

Variations in community perceptions of ecosystem services within the Tana River estuary, Kenya: Implications for ocean governance

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Abstract

Coastal communities in the Tana estuary, Kenya, rely on a variety of economic sectors linked to ecosystem services, including small-scale fisheries (SSF), commercial prawn fisheries, and tourism. Despite its environmental and social importance, the estuary has been negatively impacted by overexploitation, pollution, and climate change. As a result, developing integrated management approaches for this area is a priority. The integrated approach to ecosystem services (ES) evaluation has widespread support because it emphasizes people's views of ecological value to human well-being and aims to provide a solution to the rapid depletion of our planet's natural resources. This study applied mixed methods to understand the perspectives of the communities on ES. It was hypothesized that perceptions of ES differ across communities with different socioeconomic characteristics, and this hypothesis was tested in two communities (Ozi and Kipini) that share the same ecosystem but have different socioeconomic characteristics. Kipini is an area near the ocean, whereas Ozi is a rural area further upstream. Differences were noted in the valuation of cultural services, while there were similarities in provisioning and regulating services. Mangroves, other trees, and river systems were considered to have higher ES provision than the ocean, floodplains, and settlement areas. The Ozi community ranked the ocean higher than the Kipini community, even though Ozi was located further upstream from the ocean; consequently, the perception that communities benefit more from resources that they are close to could be false. The relevance of using social ES identification to determine the distribution of benefits from coastal ES is highlighted in this study and will be beneficial for informing decision-making and developing all-inclusive governance structures.

Keywords: land use, land cover (LULC), local knowledge, socio-cultural values, rural communities, socio-ecological systems, ecosystem services evaluation

Introduction

There is increasing pressure on global coastal zones, especially in fragile ecosystems such as estuaries, where multiple activities such as fisheries, agriculture, and tourism combine to make these areas vulnerable to degradation. Ecosystem protection efforts to preserve the productivity and quality of coastal ecosystems are needed for the sustained provision of ecosystem services (ES) for human wellbeing to coastal

communities. ES are the benefits people obtain from ecosystems. These are categorized as provisioning services (food, water, timber); regulating services (climate regulation, flood control, water quality); cultural services (recreational, aesthetic); and supporting services (soil formation, photosynthesis, and nutrient cycling) (MEA, 2005). Management interventions are especially needed in developing countries, where societal expectations have forced the need for rapid economic

expansion, driving environmental concerns to the bottom of the priority list. Rural communities whose livelihoods depend on sectors that rely on ecosystem quality, such as fishing and tourism, have been harmed because of the environmental deterioration of coastal zones (Owuor *et al.*, 2017). Creating management measures to protect and increase these ecosystem services would be beneficial to such communities.

Effective management strategies must be developed in such a way that they have no negative impact on community well-being; otherwise, such management approaches in rural coastal regions result in a vicious cycle of environmental degradation and poverty (Pelletier *et al.*, 2019). Understanding the socio-economic value of ecosystems to various user groups is critical for resource management and governance. It aids in the understanding of resource use patterns and the benefits of coastal ecosystem services to the different user groups.

Mapping and valuing ES can help the understanding of the complex socio-economic and environmental importance of coastal ecosystems to a wide range of users (Asah *et al.*, 2014; Grêt-Regamey *et al.*, 2015). Creating maps of ES and assigning a value to the ES using community participation highlights the importance of individual ecosystems, and how it can be utilized as part of a community-based decision-making process. This approach has been used to understand ecosystems globally, such as the Mida creek in Kenya (Owuor *et al.*, 2017) and the St. Lawrence estuary in Canada (Jacob *et al.*, 2021). In these cases, the approach proved to be effective in highlighting the importance of ecosystems to different user groups, which can help guide decision-makers in the conservation and management of such complex ecosystems.

The Tana River estuary is one of East Africa's most important estuarine wetlands. Because of its extensive mangrove area, the estuary offers essential ecosystem services such as biodiversity preservation for endangered species, pollution mitigation, cultural services, and food production, notably for small-scale fishers (Manyenze *et al.*, 2021; Mwamlavya *et al.*, 2021). The Convention on Wetlands of International Importance designated the area as an important ecological and bird reserve in 2012 (Ramsar, 2012). Despite the critical importance of the area, human activities such as conversion of mangroves into farm areas, mangrove overexploitation for timber and firewood, overfishing, poor land use and agricultural practices and

interruption of water flow from upstream (Samoilys *et al.*, 2011; BirdLife International, 2016) continue to impact this estuary.

