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Value chain analysis of mangrove forests in central Mozambique: Uses, stakeholders and income

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Abstract

This study aims at documenting the value chain derived from mangrove forests in selected sites in central Mozambique (Zambezi Delta, Nhangau and Chiveve River), through the identification of the services delivered by mangrove forests and assessment of stakeholder's engagement within the value chain. Furthermore, this work evaluates the income pathways as well as the current and potential benefits of different stakeholders and the socio-economic sustainability of mangroves in the three regions. Zambezi Delta is one of largest mangrove swamps in Africa and Chiveve is located in Beira City, impacted by Cyclone Idai in 2019. The main benefits obtained by the communities both in the Zambezi Delta and Nhangau were derived from commercially important wood extraction and honey production for domestic use. Within the Zambezi Delta, profit for small mangrove poles accrued at the wholesale level (82.6%), while that for large poles accrued to harvesters (125.0%), after a small initial direct investment. At Nhangau, small poles fetched profits of 17%, medium poles 11.5%, and large poles 24%; for charcoal, the greatest portion of profits went to retailers at 50%. Men were mostly involved in mangrove wood harvesting for commercial purposes, while women collected firewood mainly for domestic use. At the Chiveve, the community benefited predominantly from non-extractable services such as flooding control, water purification, nursery grounds for fisheries and aesthetic beauty. It is suggested that Mozambique mangrove forests are valued at USD 2 400 per hectare per year. This monetary accounting can be used to inform decision making on mangrove management and to improve the performance of the value chain and the wellbeing of local communities.

Keywords: mangrove products marketing, extractable goods, regulatory services, gender, Eastern Africa

Introduction

Ecological economic valuation is an effort to allocate quantitative values to the goods and services provided by natural ecosystems (Tuan, 2013) to illustrate the benefits of the extractable products that can be commercialized (Rosales *et al.*, 2017; Brander *et al.*, 2010). A value chain is the range of activities required to bring a product or service from production to final consumption (Lowitt *et al.*, 2015; Kaplinsky, 2000) and it

is useful for understanding the relationships among actors in a chain and considering the potential implications for development (Graef, 2014; USAID, 2012; Borinelli and Rocha, 2006; Kaplinsky and Morris, 2001).

Value chain analysis (VCA) includes a range of activities conducted from the material production, across actors or companies involved in the negotiation, processing, stocking, transportation and commercialization,

to the final consumer (Rosales *et al.*, 2017; Tuan, 2013, Brander *et al.*, 2010). VCA systematically maps the economic agents involved in the production, distribution, and sales of a particular product, assessing the characteristics of economic agents, profits and costs, goods flows throughout the chain, the destination and sales volumes (Rosales *et al.*, 2017; Njie, 2011).

For mangroves, the VCA is usually concentrated on extractable products (wood, firewood, charcoal and fisheries) (Tuan, 2013, Vegh *et al.*, 2014). This can include different actors, from harvesters (wood cutters, fisherman, firewood, clam and crab collectors), transporters, sellers and final consumers (Rosales *et al.*, 2017; Njie, 2011) and can be linked by a range of micro or small companies that involve wholesalers, middlemen, retailers, traders, input traders, suppliers and service providers (Zafar and Ahsan, 2006).

Studies on mangroves in Mozambique have focused on ecological parameters such as forest structure (Nicolau *et al.*, 2017; Paula *et al.*, 2014), changes in forest area (Shapiro *et al.*, 2015) and aspects of human impacts on mangrove forests (Stringer *et al.*, 2015; Bosire *et al.*, 2012; de Boer 2002). To date, studies on mangrove VCA in Mozambique are scarce or unknown, except for a recent preliminary valuation of marginal mangroves in the Maputo city area (Inácio, 2017).

This study documents the value chains derived from mangrove forests in central Mozambique with particular focus on the identification and characterization of services derived from mangrove forests in the Zambezi Delta, Nhangau and Chiveve River, as well as stakeholder engagement and their current and potential benefits within the value chain. Furthermore, this work documents the income of different stakeholders at various sites, and the socio-economic sustainability of mangroves utilization. The results can be used to inform the community, governance and management institutions, and policy makers for decision making on mangrove management.

Research Objectives

General objective

The overall objectives of this study were to: document the value chains associated with mangrove wood products in three locations in central Mozambique (Zambezi Delta, Nhangau and Chiveve River) by highlighting the extensive list of goods and services and patterns of use of products derived from mangrove ecosystems; analyse stakeholder involvement in the

mangrove value chain; evaluate economic pathways and profits gained from mangrove-associated businesses; and assess the socio-economic sustainability of mangrove exploitation in central Mozambique.

Specific Objectives

The specific objectives of the study were to: identify and compare extractable, regulating or climate-related services derived from mangrove forests in the Zambezi Delta, Nhangau and Chiveve River; describe and compare mangrove value chains and the stakeholders involved in mangrove exploitation in the Zambezi Delta and Nhangau; value economic pathways and the current and potential benefits and profits that local communities obtain from mangrove wood products in the Zambezi Delta and Nhangau; and conduct an analysis of the socio-economic sustainability of mangroves utilisation in central Mozambique.

Material and Methods

Study Area

This study was conducted in the Zambezi Delta, Nhangau and the Chiveve River in central Mozambique (Fig. 1). The climate in the area is tropical with a wet warmer season from October to March (peak in January and February), and a dry cooler season during the rest of the year. Annual precipitation varies from 600 to 1 500 mm (Macamo *et al.*, 2016a).

The central Mozambique region is characterised by a swampy coast, with approximately 24 rivers discharging into the Indian Ocean (Barbosa *et al.*, 2001), and most these have their sources in neighbouring countries to the west. The shallow inshore areas have beaches mostly made up of fine sediments or muds rich in organic matter (Macamo *et al.*, 2016a). Tidal range varies between 3.46 and 6.44 m. The most important mangrove formations in this section of the Mozambican coast are concentrated in the Púnguè and Búzi estuaries, and the Zambezi Delta (Macamo *et al.*, 2016b).

The Zambezi Delta forms the largest mangrove formation in Mozambique (Barbosa *et al.*, 2001). Recent studies conducted in the inner Zambezi Delta concluded that mangroves are increasing in coverage with a net gain of 3,723 ha (10%) over a 19 years period, from 33 311 to 37 034 ha (Shapiro *et al.* 2015).

