or strengthening require the support of external actors, the state, industry and or NGO(s). Thus, governance approaches should seek integration and move away from polarised solutions (top-down vs- bottom-up). As shown by other MPAG case studies, effective governance is dependent on achieving ‘resilience through diversity’, in terms of the diversity of both the actors and the incentives they are able to collectively employ.

### 1. Introduction

The Marine Protected Area Governance (MPAG) framework was developed to offer a structured, replicable approach to empirically assessing the governance of marine resources in protected areas [1] and recently this framework has been applied to several new case studies in this issue. Assessing marine resource management outside of protected areas, including in fisheries, requires comparable approaches to assess governance. Small-scale fisheries (SSFs), which account for an estimated 23% of global catch [2] and employ 500 million people worldwide [3], present particular governance challenges, due to their complexity, diversity and geographically dispersed nature [4]. In developing countries, they play an important role in food security and poverty alleviation [3,5]. Therefore, identifying effective approaches to SSF governance is vital for the maintenance of marine biodiversity and

the ecosystem services, on which human well-being is dependent.

Madagascar typifies the challenges of natural resource management in developing countries, with low gross domestic product (GDP), limited state capacity and rapid population growth [6]. The country has been identified as a terrestrial biodiversity hotspot, simultaneously noted for its high degree of endemism and rate of habitat loss [7,8]. Since the late 1980s there has been an influx of funding, linked to protecting biodiversity, to support integrated conservation and development projects (ICDPs), community-based natural resource management (CBNRM) and payments for ecosystems services (PES) [9]. Despite having a coastline of 5500 km, marine resource management efforts have lagged behind terrestrial efforts [10,11]. Consequently, legislation designed to support CBNRM, as with other environmental policy, has often been focussed on the terrestrial realm [12]. However, in the past decade, owing to the biodiversity value of marine habitats such coral

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<https://doi.org/10.1016/j.marpol.2017.11.022>

Received 1 November 2017; Received in revised form 17 November 2017; Accepted 18 November 2017

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reefs and mangroves and their socio-economic importance, there have been increasing efforts to promote marine resource management at the community level [10].

Madagascar's SSF sector plays an important role in nutrition and income generation [10,13,14]. Data show SSF catches account for a greater proportion of catch from Madagascar's exclusive economic zone (EEZ) than industrial fisheries [15]. However, whilst effort is increasing, SSF landings may have peaked, with many in decline [6,13]. One response to increasing pressure and limited state capacity for marine resource management has been the promotion of bottom-up management, including the development of locally managed marine areas (LMMAs) [16]. In the last decade over 100 LMMAs have been created, now covering 12,000 km<sup>2</sup> (~1% of the exclusive economic zone), represented by *Mitantana HArena sy Ranomasina avy eny Ifotony* (MIHARI - Marine resource management at the local level) [17]. The infancy of Madagascar's LMMAs and proliferation of community-based fishery management means the efficacy of these governance approaches, both ecological and socio-economically, requires critical assessment [18].

Mangrove ecosystems are known to support high levels of floral and faunal biodiversity [19], providing ecosystem services to local communities [20,21]. At a global scale they play an important role in carbon sequestration, with exceptionally high below ground carbon stocks [22,23]. Recent decades have seen widespread, significant degradation and clearance of mangroves, with principal drivers including coastal development, over-exploitation and conversion for agri- and aquaculture [24,25]. Annual global mangrove loss has been estimated to be 1–2% [26]. Madagascar's extensive mangrove systems are the fourth largest in Africa and account for 2% of the global distribution [27,28]. However, the rate of mangrove deforestation is concerning, with an estimated net nationwide loss of 21% between 1990 and 2010 [28]. These mangroves are important from a SSFs perspective, acting as nursery areas for many exploited marine species [19] and being home to commercially important fisheries. In particular, the mangrove crab (*Scylla serrata*) is targeted commercially and for subsistence [29,30]. Recently there has been increased interest in mangrove crab from foreign buyers [30], with a national catch of 3087 t in 2014, 75–80% of which was exported, principally to China [13,31,32].

In a context where bottom-up or participatory management of natural resources has often been identified as the solution to lack of state capacity for environmental governance [32,33], this study makes novel use of the MPAG framework to critically assess the governance of a locally managed crab fishery, which serves as a LMMA initiative. The study site is located within Boeny region, which is part of the (former) province of Mahajanga, the centre of the country's crab export, where SSFs employ 27% of the workforce [29]. The crab fishery of the Ankobohobo wetlands is chosen as a typical SSF, contributing to the regional export fishery and operating within a mangrove wetland system known for its biodiversity. A crucial distinction is that where many studies of SSF management in Madagascar have focussed on fisheries that have been the direct focus of NGO projects [18,34], this is not the

case for the study fishery. However, there are significant interactions with NGO(s) operating in the area, which are considered. The principal aims are to describe the fishery and expand the scope of the MPAG framework, allowing an empirical and critical assessment of the fishery's governance. Findings will have direct application to SSF managers in Madagascar and the Western Indian Ocean, and enable comparisons to be drawn with findings from other case studies of MPAs and LMMAs analysed using the MPAG framework. This will contribute to a more holistic understanding of marine resource governance, identifying convergent themes with global applications.

## 2. Methods

The MPAG framework [1] was originally designed to empirically assess the governance of marine protected areas (MPAs). Here, it is employed in a novel context to analyse the governance of a SSF. Some areas of mangroves featured in this study are considered part of Madagascar's LMMA network, known as MIHARI [35]. LMMAs may be considered as an International Union for Conservation of Nature (IUCN) Category VI Protected Area (sustainable use of natural resources), depending on the objectives of the spatially defined area, in accordance with the guidelines on applying the categories in marine contexts [36,37]. It is not assumed from the outset that the study area can be classified as a MPA (in the form of an LMMA) or by some other term. The focus here is on the novel application of the MPAG framework to the crab fishery and by extension the mangrove habitat, enabling an empirical assessment of the governance of these marine resources. To apply the MPAG framework to the study fishery, minor adaptations were made. The context section was expanded to briefly describe local ecosystem context and fishery operations. The objectives section differs from previous MPAG cases studies of MPAs, in that the crab fishery has no formally defined objectives, which is discussed.

Primary data were collected in June and July 2016 with an additional site visit in 2017 providing an opportunity to seek clarifications and verification. Semi-structured interviews (n = 7, 5 male and 2 female) lasting 15–40 min were conducted with key informants representing fishers, collectors, officials and NGOs (Table 1).

Initial key informant interviews informed the design of a questionnaire, which was a mixture of numeric, categorical and open questions. Questionnaire participants (n = 48, 5 female and 43 male) were selected by an initial purposive sample of fishers from each village (Table 2). Subsequently, snowball sampling was used, a method commonly employed to gain access to dispersed demographics [38]. Responses to open questions were coded in relation to the MPAG framework, to identify common themes. Focus groups were conducted in three communities with the largest number of crab fishers (Table 2). Focus groups consisted of five individuals, who were always a mixture of questionnaire participants and non-participants. Emergent themes are illustrated with representative quotes from interviews, questionnaires and focus groups. These were conducted in Malagasy with a translator who was experienced working with researchers in rural

**Table 1**  
Key informants and their roles in the Ankobohobo small-scale crab fishery, northwest Madagascar.

Key Informant (reference code)	Role
Informant 1 (I-1)	Fisher and local guide with extensive knowledge of the Ankobohobo wetlands, member of VOI Tanteraka, member of the Anjiamandroro Fishers' Association. Works with Development, Biodiversity, and Conservation Action Madagascar (DBCAM) and Operation Wallacea, NGOs which undertake an annual research field season.
Informant 2 (I-2)	Bekobany <i>Chef Secteur</i> (state official representing the village of Bekobany)
Informant 3 (I-3)	Deputy <i>Chef Commune</i> (deputy to the mayor of the Mariarano Commune) and former Antsena <i>Chef Secteur</i>
Informant 4 (I-4)	Coordinator of DBCAM, responsible for facilitating an annual six week research field season as part of a long-term ecological monitoring programme, whose focus is the dry forest and mangroves.
Informant 5 (I-5)	Head of Transfers of Management and Natural Resources (TGRN) at the Deutsche Gesellschaft für Technische Zusammenarbeit (GIZ).
Informant 6 (I-6)	Crab collector operating in the community of Mariarano.
Informant 7 (I-7)	Crab collector operating in the community of Bekobany.