Kenya has a well-developed coastal and marine protection governance structure, but it lacks an estuary-specific integrated management plan (Momanyi, 2016). The National Oceans and Fisheries Policy (GoK, 2008), Forest Conservation and Management Act (2016) (GoK, 2016a), the Wildlife Conservation and Management Act (2013), (GoK, 2013a) (which also applies to mangrove regions and coastal forests), and the Integrated Coastal Zone Management Policy 2013 (GoK, 2013b) are all currently used to manage the estuary (Momanyi, 2016).

The Kenyan government is speeding up efforts to improve the Tana estuary's long-term management, including funding studies that will aid in determining the value of ecosystem services to various user groups (van Beukering *et al.*, 2015). Several studies have been conducted in this area, although the majority of them have concentrated on a single issue, such as fisheries (Fulanda, 2003; Munga *et al.*, 2016), socio-economics (Odhiambo-Ochiewo *et al.*, 2016), and ecosystem biodiversity (BirdLife International, 2016; Samoilys *et al.*, 2011). Fewer studies, (e.g., van Beukering *et al.*, 2015), have provided an in-depth assessment covering social, cultural, economic and ecological aspects for a multi-disciplinary overview of the Tana River estuary. This research intends to close this gap by giving more comprehensive assessments of the region by mapping and contrasting ES across various user groups (Ingram *et al.*, 2012).

Understanding how and why ES decisions differ between societies and social groups has important implications for environmental management since it can help identify conflicting values and winners and losers in various circumstances (Daw *et al.*, 2011; Lapointe *et al.*, 2019). Different impressions of ES have been documented in both urban and rural groups (e.g., Shi *et al.*, 2016; Lapointe *et al.*, 2019). This might be due to the community's reliance on the environment – communities that rely on ecosystems for direct revenue are more likely to engage in ecosystem protection and maintenance (Lindsey *et al.*, 2007).

This study applied an integrated approach (Yang *et al.*, 2015) to examine local community perceptions on the ES provided by the Tana River estuary on the north coast of Kenya. Two distinct communities, Kipini and

Ozi, which share the same ecosystems, although one is located farther upstream with limited access to amenities such as roads, electricity, and piped water, were the basis of this assessment. Because of the socioeconomic and geographical contrasts between the two communities, the study was able to investigate how socioeconomic position and ecosystem access influenced the residents' views of ecosystem services. This will address the current gaps in the knowledge needed to understand how these communities interact with this ecosystem, which will have ramifications for the Tana estuary's governance, management, and conservation.

activities in Kipini's peri-urban population, with artisanal fishers and artisanal catch rates among Kenya's highest (Abila, 2010; GoK, 2016b). Ozi is a rural village, with most of its residents reliant on riverine agriculture and fishing (van Beukering *et al.*, 2015).

Data collection and analysis

Data was collected through household surveys and focus group discussions and was combined in a matrix approach with Land Use Land Cover (LULC) mapping to understand the perception of ES by the two communities. LULC is the classification of human activity