The Chiveve River is a water course with special features that flows through Beira City downstream

of the confluence of the Púnguè and Búzi rivers. The Chiveve River divides the city almost in the middle, flanked by mangrove trees. This feature has both an ecological and aesthetic function. The river is dominated by salty or brackish water, getting most of its

Nhangau villagers have experienced the impacts of mangrove loss after years of unsustainable extraction of wood, and have been engaged in replantation and community-based management for the last 20 years.

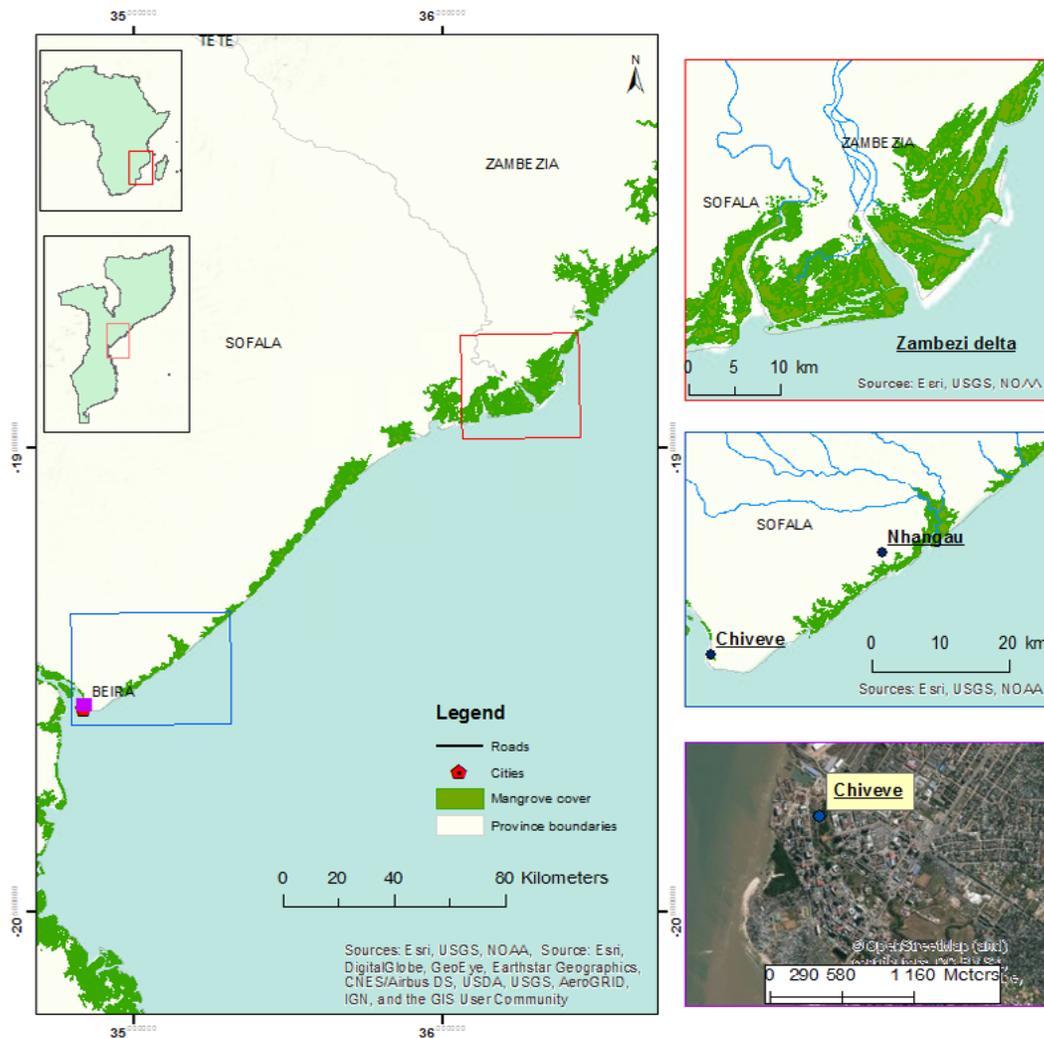


Figure 1. Study area showing the Zambezi Delta, Nhangau and Chiveve.

freshwater from upstream of Beira City (Uacane and Ombe, 2016). Beira, with a population of 533 825 inhabitants (INE, 2017), is the second largest city in Mozambique's lowland. It is located below sea level and prone to inundation from either high spring tides or storm waters (INGC, 2012). A small central section of the Chiveve River was dredged in 2015 by the local authorities to control storm water surges and avoid flooding of Beira City at high tides.

The Nhangau village is located approximately 30 km from Beira. Although being part of this municipality, Nhangau has strong rural characteristics.

Methodology

In order to understand the economic benefits derived from mangrove products, semi-structured interviews were developed and tested (Schaafsma *et al.*, 2017; ter Mors *et al.*, 2013). The questionnaires contained open-ended questions to allow the participants to give more detailed information and stimulate discussion on specific issues. The intentional sampling technique (Greenbaum, 1998; Finch and Lewis, 2003) was used for identification and selection of stakeholders for the interviews. The market price assessment technique (Schaafsma *et al.*, 2017; Mojiol *et al.* 2016; Adeyemi *et al.*, 2012) was also used to support the information given

by the respondents, as this technique helped to understand business practices and prices realised for mangrove wood products in the market.

Intentional sampling technique for selection of respondents

The intentional sampling technique (Greenbaum, 1998; Finch and Lewis, 2003) was used for the selection of stakeholders for the interview. The selection was based on nominations made by key informants that were interviewed at all sites (Zambezi Delta, Nhangau and Chiveve), and included local government personnel in the District Service of Economic Activities (SDAE), Provincial Directorate for Land, Environment and Rural Development (DPTADER), and local leaders.

Ecosystem services identification

Focus group discussions (FGDs) (ter Mors *et al.*, 2013) were conducted in the Zambezi Delta and Nhangau. In the Zambezi Delta a total of eight (8) communities were visited and 13 FGD were conducted, composed of 4 to 12 people per group and separated by gender (ter Mors *et al.*, 2013; Finch and Lewis, 2003; Greenbaum, 1998). A total of 91 participants were interviewed (20.9% women and 79.1% men). Individual interviews were conducted at Quelimane Town (northern arm of the Zambezi Delta and final destination for most wood products from the Delta), targeting mangrove product sellers in two different markets (Icídua and Janero markets), with the same approach being taken at the Chiveve River.

