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The role of indigenous knowledge in the management of marine resources: a case study of Kuruwitu and Mkunguni fishing areas in Kenya

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Abstract

Indigenous knowledge (IK) in the management of natural resources, and especially marine resources, has received increasing attention in recent years. The use of IK is due to its extensive contribution to the management of local resources and the spiritual, cultural and economic well-being of local communities. This study aimed to identify the existing types of IK and practices used in the management of marine resources. The study was conducted through a descriptive survey design using semi-structured questionnaires, Key Informant Interviews, field observations and Focus Group Discussions. The results revealed that the community relied on IK for weather forecasting to plan for fishing activities which subsequently regulated marine resource exploitation. The use of IK in the location of marine fish species and favourable conditions enables the fishers to understand the factors driving fish catches within these ecosystems. IK of sustainable resource-use allows the fishers to devise environmentally friendly fishing gears and reduce the use of deleterious fishing methods. Pearson's Chi-squared test was performed on selected variables that influenced the possession of IK among the residents in the two study areas. The Chi-square test revealed a significant association between IK and meetings (p= 5.524e-09), and IK and age (p=0.023), while IK and education level were not significant (p=0.712). The study recommends the development of conservation strategies that include IK for the management of marine resources at the local level, including consideration of all socio-economic factors.

Keywords: Indigenous knowledge, management, marine resources, livelihood, fishers

Introduction

Indigenous knowledge is a systematic body of knowledge assimilated by people through gathering experiences over time, and includes a good understanding of the environment in a given culture (Mazzochi, 2006; Abah *et al.,* 2015). This form of knowledge is in the hands of local institutions that play a crucial role in natural resource management by defining practices, assigning tasks and guiding interactions of people on issues related to resource-use (Masalu *et al.,* 2010). IK in conservation biology is often expressed in the form of customs, beliefs and taboos (Cinner, 2007; Maina, 2012). Some studies (Cinner, 2007; Rim-Rukeh *et al.,* 2013; Rocliffe *et al.,* 2014) have demonstrated the usefulness of indigenous knowledge in determining fish stocks and spawning grounds, regulating resource-use and the associated traditions. Based on this understanding, indigenous knowledge forms a rich cultural heritage that is complex and dynamic among communities (Kajembe *et al.,* 2000).

On the coast of Belize, for example, biologists used local fishers who have lived in that area since the 1920s to identify spawning sites for snappers and explain the snapper's relationship with whale sharks (Heyman *et al.,* 2001). In Madagascar, the Malagasy use taboos to regulate resource-use within and adjacent to all of the national marine parks (Cinner, 2007). Along the Kenyan coast, sacred forests (*kayas)* typify cases of the use of IK and culture in natural resource management (Wangila and Shauri, 2009). IK is still widely applied by many local communities in the management of marine resources in Kenya (Mcclanahan *et al.,* 1997; Ochiewo, 2004; Maina, 2012). The fishing communities

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in Kuruwitu on the north coast and Mkunguni on the south coast of Kenya have utilized coastal and marine resources for many years. As a result, the residents have developed a sound understanding of the natural processes regulating these resources.

The application of indigenous knowledge in the management of natural resources has, however, not been well documented in Mkunguni and Kuruwitu, two key fishing areas along the coast. There is a need for continuous documentation of IK and identification of its usefulness in the sustainable management of coastal and marine resources. The biggest challenge emanates from the fact that such crucial knowledge may not always be successfully applied to the sustainable use and management of marine resources alongside scientific knowledge. Documenting this IK will create a database for reference in the future when the older generation who are custodians of this knowledge are no longer present.

Materials and methods

Study sites

Kuruwitu fishing area

Kuruwitu is in Kilifi County on the north coast Kenya, some 27 km south of Kilifi town, off the Kilifi-Mombasa highway (Fig. 1). It covers an area of 56 km^2 with 774 households of 5-6 persons (KNBS, 2010). Kuruwitu is endowed with various marine resources such as mangroves, fish, sea turtles and coral reefs. Kuruwitu Conservation and Welfare Association (KCWA) is a community-based organization (CBO) focused on environmental and marine conservation in Kuruwitu and its environs. The CBO operates in the six landing sites of Vipingo, Kuruwitu, Kijangwani, Kinuni, Bureni and Mwanamia (KCWA, 2010; Abunge, 2011).

The communities living in the area are of mixed ethnicity; however, the Giriama and the Chonyi ethnic groups from the Mijikenda community are the majority (Cinner *et al.,* 2009). Community livelihoods in the area are heavily dependent on natural resources, and include fishing, peasant farming, tour guiding and trading, with some of the residents employed as casual labourers in the Vipingo sisal plantation on the mainland side of the Kuruwitu coast (KCWA, 2010).