**Table 2**

Crab fishing communities by *fokontany* with number of fishers, questionnaires and focus groups in each. The number of crab fishers was estimated by triangulating information from local officials, association documents and key informants.

Village	<i>Fokontany</i>	Crab fishers	Questionnaire participants		Focus groups	
			(Reference code)	(Reference code)		
Bekobany	Mariarano	43	7	(Q-B)	1	(FG-B)
Mariarano	Mariarano	8	7	(Q-M)	–	
Antsena	Mariarano	90	10	(Q-ANTS)	1	(FG-ANTS)
Anjiamandroro	Marosakoa	50	12	(Q-ANJ)	1	(FG-ANJ)
Antafiamahagandra	Mariarano	30	9	(Q-ANTA)	–	
Antafiameva <sup>a</sup>	Mariarano	5	3	(Q-AMEVA)	–	
<b>Total</b>	<b>2</b>	<b>226</b>	<b>48</b>		<b>3</b>	

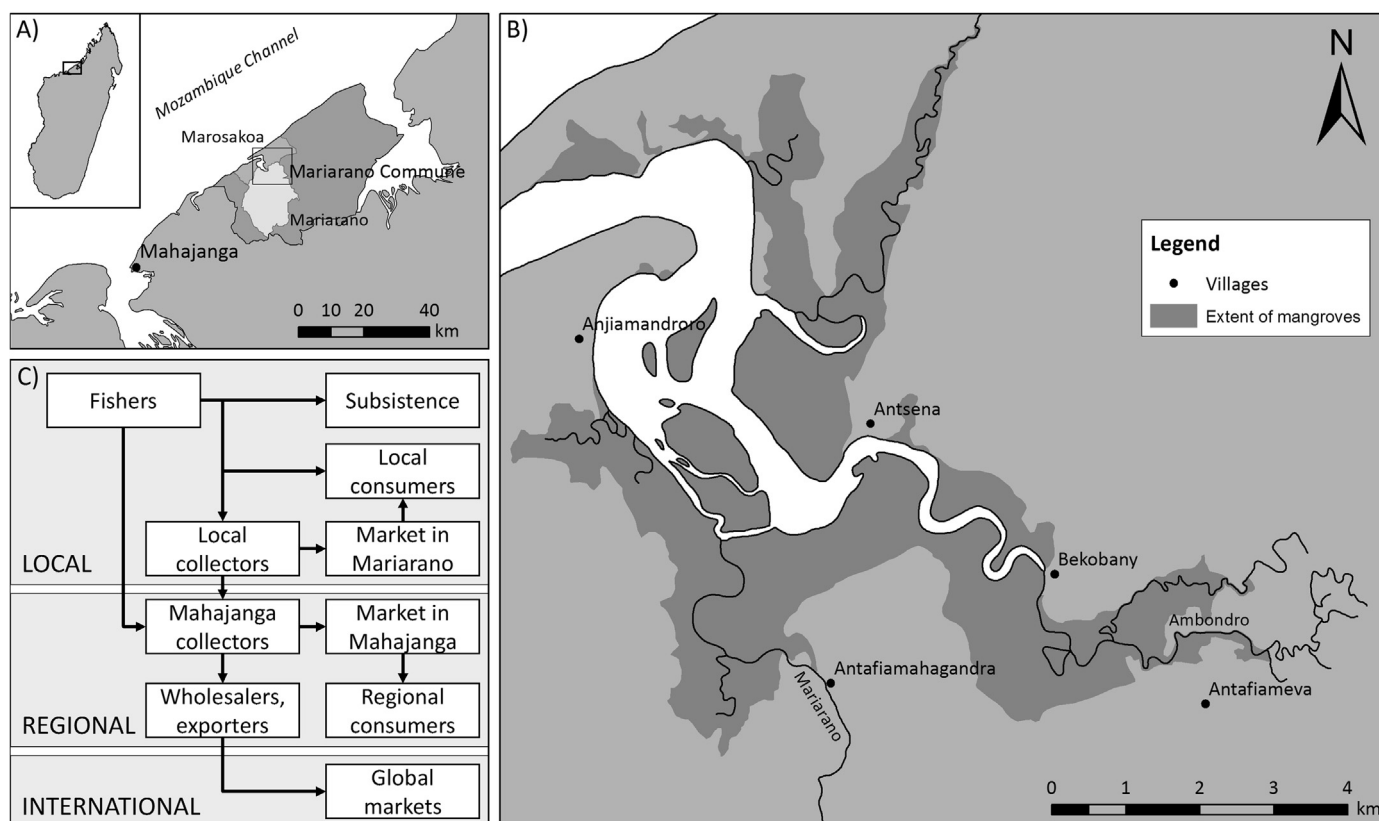
<sup>a</sup> Questionnaires were conducted at two household compounds which self-identified as Ampanolorana and Antafiabe. These were in the immediate vicinity of the larger village of Antafiameva and were included as such.

Madagascar, and able to translate for functional equivalence. The purpose of the study was outlined prior to data collection and verbal consent was obtained. Questionnaire and focus group responses were anonymised to the community level (Table 2). Key informants are not named but as they are identifiable by their role, verbal consent was explicitly obtained to proceed on this basis. The design of the study was informed by marine management monitoring guidelines specific to the Western Indian Ocean [39].

Documents obtained and reviewed include: the Commune's environmental action plan [40], the Commune's socio-economic development plan [41]; documents relating to the transfer of natural resource management responsibility to local user groups [42,43]; and paperwork from fishers' associations, including meeting minutes and articles of association.

### 3. Context

Madagascar is one of the world's poorest countries, in 2015 GDP per capita was just US\$ 402 [44], with 77.8% of the population below the poverty line and ranking 158th out of 188 countries in Human Development Index [45]. Growth in GDP was estimated to be 4.1% in 2016, compared with an average of 2.6% over the preceding 5 years [46]. This is balanced against rapid population growth of 2.8% [6], which is higher in coastal areas [13]. Political crises have disrupted growth since independence in 1960, with the last political coup in 2009 having devastating economic and social impacts [6]. The state capacity calculated for 2015 as a mean of scores (–2.5 to +2.5) for six dimensions of governance indicators was just –0.72, lower than the average of –0.68 for sub-Saharan Africa [47,48].



