The declining significance of seagrass-associated invertebrate gleaning for providing food security in Kaole, Tanzania

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Abstract:
This thesis applies the food security concept to assess the significance of seagrass-associated invertebrate gleaning for providing food security in Kaole, Tanzania. It assesses the availability, accessibility, utilisation and stability over time of this food source. To explore this, a multi-strategy research design was used. Structured interviews were held with 30 gleaning women in Kaole, using a self-developed questionnaire designed to address the four components of the food security framework. Two focus group discussions were thereafter held to explore how local ecosystem services, in particular seagrass meadows, and their food provisioning services have developed over time. The findings show that a great majority of the women who engage in seagrass-associated gleaning in Kaole rate this activity as important or very important for providing food to the household. The seagrass-associated gleaning activities were perceived as important, despite the fact that most women also glean in the mangrove area and that almost all women have alternative incomes. However, seen from a strict food security perspective, it is questionable how significant this activity currently is for food security. The study found that availability has decreased and it is not a food source that is stable throughout the year. The findings also suggest that the mangrove-associated Terebralia palustris may be easier to utilise, considering that you can store it in a sack, without being kept cold. If mangrove related gleaning hence seems to play an increasingly important role in local food security, and is a fishery that is available in all seasons, this area is less accessible to potential gleaners with small children, elderly and people with physical disabilities. The study also found that the decline in seagrass-associated gleaning activities have coincided with a number of human stressors and deteriorating seagrass meadows. Despite its’ declining significance for food security, most women rate the seagrass-associated gleaning as important and want to protect this food source. Action should therefore be taken to sustainably preserve this provisioning resource. Bearing in mind the fine balance between ecological and food security needs, such measures need to be interdisciplinary. It also needs to involve different community members, as well as other stakeholders. More research would be needed to determine the nutritional content and potential toxic contents in the most fished invertebrate species.

Keywords: Sustainable Development, food security, seagrass, small-scale fishery, invertebrates, Tanzania

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Summary:

This thesis explores the significance of seagrass-associated invertebrate gleaning for providing food security in Kaole, Tanzania. Food security exists when all people, at all times, have access to sufficient, safe and nutritious food. In poor rural settings in so called developing countries, surrounding nature can play an important role in providing food security to local people. One example is provisioning marine ecosystems, in this case seagrass meadows, which may provide seafood to poor coastal communities, for whom alternative protein sources may be scarce. Marine invertebrates are one type of seafood that may be collected, or gleaned, in intertidal areas, when waters are low and the animals can be easily accessed by foot. This thesis explores the significance of this type of fishery for providing food security in Kaole village in Tanzania.

The study applied several methods involving structured interviews with 30 gleaning women in Kaole, using a self-developed questionnaire designed to address the different aspects of food security. Two focus group discussions were thereafter held to explore how local ecosystem services, in particular seagrass meadows, and their food provisioning services have developed over time. The findings show that a great majority of the women that engage in seagrass-associated gleaning in Kaole rate this activity as important or very important for providing food to the household. The seagrass-associated gleaning activities were perceived as important, despite the fact that most women also glean in the mangrove area and that almost all women have alternative incomes. However, seen from a strict food security perspective, it is questionable how significant this activity currently is for food security. The study found that availability has decreased and it is not a food source that is stable throughout the year. The findings also suggest that the mangrove-associated Terebralia palustris may be easier to utilise, considering that you can store it in a sack, without being kept cold. If mangrove related gleaning hence seems to play an increasingly important role in local food security, and is a fishery that is available in all seasons, this area is less accessible to potential gleaners with small children, elderly and people with physical disabilities. The study also found that the decline in seagrass-associated gleaning activities have coincided with a number of human stressors and deteriorating seagrass meadows. Despite its’ declining significance for food security, most women rate the seagrass-associated gleaning as important and want to protect this food source. Action should therefore be taken to sustainably preserve this provisioning resource. Bearing in mind the fine balance between ecological and food security needs, such measures need to be interdisciplinary. It also needs to involve different community members, as well as other stakeholders. More research would be needed to determine the nutritional content and potential toxic contents in the most fished invertebrate species.