Two FGDs were conducted at Nhangau, one with 5 men and the other with 3 women, and 20 individual interviews were carried out with charcoal producers and wood cutters. Commercial mangrove cutting and charcoal production is prohibited in Mozambique, and law enforcement is greater at Nhangau. Bearing this in mind, the approach adopted facilitated the inclusion of these groups which otherwise were not willing to talk. Such apportioning of role players for the VCA follow related studies as observed in the literature (Rosales *et al.*, 2017; Tuan, 2013, Brander *et al.*, 2010; Zafar and Ahsan, 2006).

The people interviewed described the different services they extract from the mangrove forest. The three study sites were described and characterised based on site accessibility in order to help understand the willingness of the community to engage in mangrove marketing, assuming that location and means

of access would be some of the main reasons considered by potential users before becoming involved in mangrove-related businesses. Such analysis has been reported elsewhere (Vishwanathan *et al.*, 2011; Brander *et al.*, 2010; Sathirathai, 1998) and is highly relevant considering the remoteness of localities such as the Zambezi Delta which has virtually no road infrastructure and low population densities (Bandeira *et al.*, 2016b).

Mangrove value chains and stakeholders in the Zambezi Delta and Nhangau

In order to understand the role and different aspects involved in mangrove-related businesses the FGDs were separated by occupation (ter Mors *et al.*, 2013; Finch and Lewis, 2003; Greenbaum, 1998); for example, people who cut mangrove poles were grouped together. The other groups were composed of transporters, sellers, and those involved in all stages from harvesting to final selling. Each FGD focused on the aspects related to the activity that they were engaged in (USAID, 2012; Borinelli and Rocha, 2006; Kaplinsky and Morris, 2001). For example, for harvesters, questions such as how they choose the species, where they go to cut, how much money they spend and for how much they sell, were asked. Based on the responses given by the respondents a value chain map was designed (Rosales *et al.*, 2017; Tuan, 2013, Brander *et al.*, 2010; Zafar and Ahsan, 2006).

Economic benefits from mangrove forests in the Zambezi Delta and Nhangau

The market price method (Adeyemi *et al.*, 2012; Brander *et al.*, 2010; Spaninks and Beukering, 1997) was used to assess the value of each product, which was established through the exchange of goods and services in the market (Carson, 2012; Splash, 2007), and the interaction between the production value (supply) and the consuming value (demand) (Adeyemi *et al.*, 2012; Spaninks and van Beukering, 1997). The market price method estimates the economic value of ecosystem products or services that are bought and sold in commercial markets (Mojiol *et al.*, 2016; Carson, 2012; Splash, 2007) and can be used to assess value changes in quantity or quality of a good or service (Adeyemi *et al.*, 2012; Borinelli and Rocha, 2006). Through the market price and data from the interviews (Rosales *et al.*, 2017; Tuan, 2013) it was possible to calculate the income generated from mangrove wood products (Bandeira *et al.*, 2016a; Bandeira *et al.*, 2016b; Macamo *et al.*, 2016b) in central Mozambique.

The income generated from mangroves was deducted from the profit that is obtained in the marketing process, which was calculated using the following formula:

$$\text{Profit} = \text{Net income} / \text{Total cost}$$

where Net income is the difference between the production value (received price * quantity) and the Total cost (includes all the necessary expenses), and includes the taxes that are paid.

Other formulas used in the process of income calculation are described below:

$$\text{Production value} = \text{Received price} * \text{Quantity}$$

$$\text{Net income} = \text{Production value} - \text{Total cost}$$

$$\text{Cost/Benefit Ratio} = \text{Total cost} / \text{Production value}$$

Quantity of poles and small poles are measured in units; fishing products in kg, and charcoal in bags.

Results

Services delivered by mangrove forests

Based on the respondents the services provided by mangrove forests in central Mozambique were divided into:

•*Direct uses (extractable wood products)* – firewood and charcoal, used for domestic consumption and poles (for house and boat construction, production of

various domestic utensils, fishing traps and gear, and beehives), for either domestic or business; non-woody forest products included tree leaves used as animal fodder, honey extraction, and *Xylocarpus grannatum* is used for medicine, especially at Nhangau.

•*Indirect uses (non-extractable products)* – such as ecological services provided by mangroves as coastal protection against erosion and buffering of climatic events such as floods, as nursery areas for fauna, feeding grounds and habitat for many vertebrate and invertebrate species, biofiltering and water quality control, and carbon sequestration.

In the Zambezi Delta and Nhangau the community mentioned benefitting from both extractable wood products and non-extractable products. At the Chiveve, the communities primarily benefit from non-extractable services such their regulatory value and climate change buffering; marketing of mangrove products was negligible. Therefore, open interviews were conducted with key informants with questions being related to how the community benefit from the mangroves along the creek.

Mangrove benefits varied across the three sites as shown in Table 1.

Extractable use of mangrove products was found only in the Zambezi Delta and Nhangau. Non-extractable

Table 1. Services derived from mangrove forests in the Zambezi Delta, Nhangau and Chiveve.

Services	Uses	Location		
		Zambezi Delta	Nhangau	Chiveve
Non-extractable	Coastal protection	✓	✓	✓
	Tide flooding control			✓
	Flood control		✓	✓
	Water purification	✓	✓	✓
	Landscape beauty		✓	✓
	Cultural and recreation assets		✓	✓
	Nursery ground for fisheries	✓	✓	✓
	Fishery ground	✓	✓	✓
	Extractable	Fuelwood	✓	✓
Charcoal production		✓	✓	
Wood harvesting		✓	✓	
Furniture		✓		
Manufacture of canoes		✓		
Honey Medicinal use		✓	✓	✓

uses were found in all the three sites, especially Chiveve, where these uses were the most important benefit that the community obtain from mangroves. As the mangroves in Chiveve are in the centre of Beira City (which is below sea level), they have an important role in mitigation of climate-related events, storm surges and flooding control. The Chiveve area was recently identified as a centre for development of cultural and recreation assets, environmental education and ecotourism. Due to the vulnerable nature of Beira City, alternatives to mitigate the impacts of extreme events such Cyclone Idai in 2019, the largest to hit the southern hemisphere in living memory, have again become a priority.