**Fig. 1.** Location (A and B) and value chain (C) of the Ankobohobo small-scale crab fishery, northwest Madagascar. The fishery, northwest of Mahajanga, is in the *fokontany*s of Mariarano and Marosakoa, which are part of the Mariarano Commune (B). The crab fishery operates within the current extent of the mangroves on the Mariarano and Ambondro rivers and their tributaries (B). Mangrove extent was determined by inspection of 5 m RapidEye satellite data acquired on 06/10/15, granule 3832022\_2015-10-06\_RE5\_3A\_944153 provided courtesy of the European Space Agency [51], combined with and opportunistic ground truthing. Value chain schematic, identifies actors at the local regional and international level, based on key informant interviews.

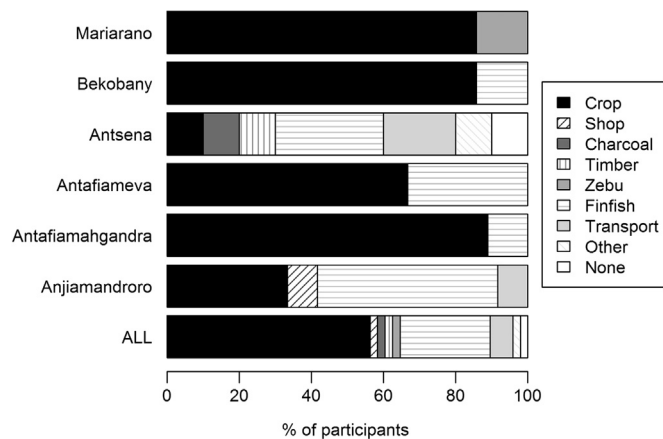


Fig. 2. Main source of livelihood, other than crab fishing, identified by questionnaire participants (n = 48) from the Ankobohobo small-scale crab fishery, northwest Madagascar.

### 3.1. Study site

Located on the Mahamavo peninsula, the study site is approximately equidistant between the larger Mahajanga Bay (Betsiboka estuary) and Mahajamba Bay (Sofia estuary) mangrove delta systems (Fig. 1). Approximately 50 km north-east of the regional population centre of Mahajanga, the wetlands are found within the Mariarano Commune, whose population was 9488 in 2009 [41]. The commune is subdivided into eleven *fokontany*, the smallest administrative district in Madagascar. The Mariarano *fokontany* is the administrative centre of the commune to which it gives its name [49]. The fishery and wetlands are found within the *fokontany*s of Mariarano and Marosakoa (populations 2412 and 796 respectively [41]). The study site is situated in a mosaic landscape of dry forest (the Ankatsabe and Analabe forest fragments); endemic palm dominated savannah; seasonally dry lakes; small-scale agriculture and the Ankobohobo mangrove wetlands. As is typical in rural Madagascar, the majority of livelihoods are in the primary sector with agriculture (principally rice and manioc), pastoralism (cattle, known locally as *zebu*) and fishing dominating (Fig. 2) [49,50]. Mariarano is accessible from Mahajanga by sea or an unmade road, impassable for several months a year during the wet season.

The wetlands include mangrove stands estimated to cover 2330 ha in 2010, the 19th largest area in Madagascar [28]. During this study six mangrove tree species were observed: *Avecinnia marina*, *Ceriops tagal*, *Rhizophora mucronata*, *Lumnitzara racemosa*, *Heritiera littoralis* and *Bru-guiera gymnorhiza*. Additionally, the tree species *Xylocarpus granatum* has been reported to be present, along with the mangrove fern *Acrostichum aureum* [52], which is prevalent in the upper less saline reaches of the mangrove system. The mangroves and wetlands have a total area of 3750 ha and are an Important Bird Area (IBA) [53,54]. The wetlands have been identified as a potential Ramsar site, by virtue of meeting Criterion 2 ‘...should be considered internationally important if it supports

vulnerable, endangered, or critically endangered species’ [53,55], as the critically endangered Madagascar fish-eagle (*Haliaeetus vociferoides*) is known to nest here [55,56]. Other fauna of interest found in the mangroves include endangered species of lemur, Coquerel’s sifaka (*Propithecus coquereli*) and the golden-brown mouse lemur (*Microcebus ravelobensis*) [57].

The fishery targets mangrove crab known locally as *drakaka* [41]. Crab fishers are predominantly from the communities of Antafiamahagandra, Anjiamandroro, Antsena, Mariarano, Bekobany and Antafiameva (Fig. 1), with landing sites dispersed throughout the river system. Fishers navigate the mangroves and river system on foot or in *pirogues* (small wooden boats stabilised by an outrigger). Fishers described a total of five gear types (Table 3; Supplementary material, Fig. 1). Gears are baited with fish, zebu or crocodile (*Crocodylus niloticus*), the latter of which is hunted locally (R. Gandola, pers. comm.).

Gear use varies considerably between communities, with the *garigary* most frequently used (58% of participants) (Fig. 3). The *tingovitra* was predominantly used in Mariarano and Antafiamahagandra, where the river is shallow and navigable by foot during the dry season. Baited lines were reportedly only used by women. Only participants from Antafiamahagandra and Antsena reported using the *treko* (Fig. 3).

There is a national closed season (1st July to 31st October inclusive) [32], which restricts commercial fishing, though subsistence fishing appears to continue year round. The majority of crabs are bought by collectors for ~3000 MGA kg<sup>-1</sup> (US\$ 1), who transport catch to wholesalers in Mahajanga from where it is exported (Fig. 1). Collectors receive 5000 to 9000 MGA kg<sup>-1</sup> (US\$ 1.60–2.94), depending on the size of crabs (I-6, I-7). Fishers with access to larger boats are able to bypass local collectors by transporting their catch to Mahajanga to attain a higher price (Q-ANTS). Additionally, crabs are sold locally for ~1500 MGA kg<sup>-1</sup> (US\$ 0.50) by fishers and through a weekly market held in Mariarano.

## 4. Objectives

In applying the MPAG framework to this novel context it is necessary to draw a key distinction between MPAs and fisheries. An MPA is established at a discrete point in time by a group of actors who in the process of forming the MPA agree, formally or informally and to a greater or lesser extent, a set of shared objectives [1]. In contrast a fishery is a subsistence and or commercial activity which emerges over time, typically without explicitly defined or collectively agreed objectives. Nevertheless, it can be presumed that the implicit objective of any fishery, including the study fishery, is to catch the target species and to sustain this activity through time.

## 5. Drivers/Conflicts

### 5.1. Migration, population growth and market demand increases effort

Madagascar has a population growth rate of 2.8% [6], which is even higher in coastal regions [13], partly due to migration. The population

Table 3  
Fishing gears types used in the Ankobohobo small-scale crab fishery, northwest Madagascar.