Keywords: Sustainable Development, food security, seagrass, small-scale fishery, invertebrates, Tanzania

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Glossary/list of abbreviations

FAO  Food and Agriculture Organization of the United Nations
IPSN  Indo-Pacific Seagrass Network
MPA  Marine Protection Area
TZS  Tanzanian Shilling
1. Introduction

With climate change, increasing human pressure on natural resources and a global population estimated to hit nearly 10 billion by 2050 (UN DESA, 2017) there are growing concerns and research on how to provide future food security (Godfray et al., 2010; Springmann et al., 2018; Willett et al., 2019). Food production is not only dependent on high biodiversity and well-functioning ecosystem services, but is also a significant driver behind the loss of these natural services (Poppy et al., 2014; Tscharntke et al., 2012; Willett et al., 2019). When human populations grow, the demand on natural resources increases (e.g. Nchimbi and Lyimo, 2019). At the same time, for many people food security is not a future problem. Roughly one in ten people across the globe are currently undernourished. The situation is most acute for poor people living in what UN classifies as the world’s “least developed countries” (World Bank, 2018). It is evident that the conditions for food security, which exists “when all people, at all times, have access to sufficient, safe and nutritious food” (FAO, 1996), are not met in all places.

In absence of other incomes, poor rural communities in less developed countries tend to have a high reliance on local ecosystem services for providing food security (Bailey and Pomeroy, 1996; Billé et al., 2012). One example is small-scale fishery, which benefit from fish and invertebrates provided by local aquatic ecosystems. Small-scale fishery may play an important and many times underestimated role in providing protein and alleviating food insecurity (FAO, 2019a; Teh and Pauly, 2018). Gleaning, or collection, of marine invertebrates in shallow intertidal waters is one type of small-scale fishery, which is easily accessed by foot and requires no fishing equipment (de la Torre-Castro and Rönnbäck, 2004; Hockey and Bosman, 1986; Nordlund et al., 2010; Nordlund and Cullen-Unsworth, 2018; Siegfried et al., 1985). This makes it an accessible source of protein to those with very limited resources (Kleiber et al., 2015). While invertebrates may be gleaned in different habitats or ecosystems, such as shallow reefs, sand/mud flats, mangrove forests and seagrass meadows (Bell et al., 2018), the role of seagrass meadows in providing food security and other ecosystem services has generally received little attention (Duarte et al., 2008; Nordlund et al., 2018; Unsworth et al., 2018a; Unsworth et al., 2018b). Seagrass meadows are highly productive underwater ecosystems, which are found in shallow coastal waters in temperate and tropical zones across the globe (Den Hartog, 1979; Short et al., 2007). Gleaning activities in these seagrass meadows as well as in other ecosystems and habitats are often unregulated and seldom appears in national fishery statistics (Fröcklin et al., 2014; Harper et al., 2013; Shali, 2017; Unsworth et al., 2018a). Without data and information on local conditions it is difficult to value the importance of a food source. Data is also needed to design sustainable use of local ecosystems services (Poppy et al., 2014), in this case seagrass meadows. This is particularly important since seagrass meadows are reported to be in global decline (Short and Wyllie-Echeverria, 1996; Waycott et al., 2009), and poverty in rural communities tend to result in overuse of natural resources (Nchimbi and Lyimo, 2019; Poppy et al., 2014). When productive ecosystems or fish stocks are degraded or overfished, the capacities to deliver food security may be reduced (HLPE, 2014).

Studies on seagrass-associated invertebrate gleaning in Tanzania have mainly been pursued in Zanzibar. These studies indicate that seagrass ecosystems are under threat and invertebrate abundance has declined (Fröcklin et al., 2014; Nordlund et al., 2010), but less is known about the situation on the mainland. There are also limited assessments of gleaning from a food security perspective. The need for data is pressing considering that Tanzania’s population is projected to grow from 60 million today to well over 100 million people by 2050 (UN DESA, 2017) and nearly a third of the population is currently estimated to experience undernourishment (World Bank, 2018). Food insecurity is particularly prevalent in Tanzania’s rural areas (Schindler et al., 2017), in households engaging in farming, livestock keeping, forestry and fishing (MAFAP, 2013).