The three selected areas were categorized according to their characteristics (see Table 2). Willingness of community members to embark on mangrove commercialization was related to accessibility/inaccessibility to the sites. The Zambezi Delta and Nhangau are both rural areas, although with some differences. The Zambezi Delta is very remote and difficult to access, whereas Nhangau is rural but near and influenced by Beira City. Chiveve River is an urban area located within Beira.

Accessibility is roughly ranked according to six categories: proximity to a regional capital, population centre, existence of transport, road infrastructure, and access to water and electricity for each of the sites. Accessibility (or access) refers to the ease of reaching goods, services, activities and destinations, which together are

called opportunities. It can be defined as the potential for interaction and exchange (Litman, 2018).

The areas were categorized into rural or urban based on the location or proximity to larger towns or municipalities. Accessibility is therefore a measure of how easy is for the community members to access the forest, which is dependent on, for example, how far it is from the community households, what transportation means they use etc. (see Table 3 below).

Species mostly harvested for wood extraction in the Zambezi Delta and Nhangau

According to key informants as well as the FGD participants, a large part of the population was engaged in mangrove harvesting, agriculture and fishing as their main activities for income generation. Although nine species of mangroves occur in Mozambique, *Avicennia marina*, *Bruguiera gymnorhiza*, *Ceriops tagal*, *Heritiera littoralis*, *Lumnitzera racemosa*, *Rhizophora mucronata*, *Sonneratia alba*, *Xylocarpus grannatum* and *Xylocarpus mulloensis*, the species chosen for harvesting varies according to the locality (see Fig. 2 below).

According to the interviewees only five mangrove species are commonly used in the Zambezi Delta with *A. marina* and *C. tagal* being most used due to their availability, followed by *X. grannatum*, *S. alba* and *R. mucronata* (see Fig. 2).

Six of the nine mangrove species that occur in the country are found at Nhangau (*A. marina*, *C. tagal*,

Table 2. Characteristics of the mangrove forests in the selected areas.

Location	Zambezi Delta	Nhangau	Chiveve River
	Rural	Rural	Urban
Accessibility to the community	Very remote area, difficult to access	Accessible	Accessible
Species composition	All the WIO nine species present	<i>A. marina</i> , <i>C. tagal</i> , <i>B. gymnorhiza</i> , <i>R. mucronata</i> , <i>S. alba</i> and <i>X. grannatum</i>	<i>A. marina</i> , <i>C. tagal</i> and <i>R. mucronata</i>
Forest trends	Increasing (see Shapiro <i>et al.</i> , 2015)	Degraded in the past. With replantation program	1/3 rd of the forest degraded. Replantation program
Main Impacts	Localized erosion, also sand accretion	Human impact – deforestation for timber extraction and charcoal production	Dredged for flood control and urban planning

Table 3. Categorization of accessibility to the study areas.

Local	Proximity to a region capital city	Proximity a to population centres	Transport	Roads	Water roads	Electricity
Zambezi Delta	1	2	1	1	2	2
Nhangau	3	4	3	3	3	4
Chiveve	5	5	5	5	3	5

¹ worst | ² below average | ³ average | ⁴ good | ⁵ very good

B. gymnorhiza, *R. mucronata*, *S. alba* and *X. grannatum*), but only four are commonly harvested in the area. *C. tagal* and *R. mucronata* are the species most commonly used followed by *A. marina* and *B. gymnorhiza* (see Fig. 2).

Use of the mangrove species by gender in the Zambezi Delta and Nhangau

In general, both men and women are involved in mangrove product use in the Zambezi Delta (Table 4), however the main products harvested vary according to gender. Because women are responsible for feeding the family, they are mostly involved in the collection of subsistence products such as firewood and small crustaceans. Men are more involved in the collection of products that will provide some cash income such as wood, poles with a larger diameter, poles with a smaller diameter commonly referred to as *laca-laca*, fish, prawns and honey. Charcoal production is mostly carried out by men, however charcoal selling involved both men and woman; nearly 50% each amongst the interviewed groups.

At Nhangau the community benefit from direct and indirect uses of mangrove products, from different types of poles from various wood sources, charcoal, to different fisheries products as well as from coastal protection, tidal flood control, nurseries for various fauna, and fishing grounds. The FGD participants reported the following main impacts of mangrove loss: drastic reduction of fisheries resources; reduction in the availability of woody resources, such as poles for house construction and charcoal production; coastal erosion; strong winds that destroyed houses, given the absence of sheltering mangroves; and heat weaves.

The different uses reported by men and women in the Zambezi Delta and Nhangau are outlined in Table 4.

In the Zambezi Delta the FGD participants mentioned that all species are used for building houses and *X. grannatum* is the only multipurpose species, used for all categories mentioned. At Nhangau the key uses mentioned were fuelwood (only by women), charcoal production, construction and furniture production (by men).

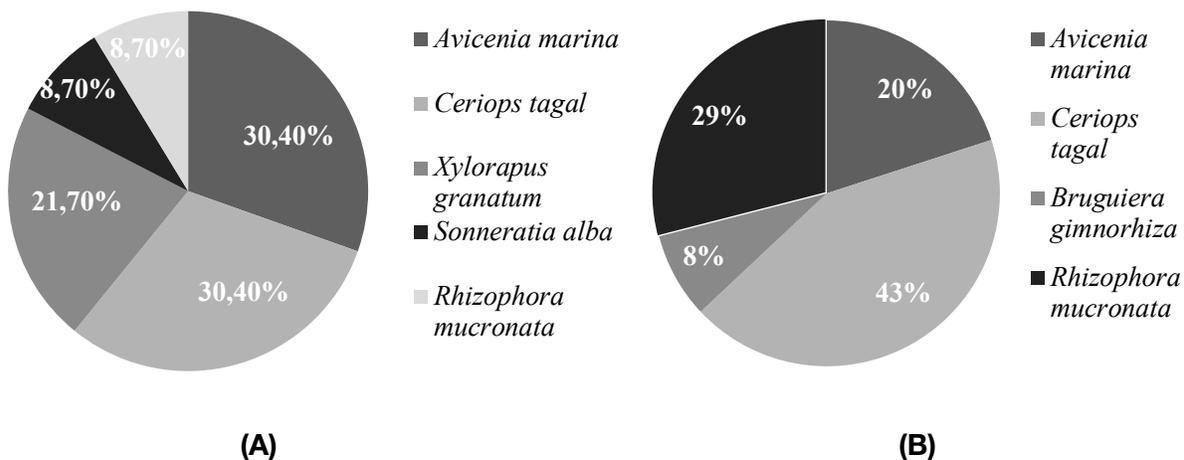


Figure 2. Mangrove species harvested in the Zambezi Delta (A) and Nhangau (B).