Gear	Type	Description	References
<i>Treko</i>	Passive trap	Conical trap made of women palm/vines (100 × 40 cm, with 10 cm opening and 6 cm mesh). Deployed and collected at low tide, secured by a stick.	(Supplementary material, Fig. 1A)
<i>Garigary</i>	Passive trap	A baited, circular lift net (diameter ~60 cm, mesh size ~3 cm). They are deployed beneath a marker (empty bottle) and left for 10 min to 2 h. Fishers operate 1–20 traps spaced 5–20 m apart.	(Supplementary material, Fig. 1B) [31]
Baited line	Active	A baited line, weighted with a stone, shell and/or a piece of lead.	(Supplementary material, Fig. 1E)
<i>Fingovitra</i>	Active	Long wooden stick (~1–1.5 m) with carved hook end. Used at low tide to remove crabs from exposed burrows.	(Supplementary material, Fig. 1C) [30,58]
<i>Fisoko</i>	Handling aid	Often used in conjunction with other gear to handle crab. Consists of a handle with a mesh held by a frame, similar to a small net.	(Supplementary material, Fig. 1D) [30]



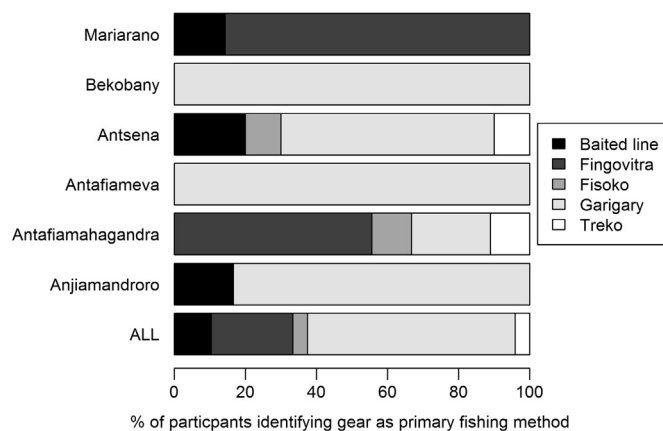


Fig. 3. Gear preference by community, where fishers (n = 48) indicated the primary method they use in the Ankobohobo mangrove crab fishery, northwest Madagascar.

of the Commune of Mariarano increased from 6140 in 2001 [59] to 9488 in 2009 [41], an annual growth rate of approximately 5.6%. Although data are not available, this trend has likely continued over recent years. Key informants, questionnaire participants and focus groups all identified the influx of migrants as being responsible for increasing fishing effort. The spatial distribution of fishing effort is continuous, throughout the mangrove extent, rather than being discretely organised around individual villages [60].

The increased effort and pressure on the crab stock is attributed to a growth in demand from Chinese exporters, which led to increased prices (I-6, I-7). As articulated in a focus group, “crabs were not that pricey before, but now with the Chinese, you can get a lot of money for the crabs. It is the main income for us. That’s why lots of people are migrating here and becoming fishers” (FG-ANTS). The majority of questionnaire participants (54%, n = 48) self-identified as being a migrant, whose family had been resident in the area for less than one generation. Similar circumstances have been reported in the Toliara region, southwest Madagascar, where crab fishing was traditionally a subsistence activity. Foreign merchants, principally Chinese, starting buying significant quantities of live crab for export, resulting in price increases of as much as 500% [32]. This is associated with increased effort and catches, leading to concerns about over-exploitation [30]. This cycle has been described as a threat to mangroves in Madagascar, with migration leading to over-fishing and decreased mangrove productivity, migrants then often being forced to turn to the exploitation of mangrove wood [29].

## 5.2. Habitat loss

Using data presented by Jones et al. [28], it is estimated that there was a net loss of 5.7% in mangrove extent, between 1990 and 2010 (Table 4). Visual surveys on foot and by boat in 2016 and 2017 revealed

Table 4

Mangrove area extent (hectares) in 1990, 2000 and 2010 for Mariarano, with mangrove areas to the north (Mahajamba Bay), south (Mahajanga Bay) and Madagascar for reference. Net change between 1990 and 2010 is calculated and presented as an area and percentage.

Source: Adapted from [28], who partitioned USGS mangrove cover map derived from Landsat imagery [27], into areas within Madagascar.

Mangrove area	Mangrove extent by year (ha)			Net change 1990–2010	
	1990	2000	2010	(ha)	(%)
Mariarano	2472	2412	2330	–142	–5.7
Mahajamba Bay	27,778	27,577	26,677	–1101	–4.0
Mahajanga Bay	12,375	11,814	9574	–2801	–22.6
Madagascar total	253,765	220,792	200,492	–53,273	–21.0

numerous sites within the wetlands with evidence of mangrove clearance, for timber and charcoal production (Fig. 4). Extensive degradation of mangroves in Mariarano and Marosakoa is highlighted in the Commune’s environmental action plan [40], whilst a previous study notes extensive degradation of mangroves within an area of management transfer (see, Governance Framework/Approach and Fig. 4) [61].

Mangroves are nursery and adult habitat for the crabs, which form burrows in sediments stabilised by the mangrove root system, so loss of this habitat can seriously impact crab populations [19,62]. Habitat loss was identified as negatively impacting the fishery in an interview with the deputy Chef Commune, “[mangrove exploitation] is one of the biggest threats facing the crab fishery” (I-3), and in all three focus groups, “the reason for the decrease in crabs is the degradation of the mangroves” (FG-B).

Whilst mangrove wood is used locally for fuel and timber, the primary driver is to meet regional demand from Mahajanga. The relative proximity to Mahajanga and accessibility via maritime routes results in mangrove exploitation for the production of timber and charcoal, to meet regional demand rather than local needs [40,41]. The exploitation of mangrove wood is prohibited by national law and local management rules (see Governance Framework/Approach), producing charcoal is perceived as an illicit activity by the local community in Mariarano [49]. Nearly all questionnaire participants (98%, n = 48) supplement crab fishing income with other livelihood activities (Fig. 2), though only 2% volunteered that this included the production of timber and charcoal. However, it was apparent that this was a common last resort to generate income, “during the closed season, crab fishermen chop mangroves because they aren’t allowed to do the only real job they have... they know that it is not good, but if they don’t have anything to eat, they will cut them down anyway” (FG-ANJ), this being reinforced by the comments of questionnaire participants (Q-ANTS; Q-ANJ).

There is thus a potential synergy between the driving forces, leading to a downward spiral of positive feedbacks, with higher external market demand for crab stimulating inward migration of fishers and increased effort, including to feed a growing local population, and thereby crab stock declines, leading to increased harvesting of mangroves as an alternative livelihood, which indirectly leads to further declines in crab stocks (Fig. 5). This downward spiral represents a typical case of synergies between driving forces [1], leading to an unsustainable trajectory of resource overexploitation.

## 6. Governance framework/approach

In terms of the governance approaches described by the MPAG framework the fishery is governed primarily by local communities. Fishery management is “...on a bottom-up basis by local users, often through local organizations, with most implementation and decision-making remaining delegated to local users/organizations, but often requiring some degree of state support for enforcement and therefore also involving some influence by central governments” [1]. The mechanisms by which the fishery is managed by the state and the local community are described below.