Mkunguni fishing area

Mkunguni area is in Msambweni sub-County on the south coast of Kenya (Fig. 1). The area has 687 households with an average household size of 6-7 persons (CRA, 2012). Like Kuruwitu in the north, the area is endowed with numerous marine resources including mangrove forests, finfish, shellfish and sea turtles. There is a local CBO also focused on marine conservation (Msambweni Turtle Conservation Group (MTCG)). The CBO covers the four fish landing sites of Mwaembe, Mkunguni, Mwandamo and Munje (Tondwe *et al.,* 2015). The main tribe dominating the community in the Mkunguni area is the Digo, a subtribe of the Mijikenda community (Lehmann and Kioko, 2005). The majority of the Digo people adhere strictly to traditional practices (Mcclanahan *et al.,* 1997). Fishing is the dominant income-generating activity in the area, while crop farming, trading and tourism-related activities also provide substantial support to community livelihoods *(*Tondwe *et al.*, 2015).

Data collection, analysis and statistical tests

Kuruwitu area was purposively selected as it presents one of the pioneer locally managed marine areas (LMMA) in Kenya. The Mkunguni area has minimal conservation initiatives except for the sea turtle conservation group (MTTG) and was therefore selected as a non-conservation area for comparison with the LMMA in Kuruwitu. Purposive sampling was used to identify the village elders and enderly fishers in the areas. The village elders and elderly fishers were assumed to be rich sources of IK for inclusion as key informants. Simple random sampling was used to select the households interviewed. All households in each study area were given numbers and the Stat Trek's Random-Number Generator was then used to pick the selected samples from the total household data.

A semi-structured interview using questionnaires was administered to the household heads of 181 households in the two areas (99 in Kuruwitu and 82 in Mkunguni). The sample size was selected using the formula adopted from Ross (2002). Three key informant interviews were conducted per area. Key informants included Beach Management Unit (BMU) leaders and elders from the areas. One focus group discussion (FGD) involving members of the conservation groups, fishers and other residents involved in the exploitation of marine resources were conducted in each area. The FGDs comprised a maximum of 6-10 persons per session, with the majority of the groups having approximately 9 members. The participants were selected on the basis of their knowledge, active participation and experience on issues captured in the thematic areas of this study. Observations were used on various occasions, for example, in the identification of local fishing

gears, gear assembling, and other related activities, to gain a greater understanding of existing knowledge.

Quantitative raw data collected was coded and entered into MS Excel®, then analyzed descriptively. Open-ended question and interview data were sorted into themes and any interview inconsistencies and unique statements noted and given particular attention in the analysis. An index of IK was generated from the questionnaire on questions that asked about knowledge related to the management of marine resources. A score was given if the answer fully matched the consensus responses obtained in the focus groups and the key informant interviews (Iniesta-Arandia *et al.,* 2015).

Further analyses using Chi-square tests were conducted to determine the significance of the views of surveyed respondents across the two areas using R. Additionally, a Pearson's Chi-squared test was performed on some variables that might have an effect on the possession of indigenous knowledge in the management of marine resources. The Chi-square test evaluates whether there is a significant association between the categories of the two variables. The null hypothesis was rejected if the p-value was less than the predetermined significance level of 0.05.

H0: The two variables are independent

H1: The two variables relate to each other.

In the case of a null hypothesis, the chi-squared test is used to assess the two independent variables.

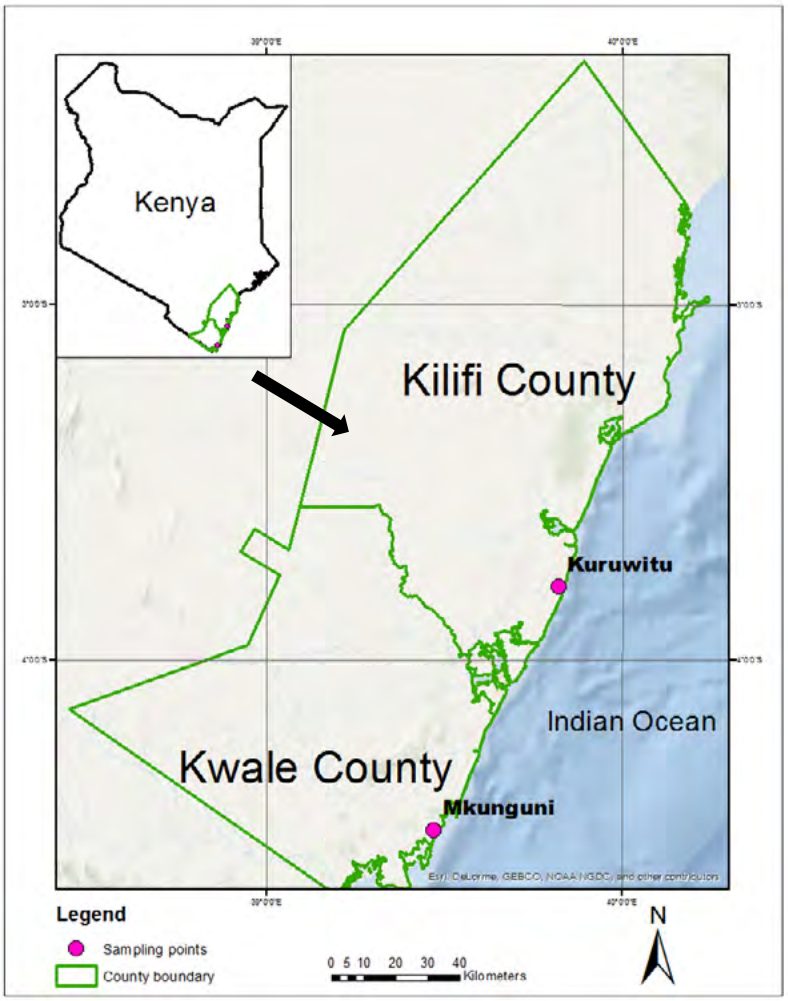

Figure 1. Map of Kenya (inset) showing the location of the study sites of Kuruwitu (north coast) and Mkunguni (south coast).