Table 4. Main uses of the mangrove species by gender in the Zambezi Delta and Nhangau.

Species	Zambezi Delta										Nhangau									
	Local Names	End Uses					Local Names	End Uses												
		Fuelwood	Charcoal Production		Construction	Furniture		Manufacture of canoes	Fuelwood	Charcoal Production		Construction	Furniture	Medicine						
			W	M						M	W				M	M	W	M	M/W	
<i>Avicennia marina</i>	Muvede	✓	✓	✓	✓	-	Mpedge	✓	✓	✓	-	-	-	-	-					
<i>Bruguiera gymnorhiza</i>							Mutalatala	-	✓	✓	✓	✓	-	-	-					
<i>Ceriops tagal</i>	Mucandara	✓	-	✓	-	-	Mucandala	-	-	✓	-	-	-	-	-					
<i>Rhizophora mucronata</i>	Murubulo	-	-	✓	-	-	Mugorongo	-	-	✓	-	✓	-	-	-					
<i>Sonneratia alba</i>	Mpia	✓	-	-	✓	-		✓	-	✓	✓	-	-	-	-					
<i>Xylocarpus graminatum</i>	Nhantazira	✓	✓	-	✓	✓	Nhantazira	-	-	-	-	✓	-	-	✓					

Use of mangroves in the Chiveve River

The mangroves at the Chiveve River (Beira City) provided a number of important non-extractable benefits to Beira City such as storm water surge flood control, tidal flooding control, water purification, aesthetic beauty, cultural and recreation assets, nursery grounds for fisheries and urban planning.

Parts of Beira City are located below sea level and are prone to inundation from either high spring tides or storm water. The Chiveve River had recently silted up reducing it to a narrow mangrove creek passage. The river was dredged in 2015 by the local authorities to make a central channel to control storm water surges and to avoid flooding at high tides. This project was welcomed by local communities given the very positive impact expected to the town. After the dredging process, mangrove seedlings were cultivated and replanted along the river. Natural regeneration was also observed to be very successful and extensive. The respondents rated the three most important benefits to their wellbeing as flood control, tidal flooding control, and water purification.

The fact that Chiveve River was dredged and restored proved to be crucial for rainwater runoff after Cyclone Idai in 2019, and is a good example of how Nature based Solutions (NbS) can be used to mitigate the impacts of extreme events and climate change, and contribute to The United Nations Sustainable Development Goals 11, 13 and 14.

Mangrove value chains and stakeholders of the Zambezi Delta and Nhangau

Based on nominations made by key informants, four groups of actors were identified within the Zambezi Delta value chain: harvesters, transporters, sellers and general users (those involved in all stages of the mangrove products value chain). Three groups of actors were identified at Nhangau, namely: harvesters, charcoal producers, and sellers.

The mangrove value chain was analysed for the Zambezi Delta and Nhangau, where different routes were followed by the mangrove wood products.

In the Zambezi Delta mangrove business activities are focused in Quelimane Town, located at the northernmost arm of the Delta, where the products that come from remote areas like Chinde (inner Delta arm) and are taken to be sold.

Quelimane Town is the last stop in the chain for mangrove products, and people travel long distances to buy and sell these products here. *A. marina* and *C. tagal* dominate the mangrove markets, and those interviewed rated *C. tagal* as the most preferred species due to the quality and strength of the wood. *S. alba*, *R. mucronata* and *X. grannatum* can also be found in the markets, but in lower quantities.

Depending on the route followed by mangrove products from harvesters to consumers, various actors are involved. These include transporters, wholesalers, retailers, and sometimes middlemen (see Fig. 3). The products are transported either by boat (most common in the Zambezi Delta), bicycle (common in Nhangau), motor vehicle, or by foot.

The first route for mangrove products identified was directly from harvesters to consumers, where the harvester takes the mangrove products directly to the consumer with the products transported by foot, mainly by the harvester himself.

The second route was from harvester to a primary buyer, then to secondary buyer, and finally to the consumer where both wholesaler and retailer markets are involved. The third route was from harvester to wholesaler, to retail seller and then to consumer. In the second and third routes there might be a transporter that

takes the products from the harvesters to the wholesaler (mostly by boat). This is the most complex option where sometimes middlemen link the harvesters to the wholesaler and the latter to the retailer (Fig. 3 - A).

Wood products (wood, poles and *laca-laca*) are usually stored in the courtyard of the place of sale, organized by type and size of product and species. In the Zambezi Delta, due to limited accessibility, there were few transport options for mangrove products from the production site to the marketplace. The middleman or wholesaler/retailer generally took responsibility for this. The most common means of transport observed was *bago* (slow moving wooden boat powered by an outboard engine), canoes which are manually operated, as well as by foot. In Nhangau the routes were similar to those in the Zambezi Delta (Fig. 3), although government authorities were also involved in providing technical assistance. The most common route followed by the products was from harvester to the consumer, where the harvester collects the poles (small and medium size) and sells directly to the final consumer. The charcoal value chain involves more stakeholders in the marketing process, and other routes were observed, where there might be a transporter that takes the products from the harvesters to the wholesaler (mostly by bicycle), with a middleman sometimes linking the harvester to the wholesaler, and the latter to the retailer (Fig. 3 - B).