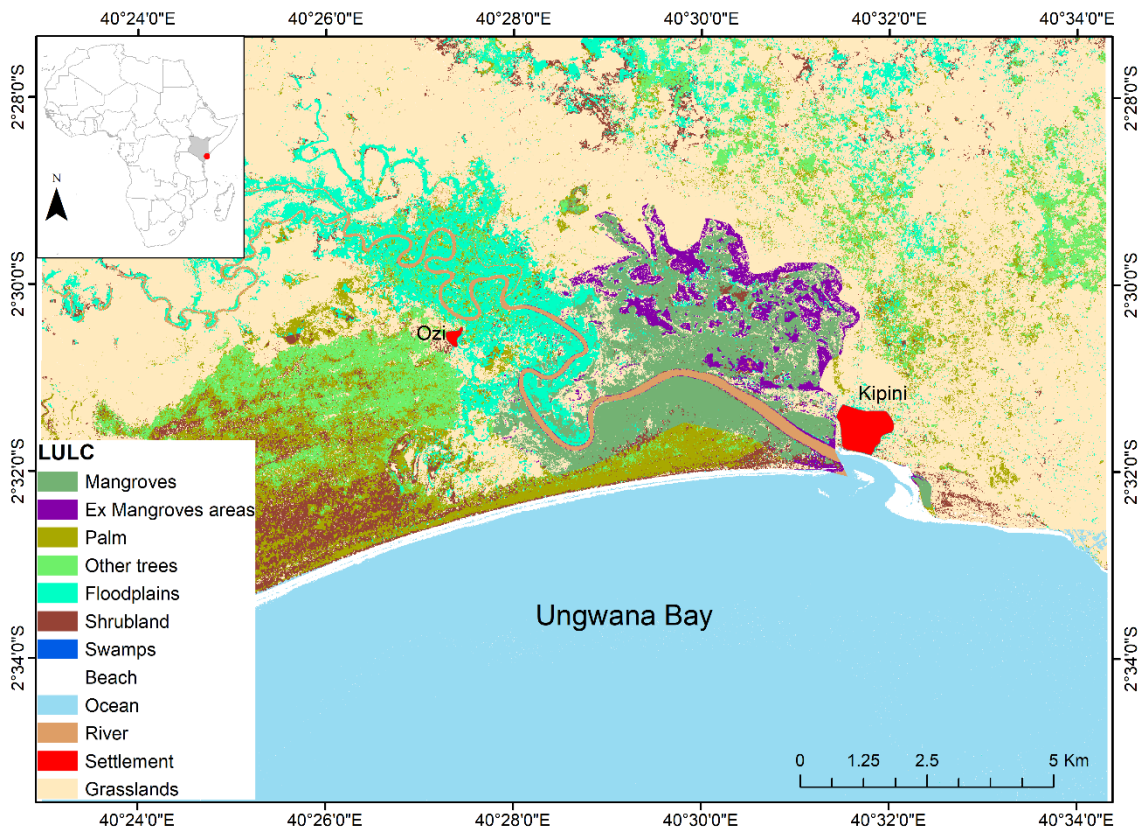


Figure 1. Map showing the location and main land use cover classes along the Tana estuary, and the location of study sites of Kipini and Ozi.

Material and methods

Study area

Tana River is the longest river in Kenya. Its estuary contains a diverse range of habitats, including mangroves, deltas, estuaries, and beaches, which sustain a wide range of fish, trees, and birds (van Beukering *et al.*, 2015). This study focused on the settlements of Kipini and Ozi in the Tana River estuary. Kipini is closest to the river mouth while Ozi is situated approximately 20 km upstream from Kipini (Fig. 1). Coastal and marine fisheries are one of the most significant economic

and natural components on the landscape over time using recognized scientific and statistical techniques. Remote sensing software approaches, such as supervised and unsupervised classification, are used for LULC classification (Di Gregorio, 2005).

Household survey

Structured interviews were conducted in the communities to obtain data on the demographics, the use of the different ecosystems in the area, and the ES they provided to the community. There are 801 households

Table 1. List of LULC classes and ES used for ranking during focus group discussions on ES scores.

LULC classes	ES Services		
	Provisioning services	Regulating services	Cultural services
-Mangroves	-Firewood	-Erosion protection	-Education and research
-Other vegetation	-Charcoal	-Carbon sequestration	-Cultural shrines
-Palm trees	-Construction poles/timber	-Flood protection	-Recreation and tourism
-Settlement	-Fishing gears	-Nutrient regulation	-Intrinsic values
-Beaches	-Honey		
-River/stream	-Medicine		
-Open inshore Ocean	-Fisheries		
-Floodplains	-Wild foods, -Palm wine		

in Kipini town and 389 in Ozi village, according to the population census (GoK, 2019). A systematic sampling design was utilized to select a total of 146 households, including 71 from Kipini (8.9 % of homes) and 75 from Ozi (19.3 % of households). The survey's target data included characteristics on home location, gender and age of the household head, household size, livelihood activity, education level, monthly revenue from livelihood activities, as well as fishing and agricultural assets.

Focused group discussion with LULC matrix

Data from the household survey helped with the identification of key LULC types based on the activities and ecosystem types mentioned by the respondents. These were used to guide the development of the LULC maps and collection of training data for a supervised classification in ArcGIS 10.5 of a Sentinel 2 satellite image obtained in August 2017. Level-1C Sentinel products are images that have already undergone pre-processing, including geo-referencing, extraction of top of atmosphere (TOA) reflectance and cloud masking. Key informants (community group leaders) from

the area helped in identification of key areas where the different LULC was identified on Google Maps, and these were used as collection points of data for the LULC supervised classification training. The community leaders represented all key groups, including women, youth, fishermen, and opinion leaders.

The LULC classes were combined with ES, based on the definition by Kandziora *et al.* (2013). The matrix from this combination was presented to respondents for ranking/scoring using the Likert scale. The participants were asked how important each ecosystem type was for providing ES. Ranking was done after a discussion among the participants and after consensus reached. Valuing ranged from 1 (low) to 5 (high) (Burkhard *et al.*, 2009). The matrix is shown in Table 1 and a summary of the methodological approach is shown in Figure 2.