Results

Results of the Pearson's Chi-square test revealed a significant difference between the two variables of

Table 1. Socio-economic characteristics of respondents.

Socio Economic Factors	Kuruwitu		Mkunguni	
	Participants (n)	Proportion (%)	Participants (n)	Proportion (%)
Age Distribution by Fishing Area				
10-17	-	-	2.0	2.4
18-30	17.0	17.2	26.0	31.7
31-40	35.0	35.4	16.0	19.5
41-50	26.0	26.3	16.0	19.5
51-60	12.0	12.1	9.0	11.0
60+	9.0	9.1	13.0	15.9
Household Size by Fishing Village				
1-4	13.0	13.1	24.0	29.3
5-8	55.0	55.6	35.0	42.7
9-13	28.0	28.3	22.0	26.8
14-17	3.0	3.0	1.0	1.2
Highest Level of Education by Fishing Area				
None	32.0	32.3	20.0	24.4
Primary	47.0	47.5	16.0	19.5
Secondary	12.0	12.1	7.0	8.5
Vocational	6.0	6.1	9.0	11.0
Madrassa	2.0	2.0	30.0	36.6

indigenous knowledge and attendance in conservation meetings, and obtained the output χ^2= 44.313, df = 2, p=5.524e-09, indicating a very high relationship between both variables. A significance difference was also found between indigenous knowledge and age of the respondents (χ^2 = 13.017, df = 5), p=0.023). The Chi-square test on the variables of indigenous knowledge and education level obtained the output χ^2= 2.1294, df = 4, p=0.712, implying that there is no relationship between these variables.

Based on the results of the FGDs in the two areas, resource users had a similar understanding of the weather conditions and state of the sea, and its relation to marine resource access and use. For instance, the loud sound of waves splashing on the reef was an indication of impending rains and the beginning of a rough-sea period, often associated with the strong South-East Monsoon winds (SEM or *Kusi*). The resource users exercised extra precaution in their fishing activities at these times, often restricting fishing to the in-shore areas and around the reef entrance (*mlango*). This may also be partly attributed to the lack of mechanized boats capable of withstanding rough weather during the SEM period, as observed during the field survey in both fishing areas.

The resource users in both areas were conversant with the 14-day lunar cycle (cycle of the moon) which is locally referred to as *bamvua*, meaning "dead waters". The "dead waters" simply refers to the calm waters with lower tidal surges mainly aligned to the period when there is a change from spring to neap tides, or neap tides to spring tides. This period, especially for some days after the highest spring tide, present the best fishing conditions for the fishermen. In addition, fishers who used certain fishing gears, for instance, bottom-lines targeting big game fish, preferred night fishing to day fishing due to the state of the sea. After this period, the next 14-day cycle of the moon would begin with the next phase of spring tides (*mwezi-giza*) (Table 2).

Table 2. Phases of the moon and resultant influence on fishing activities in Kuruwitu and Mkunguni fishing areas in Kenya.

Phases of the moon	Tides	Tides in Kiswahili/ local name	Activities
New moon or Full moon (*mwezi mchanga /giza*)	– high tides: tides rise to highest water-mark, sea is rough – low tides: very low watermark	*Bamvua la uvuvi*	Line fishers (bottom and pelagic) targeting big fish prefer night to day time-fishing
Half-bright moon (mwezi umeandama)	High and Low tides almost the same	*Bamvua la maji-mafu*	Fishing at all times

Indigenous knowledge in the location of fish species and habitats

From the FGDs, the fishers grouped the different fish species into three major categories, with examples (Table 3); Category-1, small fish which they noted were abundant in the inshore areas, mostly within the seagrass beds, continental shelf and caves; Category-2 comprised the decapod crustacean species such as lobsters as well as cephalopods including octopus, where the resource users clearly indicated that the fishing grounds for these species were mostly located within the coral reefs and around caves where the species are found to feed on organisms including juveniles of other fish; Category-3 comprised the big fish mostly found off-shore feeding on small fish and other marine species.

Further, the fishers reported that they were able to easily identify migratory behaviours of some sea birds such as the white stork *Ciconia ciconia* (*korongo*

Table 3. Knowledge of fish species and their habitats in Kuruwitu and Mkunguni areas in Kenya.