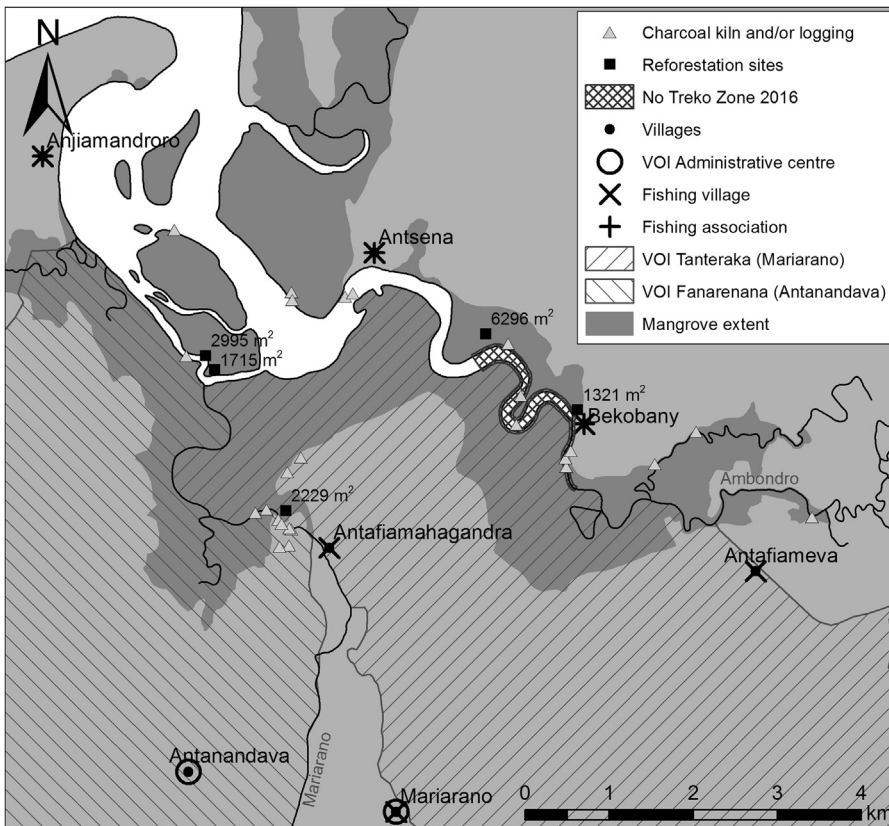


Fig. 4. Exploitation and management of the Ankobohobo wetlands, northwest Madagascar. Mangrove exploitation evidenced by observed active logging and/or the presence of charcoal kilns in June and July of 2016 and 2017 is indicated. The *Vondron’Olona Ifotony* (VOI) Tanteraka and VOI Fanarenana areas of management responsibility are indicated as determined from georeferenced management transfer documents. Mangrove reforestation sites are identified and labelled with their area (m<sup>2</sup>) determined by use of a GPS unit. The location of the No *Treko* Zone, which operated in 2016, is shown. Villages (black circle) are overlaid to indicate if they: contain fishers subject to the study (black X); have a fishing association (black cross); and/or are the administrative centre of a VOI (black circle).

6.1. State

State governance of the fisheries sector is the principal responsibility of the Ministère des Ressources Halieutiques et de la Pêche (MPRH, Ministry of Fisheries and Aquatic Resources), which is comprised of over 40 subsidiary entities, including 22 Directions Régionales des Ressources Halieutiques et de la Pêche (DRRHP, Regional Fisheries Authorities). The DRRHP’s are responsible for raising awareness of fishery regulations, maintaining statistics and issuing licences to fishers, collectors and exporters. The crab fishery is within the jurisdiction of the Mahajanga DRRHP. The Centre de Surveillance des Pêches de Madagascar (CSP, Fisheries Surveillance Centre) is responsible for the enforcement of fishery regulations and prevention of illegal fishing.

The following national legislation was identified as being of direct relevance to the fishery. Since 1997 all fishers require a licence or permit to target marine species (Arrêté 10404/97), though in practice this has never been applied [11]. The national closed season for crab fishing runs from 1st July to 31st October inclusive (I-1; MIHARI, pers. comm.) [32]. In 2014 a national minimum landing size (MLS) of 11 cm

carapace width was introduced by MPRH (Arrêté No. 32101/14) [30], though elsewhere this is reported to be 10 cm [31]. Since 2014 the extraction, transportation and sale of mangrove wood is prohibited by law (Arrêté Interministériel No. 32100/2014) [63].

6.2. Local

Introduced in 1996, to support CBNRM of forests, the *Gestion Locale Securisée* (GELOSE) legislation provides a legal mechanism for transferring management rights from the state to local communities [64]. This is achieved through a contract between the state and the local community, the latter of which is represented by a *Communauté Locale de Base* (COBA) or *Vondron’Olona Ifotony* (VOI) - an institution formed of local users created for this purpose. GELOSE was first applied in a marine context in 1999, when a community in Toliara were given management rights over a mangrove ecosystem [65]. A *dina*, a long-standing customary Malagasy system of law, can be described as a code of conduct, which is developed and enforced by communities [66]. Recognised in national law since 1996, *dina* have been divided into

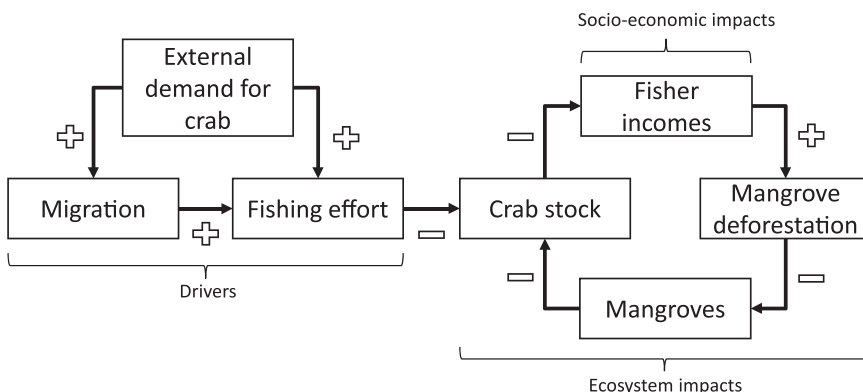


Fig. 5. Schematic illustrating the synergistic effect of drivers on the socio-economic and ecological system, in the Ankobohobo mangrove crab fishery, northwest Madagascar.

three categories by Rakotoson and Tanner [67]: i) one that is unwritten; ii) one that is aligned with national laws, and iii) one that is created via a legal institution. *Dina*, either legally ratified or not, are often the mechanism through which GELOSE contracts and VOIs establish rules to protect natural resources [68].

There are two local VOIs (Tanteraka and Fanarenana) with a legal mandate to manage the dry forest and some parts of the mangrove system. The Deutsche Gesellschaft für Technische Zusammenarbeit (GIZ), a German state aid organisation, which operates across Madagascar, was responsible for initiating the management transfers, providing technical assistance and capacity building for the VOIs. Established in 2001, VOI Tanteraka, based in the community of Mariarano, is responsible for the Ankatsabe forest and 713 ha of mangrove south of the Antsena river (Fig. 4) [42]. The VOI Fanarenana, based in the community of Antanandava and established in 2013, has management responsibility for 390 ha of mangrove which is also south of the Antsena river (Fig. 1) [43]. The management transfers and *dina* for both VOIs prohibit commercial exploitation of wood. Local subsistence use is permitted, specifically large trees may be felled with prior permission and upon payment of a fee, but the felling of small trees is prohibited, whilst charcoal can only be produced from dead wood [42,50,61]. VOI Fanarenana conducts patrols to identify illegal activity but these do not include the mangroves, where it is known there is a greater level of illicit activity [61]. VOI Tanteraka's management transfer includes a rule which prohibits crab fishing in areas of degraded mangrove [42], though neither questionnaire respondents nor key informants demonstrated any awareness of this.

Three fishing associations operate in Bekobany, Antsena and Anjiamandroro (Fig. 4). Formal, legal status had been achieved by the Bekobany and Antsena associations, confirmed by paperwork endorsed by state officials. The most established of these is the Bekobany Fishers' Association, which in 2016 had reportedly been in operation for over a year. New members are required to pay a fee (20,000 MGA, US\$ 6.50) to join the association. Benefits include a form of social security, where the association and members are committed to paying costs when other members require medical treatment. In terms of fishery management, the association had introduced a ban on using *treko* within an area of the fishery (Fig. 4), which was communicated to Antsena via a letter addressed to the *Chef* Antsena (head of the village). Further the Bekobany Fishers' Association had undertaken mangrove replantation (Fig. 4 and see Effectiveness). Collectors are required to register with the association in order to purchase crabs from members at a set price, presumably to control price fluctuations and ensure fairness. The Antsena Fishers' Association had only been formally established for two weeks in June 2016, its stated aim being to alleviate poverty through the management of the fishery using *dina*. Membership is verified through a membership card which confers access rights, though it was not clear how this would be enforced and the cards had not yet been distributed (FG-A). No management measures introduced or enforced by the Antsena Fisher's Association were identified. The association in Anjiamandroro was waiting on paperwork to formalise its status and identified being eligible for government aid as the main reason for its establishment (FG-A).