Against this background, the study explores the role seagrass-associated invertebrate gleaning plays for the food security situation amongst gleaners in Kaole village, mainland Tanzania. An earlier study on coastal resources in the Bagamoyo area, where Kaole is situated, suggests that gleaning occurs in
the village and that catches in the area are decreasing (Semesi et al., 1998), but there are no recent studies on these activities, or their potential role for providing food security. To address this, this thesis applies the food security framework to assess the significance of invertebrate gleaning in Kaole. Seagrass meadows and their role in providing food security are of particular interest. Quantitative data is collected through a self-developed questionnaire and qualitative data is collected through two focus group discussions. The following research questions are addressed:

- What is the significance of seagrass-associated invertebrate gleaning for providing food security, in particular protein, amongst gleaners in Kaole?
  - Has gleaning activities and ecosystem status changed over time?
  - Are there any measures that can protect this food source for future generations?

The findings will be discussed along the food security framework, where different ways of safeguarding food security, while maintaining ecosystem integrity, are addressed. Accordingly, this thesis does not use one of the established indicators to measure one particular aspect of food security. It rather tests to apply the food security framework to gleaning, with seagrass as focus habitat.

2. Background

2.1. Conceptual framework – food security

The concept of food security has been discussed and developed for more than four decades, and today there is a vast literature on the topic (Berry et al., 2015). While the initial focus was on food availability, the concept has become more multifaceted with time (Coates, 2013). The most common and widely accepted definition can be traced back to the World Food Summit Plan of Action in 1996. The summit defined that “food security at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 1996). There are several themes in this multi-dimensional definition and food security is usually conceptualised to contain three components; availability, accessibility and utilisation, with stability often added as a fourth factor (Barrett, 2013; FAO, 2013). The different aspects of food security may be seen as hierarchical, where availability of food is a prerequisite, but not enough for ensuring accessibility, which in turn does not guarantee the right utilisation of food available (Barrett, 2010).

The availability aspect of food security focuses on food supply in terms of production, stock levels and trade (Barrett, 2013) and was due to the energy crisis and protectionism in particular focus in the 1970s (Coates, 2013). Expanding aquaculture within fisheries, reducing post-harvest losses, closing yield gaps and increasing production limits within agricultural in developing countries are measures that may enhance the global availability of edible food (Godfray et al., 2010). However, the availability component does not consider how economically and physically accessible the food is to different individuals and households (Barrett, 2013) and some researchers argue that we already produce enough food to feed 10 billion people, it only needs to be better distributed and made accessible to the poor (Holt-Giménez et al., 2012; Tscharntke et al., 2012). This is where the accessibility component comes into the forefront.

Accessibility addresses the demand side of food security and how food is distributed amongst different individuals, households, societies and nations. This perspective was added in the early 1980s, when the Nobel Prize Winner Amartya Sen argued that it was the lack of entitlements, and not foods, which was the predominant reason behind famine in some developing regions and countries at the time (Coates, 2013; Jones et al., 2013). Researchers, who see no direct link between global food production and global food security, argue that food security and food sovereignty needs to be achieved where the hungry live (Tscharntke et al., 2012), and fish is the only source of protein that people can access and harvest themselves in many places (Henchion et al., 2017).
The third component concerns *utilisation* of food and assesses to what extent households make good use of the food to which they have access. Factors such as energy intake, nutrition and sanitation are considered (Barrett, 2013; FAO/EU, 2008). Since seafood can spoil more quickly than many other foods, it requires care during handling, processing and storage to maintain nutritional attributes and avoid post-harvest losses (FAO, 2018; Venugopal and Gopakumar, 2017). The utilisation dimension also acknowledges that food may be unevenly distributed within households and that sufficient physical and economic access to food is necessary, but insufficient, for ensuring food security for all individuals within a household. Since the mid-1990s there has also been much focus on alleviating micronutrient deficiencies (Jones et al., 2013). Some argue that fish has not received the attention it deserves in debates on food security and nutrient. Besides having a small carbon footprint compared to other animal sourced proteins, it is a protein rich in essential amino acids and many important vitamins, minerals and other nutrients, which may be difficult for poor people in developing countries to access in other ways (Béné et al., 2015; HLPE, 2014). Whilst the protein content in different aquatic species varies, invertebrates generally have a higher protein content than finfish (Venugopal and Gopakumar, 2017).