Two focus group discussion workshops were conducted in Kipini and Ozi in April 2017. All the relevant stakeholders in natural resources management

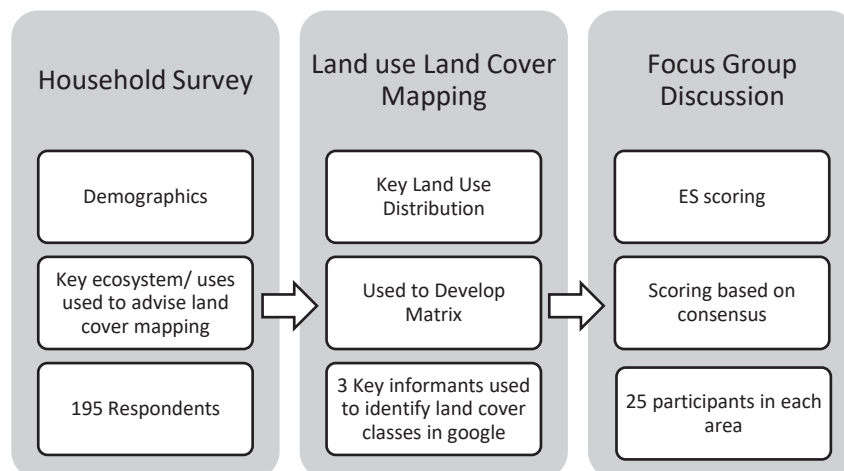


Figure 2. Summary of the methods used to collect data, the activities undertaken and the relationship between them.

were invited to participate, including the Kipini and Ozi Beach Management Units, the Kipini Community Conservation Management Forum, and the Ozi Community Conservation Association. Both workshops were attended by 25 people and took approximately three hours. The workshops were held on two consecutive days. Participants were asked to assess the LULC's importance based on a map of ecosystems.

Data analysis

Data were plotted to evaluate the difference in perception between the two areas for each of the ES classes (provisioning, regulation, and cultural services). Only questions on the socio-economic differences between the two groups were collected from the household surveys for this research. The data from the focus group discussion was used to show differences in ES perception. For proximity of the villages to the LULC, the LULC maps were converted to 100 m pixels, and the distance from the center of each pixel to villages was calculated; box plots were used to show variations in the distances of each pixel to the villages. The non-parametric Wilcoxon rank-sum test was used to compare the ranking by the two communities for the different LULC classes.

Results

The most significant source of income for the residents of Kipini was fishing, which was followed by farming and trading. Farming of rice, bananas and mango was the primary source of income in Ozi, followed by fishing and trading. Between the two

communities, there were considerable educational disparities, with Kipini having more educated people than Ozi. However, there were no substantial financial differences between the two villages (Fig. 3).

Mangroves, palms, and floodplains are among the LULC types found in the Tana estuary. Mangroves predominate closer to the river mouth, whereas farmlands on the floodplains predominate farther upstream (Fig. 1). Distance / proximity of the two settlements of Kipini and Ozi to the various LULC classes vary. Kipini is near the coast and mangroves, but Ozi is nearer to other LULC classes like palm trees and floodplains. Kipini was closer to the areas with evident cut mangroves than Ozi (Fig. 4).

Variation in ES scores between Kipini and Ozi

Both the Kipini and Ozi community indicated that mangroves and other trees provide the following ecosystem services: firewood, charcoal, erosion protection, carbon sequestration, cultural shrines, education, and research, whereas the inhabited places supported minimal ecosystem services (Fig. 5). The relevance of the LULC class differed; for example, while Ozi participants identified eight ecosystem services originating from the ocean (cultural shrines, education and research, fisheries, flood protection, intrinsic values, medicine, nutrient regulation, recreation, and tourism), Kipini participants listed three ES (fisheries, intrinsic values, recreation, and tourism). Another noticeable variation was the significance of floodplains, where Ozi participants indicated eight

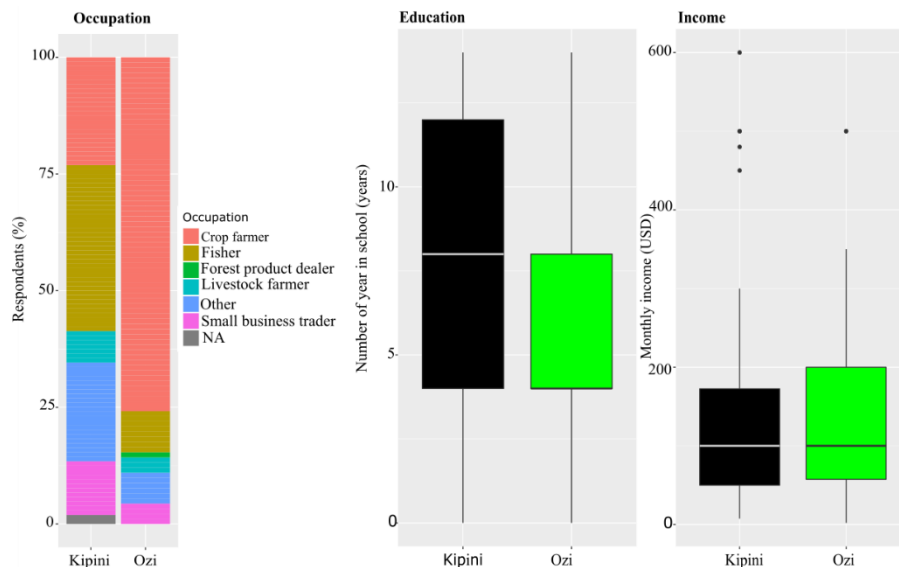


Figure 3. Stacked bar chart (occupation) and box and whisker charts (education and income) characterising the populations living in Kipini and Ozi.