Target Species	Swahili name	Habitats / areas found
Small fish species:		
Snapper	Changu/Tangu	Inshore, mostly around corals, caves and seagrass (*Bahari ya ndani sana sana hujificha kwenye matumbawe, mapango na chani*)
Parrot fish	Pono	
Rabbit fish	Tafi/Tasi	
Goat fish	Mkundaji	
Mullets	Mkizi	
Crustacean species:		
Lobster	Kamba mawe	In-shore in corals and caves (*Bahari ya ndani kwenye matumbawe na mapango*)
Shrimps	Kamba	
Octopus	Pweza	
Big fish species:		
Shark		Mostly found offshore (*Mara nyingi hupatikana katika bahari kuu/kubwa*)
Sail fish		
Queen fish		
Tuna		

mweupe) and the African fish eagle *Haliaeetus vocifer* (*mwewe*), and associate these with the location of good fishing grounds for certain species of fish.

Indigenous Knowledge in seasonality of marine resources

About 14.6% of the respondents in the Mkunguni area stated that the fish species mentioned were caught seasonally, compared to 4% of the respondents in Kuruwitu area who held the same view (Fig. 1 and 2). Thus the majority (96%) of the respondents in Kuruwitu area held the view that the fish species mentioned were caught throughout the year, compared to 84.5% in Mkunguni area. Fifty eight percent of the respondents in the Mkunguni area indicated that the occurrence of sea birds in the area was seasonal compared to 51% of the respondents in Kuruwitu area who held the same opinion. However, about 7% of the respondents in Kuruwitu area compared to 3% in Mkunguni area were not aware whether sea birds were seasonal or occurred throughout the year. Tests to establish if there were any significant differences in the awareness level of the availability of marine resources in the two areas revealed that there was no significant relationship at χ^2=1.675; df=2; p=0.196. The implication of this finding is that there was a high level of awareness of the availability of different marine resources in different seasons of the year in both Kuruwitu and Mkunguni.

According to the FGDs, tuna is one of the most preferred fish by the local communities in both Kuruwitu and Mkunguni. This is because they are easily caught by a variety of gears from hand lines, long lines, gill nets and drift nets. The tunas also have fewer intramuscular bones and are thus easily acceptable to wider range of family members including children. The respondents also indicted that tunas are also larger than most species hence when a fisher catches 1-2 tunas, the effort used is lower and the returns are higher than from other species. The participants noted that although the tunas may be caught all year round, they were more abundant during August through to December. The resource users also consider tuna as an indicator of the presence of smaller fishes, which comprise the food for the tunas as well as some target species for the small-scale fishers.

Surprisingly, from the FGDs, the resource users appeared to very knowledgeable on sea urchin– sea grass predation dynamics, the effect of the parrotfishes

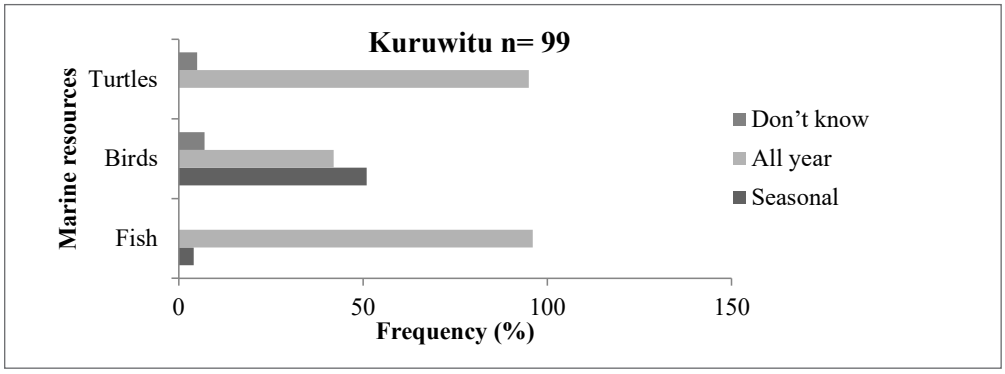

Figure 2. Availability of marine resources in Kuruwitu Village in Kenya.

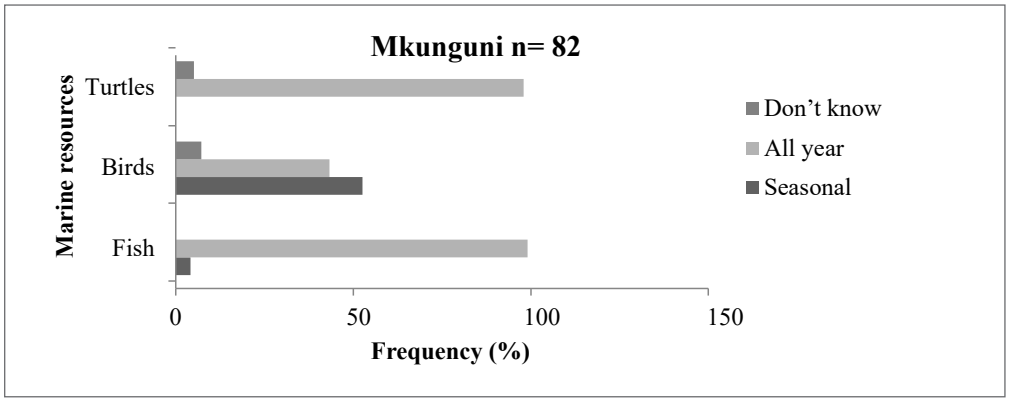

Figure 3. Availability of marine resources in Mkunguni Village in Kenya.

on seagrass populations, and the implications of sea urchin population explosions on the landings of fish from a fishery.