Food security also entails having *stability* over these three components over time (Barrett, 2013; FAO/EU, 2008). This perspective gained attention in the beginning of the 1990s, when it was argued that the security, or stability, dimension of food security seldom was operationalised. Yet, it was not until 2009 that this component was adopted by the World Summit on Food Security (Berry et al., 2015; FAO, 2009). The stability aspect acknowledges that food availability, accessibility and utilisation are dynamic components and subject to the risk of future downturns (Coates, 2013). Periodic disruptions may occur due to seasonal changes or more irregular events, such as extreme weather, deaths or conflict (Jones et al., 2013). If one has insufficient access to food on a periodic basis one may hence be defined as food insecure. As further elaborated below, the stability component could also include a sustainability aspect, indicating that our strive for food security today, should not jeopardise the food security for future generations (Berry et al., 2015).

### 2.1.1 Different ways to measure food security

There are several ways to measure food security amongst individuals or households, but there is no model that covers all four components outlined above. Some of the most common measures or indicators to assess food insecurity include the Household Food Insecurity and Access Scale; the Household Hunger Scale; Coping Strategies Index; the Reduced Coping Strategies Index; Food Consumption Score; the Household Dietary Diversity Scale and a self-assessed measure of food security (Maxwell et al., 2014), but there are several more in use (Jones et al., 2013).

While some indicators might measure food security changes over time with the aim of informing development programs, other indicators might guide the targeting of food aid (Jones et al., 2013). Most indicators that have been developed and validated in the 21st Century only measures *access* to food (Coates, 2013). Household Food Insecurity and Access Scale and the Household Hunger Scale include questions such as “[i]n the last 30 days, did you or any household member go to sleep at night hungry because there was not enough food?” Coping Strategies Index and the Reduced Coping Strategies Index incorporate questions such as “[i]n the last 30 days, has your household had to borrow food, or rely on help from a relative?” , while Food Consumption Score and the Household Dietary Diversity Scale ask what food types people have eaten in the last 30 days and how often they have eaten these (Maxwell et al., 2014). In addition to these indicators, FAO (2019b) has begun to use the Food Insecurity Experience Scale, for measuring access to adequate amounts of food in global Gallup Polls, as a complement to its’ undernourishment indicator (Coates, 2013). The Food Insecurity Experience Scale can be used to measure food security for both individuals and for households, and is one of the indicators used to measure progress towards the Sustainable Development target number 2, which aim to “end hunger, achieve food security and improved nutrition and promote sustainable agriculture” (UN, 2015).
It is to some extent problematic to have these many different measures. Various indicators tend to be used interchangeably, without clarification of which food security components are captured by which indicators (Jones et al., 2013; Maxwell et al., 2014). Another identified problem is that you might miss food insecurity in parts of the population depending on what measurements you apply (Maxwell et al., 2014). In absence of a single tool or gold standard that measures all aspects of food security, researchers and international organisations, such as FAO, suggest that different indicators may be used in combination (FAO, 2019b; Maxwell et al., 2014), if time and resources allow for this (Maxwell et al., 2014). As an alternative, it is important to clarify which aspect of food security the used indicator measures and try to avoid using an indicator that wrongly could capture only parts of the population that is food insecure (Maxwell et al., 2014).

2.1.2 Critique of the food security framework

Besides the challenges of having many different measurements, Jones et al. (2013) argues that the food security framework tends to oversimplify the relatively complex range of different food security measures. The concept has also received some critique for the components it includes. Coates (2013) proposes a slightly modified framework that consists of five, instead of four, dimensions. Food security accordingly implies that “(a)n individual must have access to food that is: (1) sufficient in quantity; (2) adequate in nutritional quality; (3) culturally acceptable; (4) safe; and (5) certain and stable.” Coates (2013) also suggests which of the existing measurements that could be used for the different components, as well as where new indicators need to be developed.