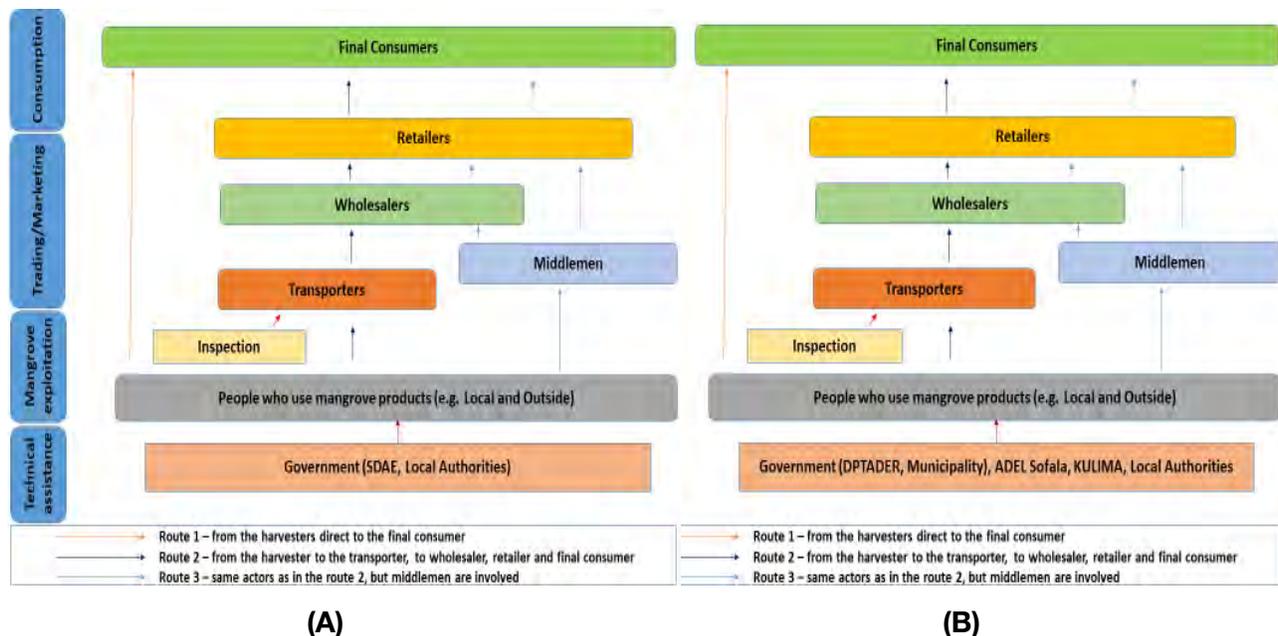


Figure 3. The value chain structure of mangrove products in the Zambezi Delta (A), where the Government is represented by SDAE (Distrital Services for Economic Activities) and Nhangau (B) where the Government is represented by DPTADER (Provincial Directorate for Land Environment and Rural Development) and the relationship between actors.

Economic benefits from mangrove forests in the Zambezi Delta and Nhangau

In the Zambezi Delta the commercialization of mangrove products plays a major role in local economies. Building materials made of large poles and *laca-laca* (small poles), charcoal, fish and prawns are all commercialized mangrove products. The price of poles varies significantly along the value chain and markets. Within the Delta the price of poles received by harvesters varies between 10 Mts (USD 0.15) to 30 Mts (USD 0.44) when sold in the local market or external market, respectively. When the poles get to Quelimane (distant external market) they are sold at two times the original price, at 60 to 75 Mts (USD 0.89 – USD 1.11).

In Nhangau, building materials such as large poles and *laca-laca*, charcoal and honey are commercialized, mostly by men. The price of mangrove wood products varies significantly along the value chain depending on the market where the product is sold. For instance, the price of poles, medium poles and small poles received by harvesters is 50 Mts (USD 0.74), 25 Mts (USD 0.37), and 15 Mts (USD 0.22), respectively.

Table 5 shows estimates of the distribution of incomes along the value chain in the Zambezi Delta and Nhangau.

Quantities of large poles collected on each occasion vary from 30 to 50 units per person while the number of small poles (*laca-laca*) harvested ranged from 50 to 75 units per person. All the FGD participants within women’s groups stated that they collect firewood for their consumption.

In the Zambezi Delta charcoal is produced and sold locally. Both men and women are involved in charcoal production; however, the quantities produced vary between them (as detailed in Table 3). Table 5 shows that in the Zambezi Delta income and profits from mangrove wood extraction vary according to the product extracted. For small poles (*laca-laca*), the income is higher at wholesaler level with 82.6% of profit accruing to them. However, for the larger poles, a greater portion of profit goes to harvesters who benefit from a share of the 125% profit. At Nhangau profits from *laca-laca* were 17%, 11.5% for medium poles, and 24% for larger poles, all accruing to the harvester. However, with charcoal, a greater portion of profits went to retailers with a share of 50%. For honey production the producer accrued 47% of profit.

Table 5. Estimated distribution of income along the mangrove products value chain in the Zambezi Delta and Nhangau. 1 USD = 67.27 Met-cais (Mozambican currency).

Item	Zambezi Delta						Nhangau						
	Poles		Small Poles		Charcoal		Poles		Medium Small poles		Charcoal		
	Harvester	Wholesaler	Harvester	Wholesaler	Retailer	Producer	Harvesters	Harvesters	Harvesters	Harvesters	Harvesters	Wholesaler	Retailer
Received Price (Mt)	30	60	75	75	45	130	50	25	15	200	250	850	
Quantity ¹	75	75	120	120	120	20	50	50	120	10	3	3	
Total cost (Mt)	1000	2675	4700	4700	4400	1400	100	100	100	100	50	50	
Production value ² (Mt)	2250	4500	5625	5625	5400	2600	2500	1250	1800	2000	750	2550	
Net income ³ (Mt)	1250	1825	925	925	1840	1200	2400	1150	1700	1900	700	2500	
Cost/Benefit ⁴ (%)	44.4	59.4	83.6	83.3	81.5	53.8	0.04	0.08	0.06	0.05	0.07	0.02	
Profit ⁵ (%)	125	68.2	19.7	20	22.7	85.7	24	11.5	17	19	14	50	

The unit used for poles and small poles is numeric, and bags for charcoal | ² Production value = Received price*Quantity | ³ Net income=Production value-Total cost
⁴ Cost/Benefit Ratio= Total cost/Production Value | ⁵ Profit=Net income/Total cost

Discussion

Mangrove ecosystems are widely used in Eastern Africa (Bosire *et al.*, 2016a) and represent a critical and irreplaceable habitat for coastal communities (UNEP, 2014; Giri *et al.*, 2011). It is estimated that over 150,000 people in Rufiji Delta (Tanzania) alone earn their living directly from mangrove resources (Mangora *et al.*, 2016), which are widely used for firewood, building material (Mainoya *et al.*, 1986), medicine (Mangora *et al.*, 2016), tannin extraction from Rhizophoraceae species (Gupta and Roy, 2012), nursery grounds for fisheries (Masalu, 2003; McNally *et al.*, 2011), and honey production (Karengi, 2012).