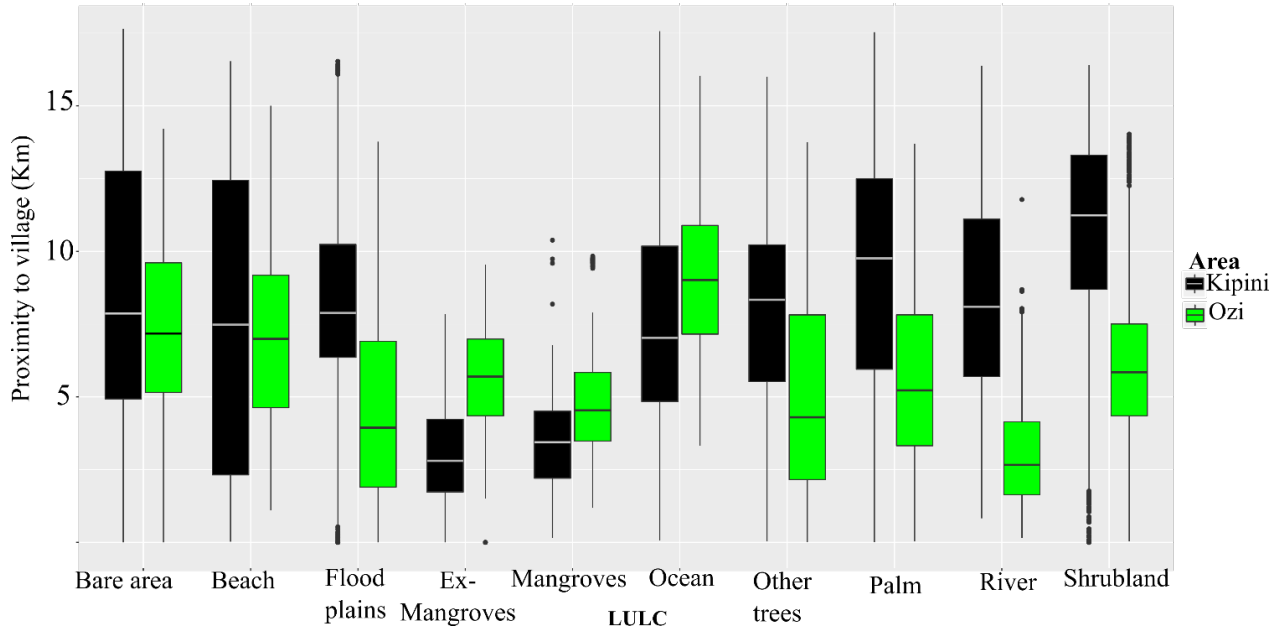


Figure 4. Box and whisker chart showing the proximity of Kipini (Black) and Ozi (green) to the different LULC classes. (Proximity is defined as the distance of each LULC pixel from the village).

important ecosystem services (firewood, construction poles, fisheries, intrinsic values medicine, recreation and tourism, nutrient regulation, and wild foods) that they draw from this land cover compared to three (erosion protection, fisheries, and nutrient

regulation) for Kipini participants. Despite Kipini being significantly closer to the beach area, the Ozi participants identified more cultural uses for the beach area, such as cultural shrines, recreation, and intrinsic values (Fig. 5).