Indigenous knowledge on sustainable resource use

Field observation revealed that traditional fishing gears such as basket traps (*malema*) were made using different materials; for example, some fishers in the Mkunguni area used bamboo, others used metal rods, while others blended the two materials in making the traps (Fig. 4). Results of the FGDs indicated that the use of bamboo in making basket traps has greatly declined due to reduced availability of bamboo plants in the Mkunguni area. Therefore, some fishers have resorted to using wire mesh and other artificial materials, indicating an inherent knowledge among the resource users in seeking innovative alternative materials for use in making the *malema*. In addition, the respondents preferred *malema* made of wire mesh because they were more durable than bamboo that wore out quickly after contacting water when fishing.

Indigenous Knowledge in environmentaly friendly fishing methods

Field observation showed that most of the fishers in the Kuruwitu area preferred the use of spear guns while the traditional basket traps were more prevalent in the Mkunguni area (Fig. 4). Other types of fishing gears used in the two areas included hand lines and various types of nets such as gillnets, driftnets and monofilament nets. FGDs revealed that the traditionally fabricated fishing gears were more acceptable to the local community and categorized as "easy to operate".

Traditional fishing gears are known to harvest small quantities of fish compared to modern fishing gears such as trawlers and ring nets. The fisher communities in the study area demonstrated a good knowledge of fishing gear operation and the limitations of the various gears. The respondents in both sites reported that fishing nets with small mesh size were prohibited due to the possibility of catching small fish, which may eventually exhaust the "fish stocks" in the area. The spear gun fishing gear is used selectively, even in

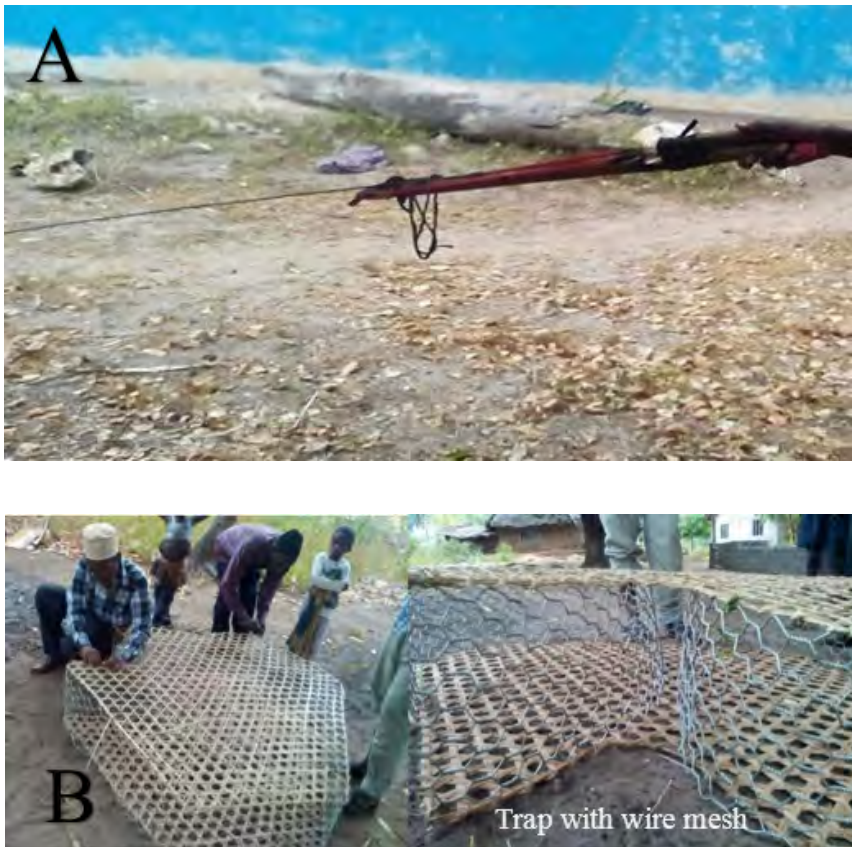

Figure 4. (A) Spear gun used in Kuruwitu fishing area, Kenya;
(B) Fishermen from Mkunguni fabricating a basket trap (*Malema*) blending both the traditional reeds and wire mesh.

the Kuruwitu area, taking care not to injure fish which were not caught or escaped the gear.

The fishers also operated different fishing gear types during different seasons of the year. For example, in the Mkunguni area, the fishers indicated that it was forbidden to use gillnets within the reefs during the SEM season (*kusi*) since it is rough and challenging to operate gillnets. It was also observed that different types of line fishing gear (hand lines, drop lines, bottom lines, as well as pelagic lines) were the preferred fishing methods for demersal (bottom) species in the shallow inshore areas, especially during rough/stormy weather.