### 6.3. Incentives used

The incentives identified as currently being used in the governance of the Ankobohobo crab fishery are described (Table 5), based on the MPAG framework taxonomy of governance incentives [1].

## 7. Effectiveness

The MPAG framework, assesses governance effectiveness on a scale of zero to five, with zero being wholly ineffective 'no impacts addressed' and five being fully effective, 'all impacts...completely addressed' [1]. Here an effectiveness score of one, 'some impacts beginning to be slightly

addressed', is assigned.

State and local management has limited efficacy in addressing threats to the fishery. There is limited awareness and compliance with national legislation. Not all fishers knew when the national closed season was, with only 29 participants (60%,  $n = 48$ ) being able to recall the dates of fishery closure. Only 19 questionnaire participants (40%,  $n = 48$ ) stated they were aware of a MLS. This may be explained by the state's limited capacity for enforcement. It has previously been reported that in practice both DRRHP and CSP lack the resources to carry out their mandates, most DRRHPs have just one or two agents and the CSP has just three boats to patrol an exclusive economic zone (EEZ) of 1 million km<sup>2</sup> [11]. Neither the state, nor local community has addressed the impact of population growth, through both reproduction and migration, increasing fishing effort and pressure on the mangroves, a situation reported in other rural areas on Madagascar's coast [70]. The introduction of membership cards by at least one fishing association (FG-A) may be the beginning of efforts to restrict or control access.

Conversely, the loss of mangrove habitat has been at least partially addressed, as evidenced by the presence of reforestation sites. A total of five were found with a combined area of 14,556 m<sup>2</sup> (Fig. 4). There may be more sites, which were not identified, either: due to accessibility (two were discussed but could not be reached to verify or measure); difficulty of distinguishing mature plantations from natural habitat; or, because informants were unaware of them. The commune's environmental action plan, developed with technical assistance from GIZ, includes provision to fund mangrove replantation of 5 ha/year in Marosakoa and 5 ha/year in Mariarano between 2012 and 2016 at a total cost of 10,000,000 MGA (US\$ 3260) per *fokontany* [40]. The management transfer zoning map for VOI Tanteraka includes an area designated for replanting mangroves [42].

It was difficult to determine which entities were responsible for the existing replantation sites in terms of funding, planning and execution. It was also difficult to ascertain to what extent this was in accordance with the commune's environmental plan and the VOI Tanteraka's management transfer. Fishers reported being paid ~2000 MGA (US\$ 0.65) per day for reforestation efforts in Antsena (FG-ANTS), Bekobany (FG-B) and Antafiamahagandra (I-1) though they were not always sure whether this was from the state, an NGO or the VOI. Payments may have been made by the state via the VOI. Two key informants stated the official standing of the VOI was the reason for receiving government funding for mangrove restoration projects (I-3; I-4). In Antsena, government funding went specifically to the Women's Association, who adopted mangrove conservation as a group mission and undertook replantation (F-ANTS). The Bekobany Fishers' Association undertook replantation in collaboration 'with the mayor' (FG-B), replanting a total area of 0.76 ha across two sites (Fig. 4). One key informant highlighted two replantation sites (Fig. 4) which he stated were undertaken as a personal initiative, his evident knowledge and enthusiasm making this plausible (I-1). This latter example appears to have occurred organically and without monetary incentives.

## 8. Incentives in need of strengthening or introduction

The empirical analysis highlighted the need for the strengthening and introduction of a number of incentives in order to improve the effectiveness of the fishery's governance (Table 6).

## 9. Cross cutting issues

### 9.1. Participation

Despite widespread adoption of GELOSE management transfers, with 453 in operation by 2004 [71], there have been a number of criticisms [64], some of which apply here. For VOIs to operate as intended they must be representative of local resource users, but not all users may be willing or able to participate. It has been demonstrated that in

**Table 5**  
Incentives used in the governance of the Ankobohobo small-scale crab fishery, northwest Madagascar.

Category	Incentive	How the incentive is applied
Economic	Assigning property rights	Management transfers from state to VOIs assign property rights to local resource users, promoting stewardship and sustainable exploitation of the mangroves.
	Promoting alternative livelihoods	Bee-keeping and ecotourism have been promoted as an alternative livelihood by GIZ. The Operation Wallacea and DBCAM research field season is associated with employment opportunities, including guiding, portering, and other services.
	Provision of NGO, private sector and user fee funding	The VOIs collect an entrance fee from visitors (2000–14,300 MGA, US\$ 0.65–4.66) and charge for the use of campsites (2200–6600 MGA per tent per week, US\$ 0.72–2.15) (I-4). Funding from GIZ has supported the VOI to build management infrastructure including campsites and local offices.
Interpretative	Raising awareness	Operation Wallacea present research findings annually to the VOI, but the focus is on dry forest and to a lesser extent mangrove without any explicit mention of crab fishery.
	Promoting recognition of regulations and restrictions	The DRRHP announces the national closed season via local radio, which was confirmed by several participants. The Bekobany Fishers' Association informed other fishers of the ban on using <i>treko</i> verbally and with a letter sent to another community (FG-B).
Knowledge	Promoting collective learning	There is a history of limited knowledge sharing between local people and scientists associated with Operation Wallacea and DBCAM [56,69]. This includes in the mangrove system, though the research focus has been on wetland bird and the crocodile populations.
Legal	Penalties for deterrence	The VOIs have developed <i>dina</i> which includes penalties for unauthorized collection of wood from mangroves and forest.
Participative	Rules for participation	All members of the local community, over the age of 18, who use natural resources within the area of management transfer, are eligible for VOI membership. Participation levels are known for the VOI Tanteraka, where around half of eligible people in Mariarano are members [50]. In Antanandava, the centre of VOI Fanarenana, 63% of people in surveyed households were members [61]. Membership of fishers' associations is limited to those living within the respective communities.
	Decentralising responsibilities	The VOI is the legal mechanism through which management responsibility for local resources has been devolved to local users. This has been facilitated by GIZ who provide technical expertise, capacity building and financial support.
	Peer enforcement	<i>Dina</i> are a customary system of law, long established in Madagascar which rely on peer enforcement. The fishing associations rely on peer enforcement of their management measures
	Building on local customs	The use of <i>dina</i> , to achieve community recognition of VOI management measures is an example of building on local customs.

**Table 6**  
Incentives that require strengthening (strengthen) or introduction (needed) to improve the governance of the Ankobohobo small-scale crab fishery, northwest Madagascar.