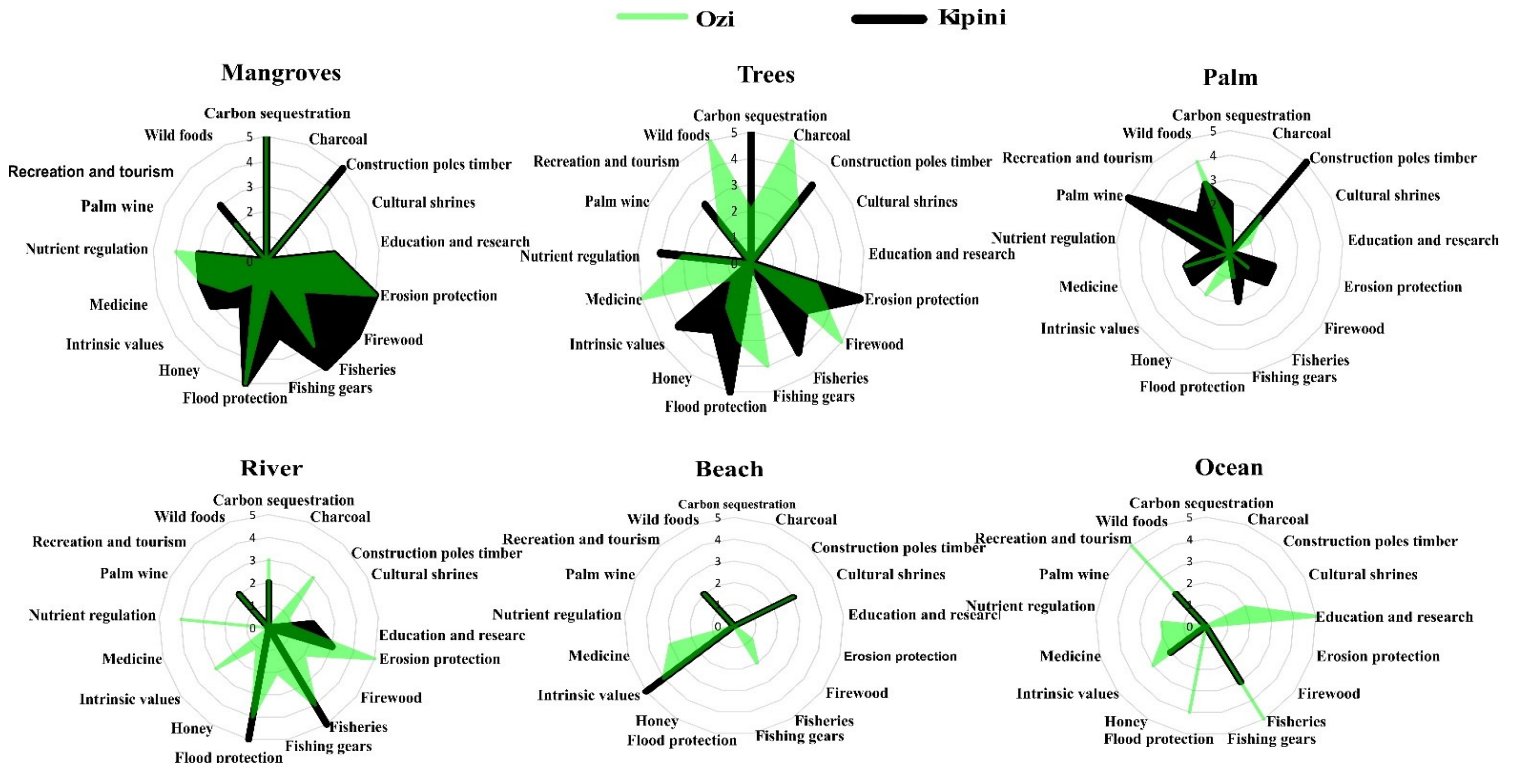


Figure 5. Spider charts comparing the differences in perception of the value of ES derived from the different habitat types, by participants from Kipini (in black) and Ozi (green).