Further, the respondents reported that the use of beach-seines and ring nets in coral reef systems was a forbidden fishing method because it destroyed corals reefs which act as fish habitats and the associated polyps which act as sources of food for certain species of fish. According to the FGDs, fishers in Mkunguni reported that they have resorted to the use of elders who use religious teachings and their wisdom to enforce the regulations. In Kuruwitu, the elders and BMU leaders were regulating the prohibitions.

Indigenous Knowledge of ecosystem degradation and pollution

The awareness level of respondents of different causes of pollution and degradation of the marine ecosystems was gauged using a presence/absence (yes/no) score, as shown in Figs. 5 and 6. Based on the analysis, 72% of the respondents in Kuruwitu area expressed their feeling that quarrying was a major cause of pollution in the area, compared to only 7% in the Mkunguni area. This may be attributed to the presence of a cement factory in the Vipingo area of Kuruwitu, as well as smaller private quarries which produce noise pollution, as well as limestone dust, which the fishers felt was impacting adversely on the fishing grounds. Further, a key informant in Kuruwitu reported increasing incidences of marine pollution and ecosystem degradation, saying "*Pollution is a constant problem we face... The water quality has reduced, and so has the marine environment in which we go fishing*", a clear indication that

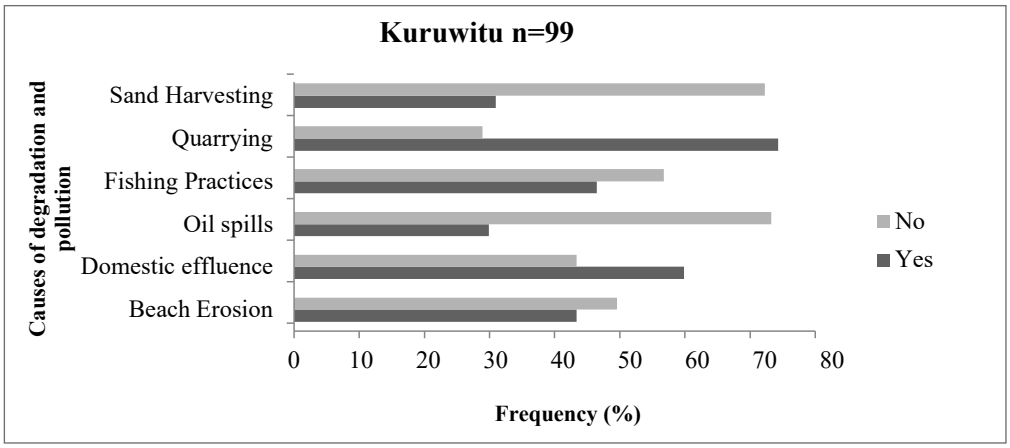

Figure 5. Knowledge of marine ecosystem degradation in Kuruwitu Village in Kenya.

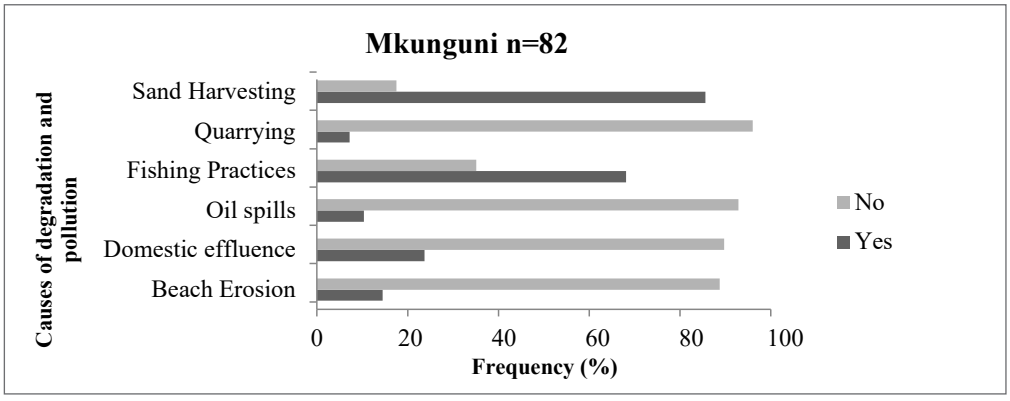

Figure 6. Knowledge of marine ecosystem degradation in Mkunguni Village in Kenya.

he understood the connection between marine pollution, ecosystem degradation and the likely impacts on their livelihood sources.

In Mkunguni, 66% of the resource-users listed deleterious fishing practices as the most serious causes of ecosystem degradation, compared to 45% of the respondents in Kuruwitu. Further inquiry through FGDs revealed that fishing practices such as the use of ring nets in coral reefs were to blame for marine resource degradation. In addition, the study noted that the emerging threat of illegal, unregulated and unreported (IUU) fishing along the coast was to blame for the decline of some of the fish stocks as well as destruction of marine habitats.