Category	Incentive	Strengthen or Needed?	How/why?
Economic	Assigning Property Rights	Strengthen	Fishers are poorly represented in VOIs which are focussed on terrestrial resources (dry forest), and have no responsibility for fisheries (I-5). Fishing effort is overlapping (between communities) [60] but associations are discrete, so management is not aligned with <i>de facto</i> access.
	Reducing the leakage of benefits	Strengthen	Unsuccessful attempts to fix prices and manipulate the value chain (I-2), post-harvest actors holding disproportionate power and receiving a greater proportion of management benefits than the users who implement them [32].
	Promoting profitable and sustainable fisheries	Needed	Periodic no take zones (NTZs) have proved a socio-economically viable model elsewhere in Madagascar [18,34]. Has the potential to protect habitat and target stock.
	Promoting alternative livelihoods	Strengthen	Existing livelihoods (Fig. 2) do not provide sufficient opportunities, resulting in high fishing effort and mangrove exploitation particularly in the closed season (FG-ANTS).
Interpretative	Promoting recognition of regulations and restrictions	Strengthen	Limited awareness of national legislation, association management measures and their spatial coverage. Radio is an important communication mechanism for state regulation e.g., national closed season.
Knowledge	Independent advice and arbitration	Needed	Crab fishery management advice to inform evidence-based decision making and introduce design participatory monitoring [32].
Legal	Penalties for deterrence	Strengthen	More effective use of ratified <i>dina</i> to get state enforcement of regulation designed at a local level – as seen in other LMMAs in Madagascar [18].
	Protection from incoming users	Needed	Currently no barriers to entry, though one fishing association is in the process of introducing membership cards conferring access rights (FG-A). The study site is close to regional population centre (Mahajanga) which is a source of demand for natural resources and a source of migrants.
	Cross-jurisdictional coordination	Strengthen	Coordination required between terrestrial conservation/management efforts and the fishery, between fishers' associations and with VOIs.
Participative	Rules for Participation	Strengthen	Better representation of fisher interests in VOIs is required.
	Establishing collaborative platforms	Strengthen	Better coordination between communities. Potential to unite the fishers' associations under one structure. There is potential to share experiences with other fishing communities through MIHARI. Despite being listed as members of the MIHARI LMMMA network, no evidence of this was found; it was not mentioned in any interview, questionnaire or focus group.
	Building linkages between relevant authorities and user representatives	Strengthen	Fishers are disconnected from regional and national fishery management authorities, with limited awareness of state legislation. Potential to link fishers' associations with DRRHP, which has been achieved elsewhere [18].



Mariarano richer and more educated people are more likely to be VOI members [50]. This so called ‘tyranny of localism’ results in the capture of governance processes by local elites and marginalises the less advantaged [1,72]. Some individuals may not be able to commit the time required to be active members of the VOI, attending meetings and undertaking actions, thus reducing representation. Non-participation in CBNRM can also result in a ‘free rider’ effect where individuals receive the benefits without the costs [73]. Eligible non-members of both local VOIs cited not being able to commit the time as a reason [50,61]. VOIs are based in Mariarano and Antanandava, which would be a round trip of several hours for some fishers that operate in the areas of mangrove within this VOIs’ jurisdiction. Key informant interviews highlighted that fishers were underrepresented in the VOIs and that this was resulting in limited attention to the mangrove habitat (I-4 and I-5). Another common criticism is that due to the complexity of GELOSE, contracts are always facilitated by NGOs, who seek to formalise resource management and introduce regulation preventing extractive resource use, accordingly there is often a suspicion of external actors [74]. The introduction of a new institution alters community dynamics, moving customary power of *fokonolona* (community) leaders to control access to land and resources to others, who are typically younger, more educated and often recent migrants [64,75].

### 9.2. Ownership of fishery management

Absence of effective state management of the crab fishery and mangrove habitat leaves a vacuum to be filled by CBNRM. This was emphasised by the deputy Chef Secteur, who volunteered that the mayor's office did not have any management responsibility for the fishery (I-3), suggesting there was neither the legal mandate nor the appetite for involvement in management. Management transfers represent a nationally and locally recognised mechanism by which a portion of the mangrove habitat, but not the fishery, is managed by the VOI. However, Cinner et al. [12] point out there is an uneasy application of the GELOSE law to the aquatic environment due to the law being transposed from a terrestrial context, with contracts authorised by the Ministry of Environment but not recognised by the Ministry of Fisheries. Le Manach et al. [11] suggest that this source of tension and confusion stems from the principle that marine resources should belong to all Malagasy people and not just the communities dependent on the natural resources who gain the management rights. A further problem is that the VOIs do not operate at the scale of the fishery, covering only a portion of the mangroves, a problem noted at other sites where VOIs manage marine resources in Madagascar [76]. The fishers’ associations, although in their infancy, have taken ownership of the management of the fishery. However, the lack of inter-association coordination and coordination between associations and VOIs is clearly limiting their efficacy. The current *status quo* means that management ownership is divided among local actors and is not synergistic. The resources are not being managed at an appropriate spatial scale, in terms of the mangrove extent, crab population or spatial distribution of fishing effort.

### 9.3. Role of NGOs

There are three key NGOs which have been operating in the area for multiple years. GIZ have had a presence since at least 1999 when efforts began to facilitate the first GELOSE management transfer, establishing VOI Tanteraka and subsequently VOI Fanarenana as part of their Programme d’Appui à la Gestion de l’Environnement (PAGE). NGOs have their own agenda, as the organisation responsible for both facilitating the management transfers and ongoing VOI capacity building, GIZ have significant influence on the focus and priorities of CBNRM. The interview with the head of management transfers at GIZ highlighted that whilst the mangroves were included in the management transfer, a lack of membership of fishers in the VOI means the bulk of the organisation's conservation activities are directed at the dry forest

(I-5). This may likely reflect GIZ aims rather than a greater local appetite for forest management. Since 2010, Operation Wallacea and DBCAM have been conducting a landscape-scale long-term ecological monitoring project. The project aims to identify spatial and temporal trends in biodiversity, monitor the condition of the forest habitat, generate revenue in the local communities and use research results to leverage funding for environmental projects [56]. Again, the focus is on the dry forests rather than the mangroves. To date the project has not fulfilled its aim to secure additional funding for environmental projects. A shared goal of DBCAM, Operation Wallacea, GIZ and the VOIs is to promote ecotourism, particularly through paying volunteers facilitated by NGOs [50]. The long-term ecological monitoring field season, six weeks in June and July, brings a large number of visitors to the area and is a source of revenue for some local households. However, beneficiaries are predominantly in Mariarano, with little or no benefits reaching communities more dependent on the crab fishery and mangroves. The relative inaccessibility of the area means that outside of this field season there are few visitors, making ecotourism only a seasonal opportunity. A closer strategic working relationship between Operation Wallacea, DBCAM, GIZ and the local community (represented by the VOI) could seek to design conservation or developments projects that provide year-round benefits across a wider area. This could potentially address threats to the fishery and mangrove habitat if fishers’ interests were adequately and equitably represented. However, there is currently limited information sharing between these actors, and indications of mistrust between DBCAM and the VOIs [77].

### 9.4. Conflict, coordination and cooperation

The spatial distribution of fishing effort is continuous, rather than restricted to discrete areas, meaning that fishers from different communities overlap. This appears to be a source of conflict as management decisions are made at the village level, but this occurs in the absence of any spatial delineation of access or management responsibility. Focus group participants in Antsena reported an unsuccessful attempt to limit access to areas immediately adjacent to the community ‘*we sent a letter to Anjiamandroro to ask them to stop fishing here, but...they can fish anywhere they like*’ (FG-ANTS). This conflict between communities was highlighted by efforts to restrict certain gears. Some participants identified the *treko* as a threat to the fishery as it is a non-selective gear which catches undersized crabs (< MLS, 11 cm). In response to this perceived threat the Bekobany Fishers’ Association established a ‘No Treko Zone’, an area where the use of this gear was banned (I-2, Fig. 4). ‘*The association forbids the treko. We shouldn’t use it because it takes small crabs*’ (FG-B). However multiple *treko* were observed deployed or awaiting deployment in the ‘No Treko Zone’ in 2016. Members of the Bekobany Fishers Association were keenly aware that forfeiting the use of this gear put them at a disadvantage (F-B). The Anjiamandroro group expressed similar frustrations, articulating the desire for a system that would allow them to penalize fishers from other villages when they were caught using *treko* (F-ANJI). In 2017 a key informant (I-1) explained that in the current season fishers from all communities had agreed to a universal ban on the use of *treko*, which was being observed. In contrast to the previous year no evidence of *treko* deployed or awaiting deployment was seen throughout the fishery during 2017 field visit.