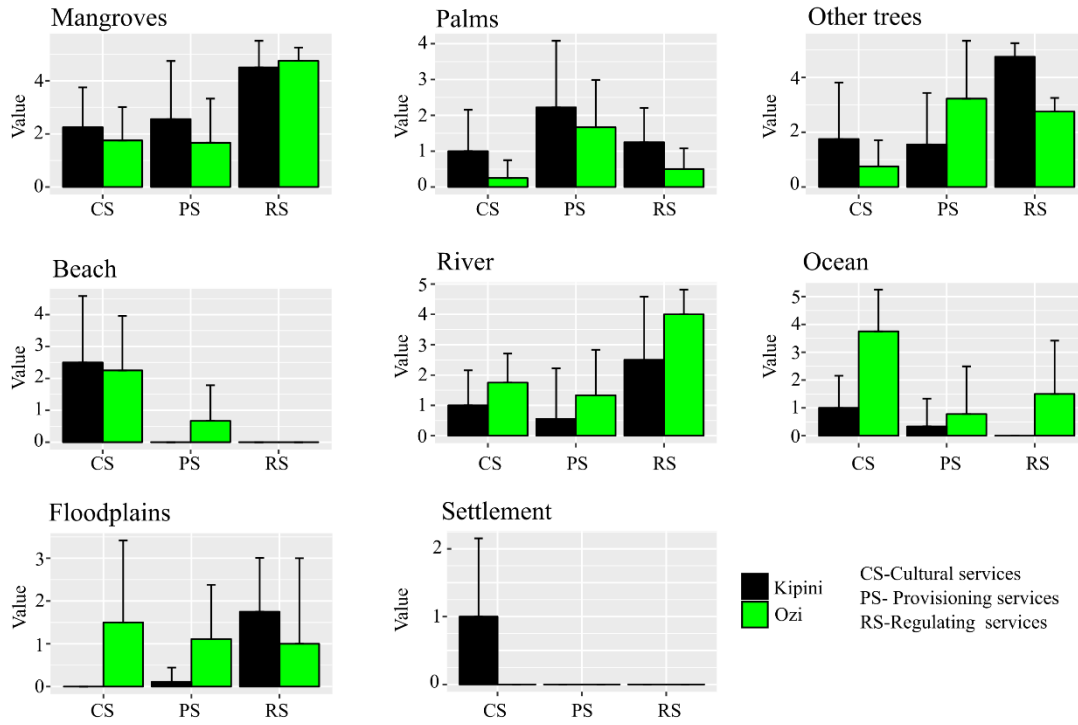


Figure 6. Bar charts showing the difference in perception of the importance of the different ecosystem for provision of the different categories of ES between Kipini (black) and Ozi (green) communities.

Other trees, palms, rivers, beaches, and flood plains scored highest in value, while ocean and settlement scored lowest. Other trees received the highest scores from Ozi, followed by mangroves, river, ocean, flood plains, and palms with the beach receiving the lowest score. Carbon sequestration, construction poles, timber, flood and erosion prevention, firewood, fishing equipment materials, and wild fruits are among the top ranked uses of other trees (Fig. 6). The Wilcoxon rank-sum test indicated a difference in ranking between the two locations for the river and ocean LULC classes (Table 2).

Discussion

This study sought to find whether there was a difference in the assessment of ecosystem services in the Tana estuary between two community groups (Kipini and Ozi). The Tana estuary provides a variety of ES to the two communities assessed, including carbon sequestration, construction poles, timber, flood and erosion prevention, firewood, fishing equipment materials, and wild fruits, highlighting the importance of this ecosystem to the community. The study found that there were variations in the identification and scoring of the ES by the two communities. ES

Table 2. Test results (*p*-values, 95 % confidence level.) of the Wilcoxon rank-sum test (W) for the difference of means of Kipini and Ozi scoring of the importance of the different ecosystems.

Land Cover/Ecosystem	W	<i>p</i>
Beach	138	0.32
Floodplains	122	0.13
Mangroves	0.4457	0.44
Other trees	199	0.22
Palm trees	199	0.22
River	106	0.05
Ocean	111.5	0.05
Settlement	180	0.163

derived from mangroves, palm trees and other trees had the highest scores from the Kipini community, while ES derived from other trees, mangroves, and the river received the highest scores from the Ozi community. The variation in the scoring of ES could be attributed to the difference in the cultural and economic activities connected with these two communities; farming was the primary source of income in Ozi, while fishing was the primary source of income at Kipini.

The Tana estuary communities have shown that, through the ES approach, they can identify benefits derived from the estuary. It is not the provisioning services but the regulating services that received the highest scores overall, followed by cultural services. The Kipini community assigns high scores to the regulating services from mangroves and other trees, while the Ozi community values those from mangroves and the river. The highest scoring of regulating services for mangroves is for flood protection (both communities), erosion protection, and carbon sequestration. Previous studies have shown that coastal erosion is a major concern for many coastal areas in Kenya and that mangroves can offer coastal protection against erosion, storm surges, and floods (Kairu and Nyandwi, 2000; Zhang *et al.*, 2012). The mangroves in the Tana estuary, as well as other vegetation, provide flood protection. The river is essential to the Ozi community because it provides water for agriculture. Floods occur mostly upstream, affecting Ozi more than Kipini, which is largely shielded from river flooding by mangroves and dunes.

The ecosystems in the Tana estuary also provide important cultural ES to the communities. For the Ozi community, it is the ocean (cultural shrines, traditional medicine, intrinsic values), the beach (intrinsic values, medicine, cultural values), and mangroves (medicine, education, recreation). For the Kipini community, it is mainly the beach (intrinsic values, cultural values, recreation), mangroves (recreation, medicine, intrinsic values), and other trees (intrinsic values, recreation). The Ozi community is more rural with limited access to amenities such as hospitals and good road networks, therefore the majority of the residents use traditional medicine from mangroves and other trees (leaves, fruits, bark, and roots) for stomach disorders, fever, the removal of hookworms and fly eggs, and warding off bad spirits (Rönnbäck *et al.*, 2007). This explains why its residents gave high scores for the provision of these ES.