Hoegh-Guldberg *et al.* (2015) rated mangroves as providing ecosystem services valued at USD 57,000 per ha/year in South – East Asian mangroves. In Mozambique it is estimated that mangroves contain 500 – 2000 poles per hectare (Bandeira and Paula, 2014; Paula *et al.*, 2014, Bandeira *et al.*, 2009, Nicolau *et al.*, 2017, Macamo *et al.*, 2018) and this study estimates that one mangrove pole is sold for 1 – 1.2 USD. Based on this assumption it is anticipated mangrove poles in Mozambique have a minimum value of USD 2 400 per hectare, excluding other wood and non-wood products, such as fisheries.

The Zambezi Delta harbours one of the largest mangrove forests in Africa, spanning some 200 km of coastline (Barbosa *et al.*, 2001). If exploited, it has been estimated that the inner Delta area of 37034 ha would yield both direct (timber, poles, firewood and charcoal) and indirect (regulating and climatic function) use value of USD 2 772 per ha/year (WWF, 2017). This amount is similar to that estimated in this study of USD 2 400 ha/year, however it may not be realistic to calculate the potential of harvesting the entire mangrove forest given the remoteness of the area which lacks road/transport infrastructure, has a low demand for mangrove products and low population densities.

At the Chiveve River non-extractable uses are predominant, as acknowledged by the community, through the ecological benefits of the river such as in flood control. The river runs through the city for around 3 km and plays a key role in reducing the impacts of floods and protecting the city infrastructure (e.g. buildings, roads), a function of particular importance in a city like Beira which, with an altitude below sea level, is rated as highly vulnerable to sea level rise and floods (INGC, 2012). In this context, the river was dredged in 2015 since silting was negatively

affecting the delivery of this function. During the recent Cyclone Idai in 2019, the Chiveve River and other constructed drainage systems helped the city by buffering floods and storm water, protecting people and infrastructure (Charrua *et al.*, 2020). Cyclone Idai was one of largest to hit the southern hemisphere and left a trail of massive destruction and over 1000 dead in several southern African countries (Devi, 2019).

Additionally, the community confirmed that they did not extract wood products within the Chiveve River because the forest is relatively under-developed in terms of size, structure of the plants as well as species composition. Other well-developed mangrove forests near Beira (such as Nhangau) produce wood products with market value. These results are supported by a previous study by Uacane and Ombe (2016) in the same area, and in Kenya by Kairo *et al.* (2009) and Bosire *et al.* (2016b), who also reported valuable non-extractable uses in Gazi Bay. In this area, mangroves were found to be valuable assets for the purpose of ecotourism and recreation. Tourism around mangrove ecosystems is an area with great potential for development in Mozambique, and it can also be paired with conservation objectives, while providing livelihoods for communities.

The Nhangau area has a history of intensive, non-sustainable exploitation of mangrove woody resources dating back to the 1990s when former soldiers were demobilized (after the civil war ended in 1991) and had to rely on mangroves for livelihoods. A large part of the population engaged in mangrove harvesting resulting in uncontrolled exploitation that led to rapid deforestation and degradation of the mangroves, with social and ecological impacts. This community is now engaged in mangrove rehabilitation (Bandeira *et al.*, 2016a), but financial constraints are hindering the implementation of other management measures. Exploring mangrove tourism or financial compensation for other mangrove-related environmental services could provide alternative income to support conservation and management activities.

This study mapped the value chain for mangrove wood products in central Mozambique; commonly carried out to analyse the value of a resource (Brander *et al.*, 2010; Rosales *et al.*, 2017). These studies usually map the routes followed by a particular resource until the final consumer (Lowitt *et al.*, 2015; Kaplinsky, 2000). Studying the chain may show why pressure on natural resources can lead to degradation (Macamo

et al., 2018; Macamo *et al.*, 2016a) and unsustainable exploitation (Masalu, 2003), and can show how the “values” attached to each part of the chain are distributed (Thyresson *et al.*, 2013; Zafar and Ahsan, 2006; Sathirathai, 1998). Similar studies in different locations such as Asia (Hoegh-Guldberg *et al.* 2015, Tuan, 2013), Kenya (Huxham *et al.*, 2015) and Gambia (Njie, 2011) showed that natural resources such as mangroves can have a value chain at local level (O’Neill and Crona, 2017; Kaplinsky, 2000) as well as provide potential for regional international marketing (Crona *et al.*, 2016; Purcell *et al.*, 2017).

In the Zambezi Delta three routes were present, and when the route is more complex, such as where middlemen are involved, the product reaches as far as Quelimane Town (northern part of the Delta) where formal markets for mangrove products are well established. In Nhangau charcoal is the product that involves most stakeholders in the marketing process, and this explains how this product reaches formal markets such as in Beira City. Usually the longer chains are related to products with higher demand, and under higher exploitation pressure. These products also tend to be more expensive at the final destination.

In the Zambezi Delta and Nhangau a greater portion of profits went to the harvesters because they invest very little besides time into the activity, and obtain money by selling the products. However, this scenario can be controversial because the harvester receives the least income in the chain, with the price increasing by more than 100% in the next level (wholesale or retail). A pole that costs 30 Mts (USD 0.44) at the harvester level costs 60 Mts (USD 0.89) at the wholesale level, and the wholesaler usually obtains products from more than one harvester. For charcoal, a greater portion of profits went to retailers. This can be explained by the fact that the retailer buys the charcoal in bulk and has the option of selling bags individually or in small lots. In this scenario a bag of charcoal that initially costs 200 Mts (USD 2.96) at the harvester level, increases to 850 Mts (USD 12.57) at the retailer level.

Studies document that the income distribution (Kaplinsky and Morris, 2001; Kaplinsky, 2000) along the value chain is usually unequal (Wamukota *et al.*, 2004). The profits are widely different for different actors (Rosales *et al.*, 2017) contributing in the willingness of people to engage in mangrove marketing (UNEP, 2014; Vegh *et al.*, 2014) and in various parts of the complex value chain (Lowitt *et al.*, 2015; Adeyemi *et al.*, 2012).