Sand harvesting was listed by 83% of the respondents in Mkunguni as a major threat to habitats, compared to 30% in Kuruwitu area. The FGD in Mkunguni revealed that sand harvesting was a major activity in the areas and a major threat to the marine ecosystems due to sedimentation which negatively impacts on the sea grass beds resulting in declining fish catches.

Oil-spill was listed as a threat by 29% of the respondents in Kuruwitu area compared to only 10% of the respondents in Mkunguni area. The resource users in Kuruwitu reported that oil spills had become more frequent as a result of increased traffic of marine vessels. The oil spills were associated with the ongoing development of the Lamu Port under the Lamu Port-Southern Sudan-Ethiopia Transport (LAPSSET) project, however, the resource users in Mkunguni did not associate the increased maritime traffic to marine degradation in the area. This might be because of the closer proximity of Kuruwitu to the shipping route and the port of Mombasa at Kilindini, compared to Mkunguni area. A further analysis of this data using the Chi-square test revealed that the awareness among the participants was significantly related in both the areas at χ^2 = 13.017; df=5; p=0.001.

Discussion

Possession of IK knowledge is pegged on several factors such as age and attendance to management meetings. The strong association of age and IK found in this study could be explained by the fact that the elderly were more knowledgeable because of their experience and their involvement as elders in overseeing the rules and regulations pertaining to use of marine resources. There is an association between attendance to management meetings and IK. The management meetings were organized by the BMUs and attended by registered residents and were a forum that aimed at empowering the residents on how to conserve the environment. Meetings favour knowledge exchange and give people more opportunities to learn about their environment (Shackeroff and Campbell, 2007). There was no association between education level and IK in the present study. These findings are in agreement with Paniagua-Zambrana *et al.* (2014) and Iniesta-Arandia *et al.* (2015) who argue that formal education tends to detach learners from their physical environment and culture, thus limiting them from learning and participating in activities related to the transmission of IK from their elders.

The two communities have historically accumulated significant understanding of weather patterns based on their close association with the sea, and this has led to the evolution of fishing activities that are responsive to weather changes and the state of the sea. This form of indigenous knowledge serves the purpose of regulating marine resource exploitation and ensuring the safety of the resource users. Fishing is considered to be one of the most dangerous occupations (FAO, 2018), therefore understanding the weather is imperative if accidents are to be reduced and safety conditions improved (FAO, 2007). Similar findings have been reported where changes in monsoon weather patterns often limit fishing ventures on the southern coast of Kenya (McClanahan and Mangi, 2004; Okeyo, 2010), especially during the May-August period. The period of reduced fishing activities contributes to the prevention of depletion and rehabilitating of fish stocks (FAO, 2007). The phenomenon of using the moon cycle to guide fishing behaviour and patterns has been recorded in several areas of the world (Poisson *et al.,* 2010; Vinson and Angradi, 2014). In addition, these findings relate well with a study conducted in Brazil, where crustacean fishers applied indigenous knowledge of the tidal patterns to plan their fishing activities (Bezerra *et al.,* 2012).

Locating fish habitats is essential for maintaining healthy fish populations and designing best approaches for fishery management (MacNeill, 2010). By locating fish habitats fishers in both Kuruwitu and Mkunguni can harvest fish for food security and human development. This implies that fishers with such knowledge were able to save time in their fishing operations. These findings are in agreement with the results of Matiru *et al.* (2002), and Tunje and Muturi (2005) who observed that approximately 70-80% of

the demersal fish catches are mainly harvested from the shallow waters and reefs. Additionally, Tunje and Muturi (2005) observe that the demersal catch within these coasts normally comprises parrotfish, rabbitfish, snappers and goatfishes, as well as decapod crustaceans including lobsters and shrimps, which are common in shallow waters and reef. The use of migratory birds to determine fishing points and speculate on the type of fish that can be caught has been noted in Kuruwitu and Mkunguni areas. Similar observations have been made in fisheries of the Western Indian Ocean where fishers locate areas of schooling tunas by watching for the Wedge-tailed Shearwater and the Red-footed Booby birds (Danckwerts *et al.*, 2014; Sebastian, 2011). This further lends credit to the idea that traditional knowledge is still helpful and being applied in the fishing activities of the residents in the two areas.

Indigenous knowledge accumulated over generations assists communities to anticipate how the availability of various marine resources varies. Indigenous knowledge of seasonality is critical since it influences the timing in species availability and consequently fishing patterns (Johannes *et al.,* 2000). The results on tuna abundance revealed in this study concur with those of a study by Gopalakrishna *et al.* (2012) which allude to the fact that tuna may be caught throughout the year but are generally a seasonal species.

Environmental sensitivity of the respondents in terms of gear use was based on suitability of the selected gears in different seasons and in enforcement of the gear use. For example, the use of the spear gun, although contested in some areas, was accepted in the Kuruwitu area because of the agreement that the gear should be used in a careful and selective manner. The spear gun used in Kuruwitu allows it to be used in a selective manner that does not damage non-target species. Therefore, despite it being an illegal gear, if well used, it could be considered as an option for selective harvesting.