Furthermore, the communities' perceptions of the cultural benefits provided by floodplains and settlements differ. Floodplains were valued by residents of Ozi for their intrinsic and recreational worth, however Kipini did not score this habitat. Ozi did not award any scores for settlement (manmade places inhabited by people), but Kipini appreciated it for recreational and educational benefits. These findings could be because Kipini is a peri urban area with more buildings that provide social services, such as churches and schools, being in place compared to Ozi which is more rural with limited amenities. The Ozi community are closer to floodplains, thus their importance. This shows that certain ecosystem services are only accessible near the ecosystem that delivers them. Additionally, inhabitants of the Kipini village appear to utilise nearby recreational possibilities (settlement and the beach) rather than traveling inland to the floodplains for pleasure.

This finding, on the other hand, contradicts the scores given to the ocean. Even though Ozi is located inland and distant from the ocean, the community identified more uses of the ocean and ranked these higher than Kipini, particularly for recreational activities, flood prevention and nutrient management. Since they rely heavily on the ocean for fishing, it was expected that residents of Kipini would place a higher value on the ocean than Ozi. While fishing is the most valuable provisioning service provided by the ocean for Kipini, Ozi placed a considerably greater value on the ocean in general (Fig. 4). Fishing is the most significant source of food for Kipini, followed by mangroves and other plants. Palm trees and mangroves were also valued for their ability to provide fishing gear. The Kipini community is dominated by fishermen (Fig. 3), suggesting that socioeconomic considerations could determine the emphasis given to certain ES. Ozi is more rural, with limited access to roads and no access to power or gas. As a result, the score for using mangroves and other trees for charcoal and fuel in Ozi (Fig. 5) is higher, as this is their only source of energy for cooking. Furthermore, Ozi places higher importance on the provisioning service of wild food, as its harvest supplements the farming activities taking place in this village.

These results support previous research by Daw *et al.* (2011) and Lapointe *et al.* (2019) that indicate that various groups of people benefit from ecosystems in different ways, which could be impacted by their activities, access and socioeconomic position. Most of the disparities in community perceptions of ES in the

Tana estuary may be explained by their position and availability to the supplying ecosystems, as well as the communities' socio-economic culture. These hypotheses, however, do not account for all the evidence, such as the importance of the ocean to riverine Ozi community members.

Conflicts can emerge when one community's use of the ES has a negative impact on the provision of ES to the other. The cutting of mangroves by the Ozi community, for example, could have an influence on the Kipini people's food security as mangroves are fish spawning grounds. Furthermore, provisioning and regulating service trade-offs are sometimes made at the price of regulating services. This puts all ES at risk, because regulatory services are frequently related to the long-term supply of cultural and provisioning services (Turkelboom *et al.*, 2015). The estuary's ecosystems are interrelated, and activities in one area of the estuary can have an impact on ecosystem functioning and ES provisioning in other regions. Unsustainable agricultural practices by Ozi farmers on the floodplains could result in increased nutrient introduction into the ocean, posing a threat to Kipini fishermen. At the same time, because the Ozi community derives many cultural and regulating ES from the ocean, this could impact them too. To manage such an interconnected system as the Tana estuary, it is critical to bring the two communities together as stakeholders to establish ways that can promote activities that ensure equitable sharing of the resources from the ecosystem (Turkelboom *et al.*, 2015). This study creates a platform for developing integrated management objectives for the region, considering trade-offs to minimize possible conflicts, by explaining the value of distinct ecosystems to the two most significant groups in the lower Tana estuary. The information can be used to develop governance frameworks for the estuary.

Because estuaries are located at the land-ocean interface, governance frameworks that explicitly handle this interaction while also encompassing land and ocean-based sources of pollution and degradation are required (Momanyi, 2016). Analyzing the distribution of ES, who benefits from terrestrial and coastal services, and which activities have negative effects on ES is a critical first step in building suitable governance frameworks for the area. Area or place-based management is critical, as is management based on integrated evaluations that incorporate several types of information (e.g., social, cultural, local, traditional, and scientific knowledge) (Haas *et al.*, 2021).

Conclusions

This study highlights how the resource users' perceptions of ES from the different LULC classes found in the Tana estuary varied by location of the respondent and the type of LULC, such as mangroves, floodplains, and ocean. These findings provide a baseline for the importance of the different LULC classes found in the Tana estuary, therefore, showing the need for consideration of different landscapes in resource use planning and the need for integrating the preferences of the different resource users. Similar perceptions about provisioning and regulating services among respondents can be leveraged to reinforce participatory management and governance of the Tana estuary. The study also provides a knowledge sharing forum for the different resource users on the importance of the different LULC classes hence fostering an understanding on the need to conserve these ecosystems. The findings can be applied to the implementation of estuary management plans, community-based natural resources management programmes and activities within the Tana estuary or other estuaries in the Western Indian Ocean region.

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