As observed in the study areas, women benefit least monetarily from mangrove wood products (Kaplinsky, 2000; Kaplinsky and Morris, 2001; Adeyemi *et al.*, 2012). Both in the Zambezi Delta and Nhangau, women are mostly involved in fuelwood harvesting, and this activity is mainly for personal domestic use. Although the women do not harvest firewood for commercial purposes they benefit from the existing value (Brander *et al.*, 2010) were the money that could be spent to buy firewood is kept and used for another purpose in the household. In Quelimane Town, a few cases were found of women being engaged in commercial activities around mangrove wood products at the retail level in formal markets. This included a particular case of one woman well-known for doing a “*man’s job*” by selling mangrove wood products.

The information regarding distribution of income according to gender can be important for decision making when targeting the issue of gender equity in the distribution of economic resources, as well as the empowerment of women around the use of natural resources. This is a global discussion, and is captured in Sustainable Development Goal 5 that focuses on the empowerment of women and gender equity in the use of natural resources. At a national level, Mozambican law is being developed taking the empowerment of women into consideration.

Mangrove ecosystems were initially perceived as wastelands (Kathiresan and Bingham, 2001), but in recent decades studies on mangrove forests (FAO, 2007; Giri *et al.*, 2011) have shown that they play an important role in providing a myriad of ecosystem goods and services (Donato *et al.*, 2011; Taylor *et al.*, 2003; Walters *et al.*, 2008), and contribute significantly to incomes (Lowitt *et al.*, 2015; Kaplinsky, 2000; Sathirathai, 1998).

Valuation of mangroves may encompass concepts such as Payment for Ecosystem Services (Engel *et al.*, 2008; Brander *et al.*, 2010; Taylor *et al.*, 2003) and global capital schemes known as REDD+ (Donato *et al.*, 2011; UNEP, 2014); such market schemes play an important role in conservation of biodiversity and maintenance of mangroves ecosystem services (Lee *et al.*, 2014; Engel *et al.*, 2008; Adeel and Pomeroy, 2002). Recent studies have used monetary valuation for environmental decision making for ecosystem management (Schaafsma *et al.*, 2017) and for design of policies for Payment for Ecosystem Services or

other pricing mechanisms (Bouma and Van Beukering, 2015). The use of these tools has been criticized widely because of a lack of appropriate survey design (Kallis *et al.*, 2013; Splash, 2007) and according to some researchers can be improved (Carson, 2012; Loomis, 2011, Vossler and Watson, 2013).

Management of mangrove forests is essential as there is evidence of mangrove depletion in Mozambique (Macamo *et al.*, 2016b; de Boer, 2002). The current study provides information on the importance of mangrove products to the community (Kathiresan and Bingham, 2001; Cohen *et al.*, 2013; UNEP, 2014) and the people involved in their exploitation (Walters *et al.*, 2008; Taylor *et al.*, 2003), and can be used for better management of the resource (Lee *et al.*, 2014; Chevallier, 2013; Kairo *et al.*, 2009; Adeel and Pomeroy, 2002). This information can also be used to identify ways to improve the performance of value chains and the wellbeing of participants in the chain (Kaplinksky and Morris, 2001; Kaplinksky, 2000).

Mangrove sustainability in Chiveve/Beira City, where regulatory and climate value is dominant, will rely on active stakeholder engagement and sensitization. Furthermore, future studies need to attempt to identify and calculate the value of assets and infrastructure saved from destruction during extreme climate events such as in Beira during Cyclone Idai. Many studies have involved concerted public awareness (e.g. for Beira, those mediated by Beira Municipality, Government, NGOs, communities and research institutions), participation and engagement (Mojiol *et al.*, 2016; Olaleye and Omokhua, 2012) on best practices for mangrove protection and management as a way forward. This was also evident in the mega delta of Myanmar after a climate event in 2008 (Aung *et al.*, 2013). Mangrove harvesting management as observed in other parts of eastern Africa (Bosire *et al.*, 2016b; Lowitt *et al.*, 2015, Adeel and Pomeroy, 2002), coupled with strong community participation, is desirable for areas where direct wood extraction occurs, such as in the Zambezi Delta and Nhangau (Hulusjo, 2013; Tuan, 2013; Sathirathai, 1998). Furthermore, given the relatively successful mangrove restoration efforts in Nhangau (Macamo *et al.*, 2018), a REDD+ payment for ecosystem services initiative, as has been implemented in Gazi Bay, Kenya (Bosire *et al.* (2016b; Kairo *et al.*, 2009), could be considered. This would require appropriate science and community issues to be properly addressed (Lopes and Videira, 2019). Global processes, especially those around achieving

Sustainable Development Goal 14, offer opportunities for mainstreaming mangrove management and conservation with direct collaboration of key actors, including communities. The recent approval of the Mozambique Mangrove Management Strategy (2020-2024) represents an added opportunity for mainstreaming mangrove sustainability, and to emulate success stories from elsewhere in the WIO (Bosire *et al.*, 2016b; Kairo *et al.*, 2009) and in places such as the Philippines (Pulhin *et al.*, 2017) and the Indian sub-continent (Iftekhhar, 2008)

Conclusion

This study highlighted the value chain associated with mangrove forests in central Mozambique, eastern Africa. Extractable use value was documented for the Zambezi Delta and Nhangau, focusing on timber for poles and charcoal production. The non-extractable value of mangroves is vital for Chiveve, which is located in low-lying Beira City, the second largest city in Mozambique, and highlights the role of mangroves in flood and storm water control, and also for carbon sequestration and as nursery grounds for fisheries, water purification, urban landscaping and as a space for cultural and recreation activities. Value chains are described, with the impacts of different locations and stakeholder involvement (harvesters, transporters, wholesalers, retailers and middlemen) on price, revenues and distribution of incomes clarified.

These results showed that goods and services provided by mangroves in Mozambique are important for the community, who benefit both directly and indirectly. This study estimated a minimum conservative mangrove value of USD 2 400 per ha/year. Such calculations of the economic value of ecosystem goods and services is increasingly being recognized as a necessary metric for integrated environmental decision-making towards mangrove sustainability and conservation.

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