The relationship between fishers and collectors (Fig. 1) was also highlighted as an area that was impacted by the lack of coordination between villages. Throughout the mangrove crab fisheries of Madagascar's west coast it is noted that post-harvest actors hold a disproportionate amount of negotiating power [32]. The practices of collectors were identified as a ‘*social*’ threat to the fishery (I-3). According to the Deputy Mayor, some villages allowed collectors from anywhere to buy crabs from the fishers. This competition resulted in variations in the price that fishers were getting for their crabs and created ‘*social tension*’ (I-3). The Bekobany Fishers’ Association's documents showed

that there was an attempt made to fix the price of the crab, but according to the interview with the Chef Secteur, this never came to fruition, because the villages could not coordinate the action, and just applying the rule solely in Bekobany would put them at a disadvantage (1-2).

The need for a co-ordinated approach between communities was repeatedly identified, though many were resigned to the fact that this would not happen, as the governance framework does not allow management measures to be designed and enforced at the scale of the whole fishery. This is best summarised by comments from the focus group held in Anjiamandraro ‘it is good if you have the same opinion and values, but that will never happen here. What would be good is if the villages could discipline each other, or apply some sort of penalty when rules are broken’ (FG-ANJIA). Nevertheless, the apparent cooperation between communities in apparently successfully banning *treko* gear in the 2017 season, as evidenced by the comments from a key informer and empirical observations, is a positive indicator of the potential for an effective local governance framework at the ecosystem and fishery wide scale. There remain challenges in terms of a lack of integration between management units at the community scale and a lack of capacity to enforce restrictions, particularly between communities and in the face of synergistic driving forces.

## 10. Conclusion

The study demonstrates the value the novel application of the MPAG framework to a fishery, yielding critical governance insights. The readiness with which the framework could be applied is a result of the fundamental similarity between fisheries and MPAs, in that they are both spatially defined areas in which management aims to achieve the collective sustainable use objectives of the actors. Indeed, it could be argued that the study site can legitimately be simultaneously described as a SSF, a LMMA and an IUCN Category VI MPA.

The study site is an example of genuine community-based, locally-led, fishery management that has developed organically. Significant challenges to this local approach remain. Specifically the VOIs, the community based natural resources management institutions, are focussed on terrestrial resources, with fishers being underrepresented. This is a product of the underlying GELOSE legislation and its application, which was developed from the long-standing focus on the conservation and management of terrestrial ecosystems in Madagascar. A result of this is the development of three nascent fisher associations, which will need to co-ordinate their efforts as seen in the seemingly successful implementation of a fishery wide ban of a gear, the *treko*, in 2017. This local management has resulted in measures such as replanting of mangroves being undertaken, at least in some cases by fishers without external funding or support.

However, the analysis shows that the main threats to the fishery are external drivers, namely migration and demand for charcoal, timber and crab, the latter fuelled by crab merchants supplying Asian markets. These drivers have synergistic effects negatively impacting the mangrove habitat on which the fishery is dependent and are beyond the control of local management. This accounts for the limited efficacy of this bottom-up approach. The majority of the incentives identified as needed or in need or strengthening require the support of external actors, the state, industry and or NGO(s). This highlights the need to move away from polarised governance solutions, often characterised as top-down vs- bottom-up, and seek integrated approaches. It is key the full range of actors contribute to governance systems to ensure ‘resilience through diversity’, both in terms of the governance actors and the incentives they are able to collectively employ. This theme has repeatedly been identified as critical in numerous previous MPAG case studies [1,78]. This case study again emphasises the need to focus on the co-evolution of a diversity of incentives in the building of a governance framework. This is especially evident where an ecosystem-scale fishery is divided between relatively autonomous communities, amongst which

mutual cooperation and reciprocal enforcement of restrictions needs to be ensured and supported by the state, in the face of synergistic driving forces that have the potential to perturb the social-ecological system. Only a combined approach to governance through the co-evolution of a diversity of incentives can address such challenges.

## Acknowledgements

This study would not have been possible without the support and contribution of the following: the local community and fishers of the study area; VOI Tanteraka; VOI Fanarenana; Chef Commune Mariarano; Peter Long; Sam The Seeing, Virginie Marie Clementine; Gael Rakotomanga; Felix Rakontondraparany; Michael Darling; Barry Ferguson; Rachel Daniels; Rob Gandola; Herizo Andrianandrasana; Operation Wallacea; and Development Biodiversity Conservation Action Madagascar (DBCAM).

## Funding

This work was supported by The Tropical Agricultural Association, Gilchrist Fund, Linacre's Fredrick Mulder Fund, Oxford University School of Geography and the Environment BCM Fund, Operation Wallacea and a NERC Doctoral Training Programme studentship (grant number NE/L002485/1). The funders of this work had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.marpol.2017.11.022>.

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## Glossary

- CBNRM*: community based natural resource management
- Chef Commune*: elected official, mayor of the *commune*
- Chef Fokontany*: mayor of the fokontany
- Chef Secteur*: representative at the sub-fokontany level, appointed by the *Chef Fokontany*
- COBA*: *Communauté Local De Base* institution formed of local natural resource users, with management responsibility transferred from the state through GELOSE legislation. See also VOI
- Commune*: administrative district comprised of multiple *fokontany*
- DBCAM*: Development, Biodiversity, Conservation Action Madagascar, a Malagasy NGO
- dina*: customary form of law acting as a social contract, recognised in national law since 1996
- DRRHP*: *Directions Régionales des Ressources Halieutiques et de la Pêche*, regional fisheries authorities, which are subsidiaries of MPRH
- fokonolona*: community
- fokontany*: smallest administrative district in Madagascar
- fangovitra*: fishing gear, a wooden stick with a hooked end used to remove crabs from burrows
- fisoko*: fishing gear, a small hand net, used for handling crab
- garigary*: fishing gear, a circular lift net which is baited and used to catch crabs
- GELOSE*: *Gestion Locale Securisée*, legal mechanism for the transfer of management responsibility of natural resources to local communities represented by a COBA/VOI
- GIZ*: *Deutsche Gesellschaft für Technische Zusammenarbeit* (German society for technical collaboration), a German state aid organisation
- LMMA*: Locally managed marine area
- MIHARI*: *Mitantana HArena and Ranomasina avy eny Ifotony*, Marine resources management at the local level, Madagascar's LMMA network
- MLS*: minimum landing size
- MPRH*: *Ministère des Ressources Halieutiques et de la Pêche*, the Ministry of Fisheries and Aquatic Resources
- NGO*: non-governmental organisation
- Operation Wallacea*: a UK NGO
- pirogue*: traditional wooden fishing vessel, powered by sail or oars, usually incorporating an outrigger for stability
- treko*: fishing gear, a baited crab trap made of women palm/vines
- VOI*: *Vondron'Olona Ifotony* institution formed of local natural resource users, with management responsibility transferred from the state through GELOSE legislation. See also COBA