Selection of fishing gears largely depends on the fishers' level of interaction with the environment and, by extension, the level of understanding of the ecology of the species. Kynoch *et al.* (2015) and Tunje *et al.* (2016) further confirm that the use of different fishing gear during different seasons was a way of ensuring that there is sustainability in the exploitation of the fisheries resources in different fishing grounds and seasons. The residents were aware that they faced resource limitations within the inshore waters and that poverty disenfranchised them from the sustainable use of the marine resources. Johannes *et al.* (2000) and Masalu *et al.* (2010) note that traditional fishing vessels without engines cannot withstand harsh conditions at sea, thus indirectly serving as a regulation of resource use. These findings are supported by a study by Daw (2008) which noted mass migrations of fish from disturbed fishing grounds to neighbouring habitats.

There is an increasing use of ring nets in the shallow waters on the south coast of Kenya, particularly in Vanga, Msambweni and Gazi, where they are threatening the shallow water ecosystems, and are a significant cause of resource use conflict (Okeyo, 2010). The opposition of local communities to the use of non-traditional fishing gears demonstrates that the residents understand the inherent threats of non-traditional fishing equipment to their efforts in the conservation and sustainable utilization of marine resources.

The use of wire mesh and similar innovations in replacing traditional materials with alternatives in the making of fishing gears has also been noted in other areas along the south coast such as Diani (Mbaru and McClanahan, 2013). These modified gears are more durable than the bamboo ruffians and their environmental impact is reduced as they are not abandoned or lost as often. The use of the mesh also ensures that damage to the environment (harvesting of materials for *malema*) is minimized. In addition, wire mesh is made of iron, and is bio-degradable. IK constantly evolves and may be based on the latest external knowledge adjusted to local circumstances (Fabricius *et al.,* 2007). Therefore, seeking alternative materials to ensure the continuity of traditional fishing gears such as basket traps is important in ensuring the continued supply of fish from the marine environment with reduced impact (Mbaru and McClanahan, 2013). Lastly, it reduces reliance on traditional materials that were used in the making of fishing gear, such as mangroves.

Sand mining in shallow nearshore or beach areas has resulted in negative impacts on adjacent coastal areas including sedimentation during heavy rains and stormy conditions that can impact the sea grass beds, key habitat for the majority of the demersal species targeted by the small-scale fisheries (Otay *et al.,* 2004). The residents noted that such a practice never existed in their collective recollection from the folklore handed down from the past. Therefore, within the meaning of their traditional knowledge, this is an

invasion of modern-day extractive demands on the environment and reduces the quality of the shores and the ability of the marine environment to positively affect their lives.

Oil spills have both short- and long-term effects on the marine ecosystem, and high concentrations of the toxic components of oil could lead to the death of bottom-dwelling marine species (Ismail, 2005). While major oil spills have not been documented in Kenya, the effects of minor spills can have serious consequences on the environment, as evidenced in a study conducted by Ainsworth *et al.* (2018). Such effects have been witnessed on the shores of Kuruwitu and Mkunguni, impacting negatively on conservation efforts. The residents do not know traditional customs and practices for dealing with such spills since it was a non-existent phenomenon in their historical relationship with their marine environment.

The failure to manage environmental issues, and especially emerging problems as posed by modern industries such as sand mining or oil spills demonstrate the limitations of IK. Studies by Ruiz-Mallén and Corbera (2013) and Jauhiainen and Hooli (2017) assert that some communities are structurally thin and lack various crucial resources, and therefore capacity, in high-end development. This makes them rely greatly on external knowledge and experts (Ruiz-Mallén and Corbera, 2013). Further, Jauhiainen and Hooli (2017) adds that not all indigenous people have lived or are living in peace and harmony with nature. There are some world phenomena that are too complex to be explained into static conceptualizations (Mazzocchi, 2006). In order to manage these complex phenomena, there is need to maintain continuous openness, willingness to discover and learn from other civilization to the understanding of nature (Mazzocchi, 2006).

Conclusions and Recommendations

There are various types of IK used in the management of marine resources in the Kuruwitu and Mkunguni areas along the Kenya coast; for example, indigenous knowledge on weather and state of the sea have served the purpose of regulating marine resource exploitation and ensuring the safety of the resource users. Resource users demonstrated the use of IK in the identification of marine species and their habitats in both areas. This knowledge provided precision on target species and habitats, thereby reducing the time spent "searching" for fish. The fishers identified the different causes of marine pollution and degradation and were able to explain how they impacted fishing grounds, fish catches and ultimately, their livelihoods.

The County governments of Kilifi and Kwale should harness the IK in these local communities and also build the capacity of the residents in both areas to synchronize indigenous knowledge with new interventions in the effort to harmonize the management of marine resources. There is a need for an integrated approach to the management of marine resource to address concerns by communities. This will strengthen the different types of IK in the face of modernization and urbanization. Lastly, the County governments of Kilifi and Kwale and environmental agencies should actively get involved in creating awareness of ecosystem degradation and pollution and the impacts on marine resources.

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