The cultural dimension is important by reminding that religious and cultural taboos may prevent people from eating certain things, even if a certain food source may be nutritious and part of a food intervention program (Briones Alonso et al., 2018). The cultural dimension also captures all aspects of the above cited 1996 definition, which implies that food security meet both dietary needs and “food preferences” (FAO, 1996).

Besides the cultural aspect, it is interesting to note that neither Coates (2013) nor the established food security framework include any environmental references, indicating that our food security relies on ecosystem services, which is of particular interest in this paper. The Millennium Ecosystem Assessment (2005) defines ecosystems as “...a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit”. They provide a number of supporting, regulating, provisioning and cultural services, which benefit and enable human life (Daily et al., 2000). Considering that food security is not only dependent on provisioning and non-provisioning ecosystem services, but is also one of the major drivers behind their degradation (Poppy et al., 2014), it might seem strange that it has not been integrated to the food security framework. While there have been some discussions on whether sustainability should be added to the availability, accessibility or stability component, or perhaps as a separate dimension, its position in the food security framework has yet to be established (Berry et al., 2015). Berry et al. (2015) suggest that biodiversity and water and carbon footprints are examples of environmental indicators that could be incorporated into the concept. They further argue that “the addition of some indicators for the environmental dimension could well complete a food security set of indicators, especially if they focus on availability of, and accessibility to, natural resources.”

From a slightly different angle, Poppy et al. (2014) propose that food security and environmental sustainability could be integrated into an ecosystem services framework. To achieve the multiple goals of food production, ecosystem integrity and resilience, one need to integrate spatial and temporal analysis. Local issues need to be connected to a national context and we need to learn from past events. One should also map who benefits from ecosystem services in space and time, and how the benefits flow through food production. While much policy-level work on food security focuses on national and regional levels, and ecosystem services concentrate on whole catchments or larger, there is limited focus on those that benefit from the ecosystem services. Household and community-based studies can add important information in this regard and highlight the interplay between local and global conditions necessary for governance of ecosystems services. Whilst recognising that there will
always be trade-offs, Poppy et al., (2014) suggest that their approach provide greater opportunity for integration of social and ecological needs.

Despite conceptual limitations of the food security framework, there is a growing literature on how best to achieve food security for a significantly growing global population, while safeguarding a sustainable future (e.g. Godfray et al., 2010; Springmann et al., 2018; Willett et al., 2019). In one of the most comprehensive and recent articles on the topic, Willet et al. (2019) present what constitute a healthy and sustainable diet, which in the face of a growing global population can be consumed with respect to planetary boundaries. Their proposed diet is set with reference to environmental targets concerning climate change, biodiversity loss, freshwater use, land system change, and interference with natural phosphorous and nitrogen cycles. In their article they focus mainly on the consumption and production of food. Seen through the lens of the food security concept, they relate mostly to availability, utilisation and stability over time, and not so much to the accessibility aspect of food.

The conceptual challenges are not surprising, considering that measures to achieve food security in respect to environmental limits involves both natural and social sciences, and addressing food insecurity demands multi-disciplinary solutions (Poppy et al., 2014). While this study recognises the conceptual limitations, it uses the food security framework to assess the situation amongst gleaners in Kao. But it also connects the findings to broader discussions on different ways to protect the food-provisioning seagrass ecosystems, whilst maintaining food security. Some sustainability and environmental dimensions are discussed in relation to both availability, accessibility, utilisation and stability over time, and some of the insights from Poppy et al., (2014) are returned to in the discussion chapter. This endeavour requires background information on both seagrass meadows and previous research on seagrass-associated gleaning.

### 2.2. Seagrass meadows and their ecosystems services

Seagrass meadows are highly productive ecosystems (Duarte and Chiscano, 1999; Green and Short, 2003). These ecosystems consist of marine flowering seagrass plants, which flower, fruit and seed, just as terrestrial flowering plants do (Green and Short, 2003; Short et al., 2007). Together they may create underwater meadows ranging from one square metre up to tens of thousands of hectares (Short et al., 2007), which are found in shallow coastal waters across temperate and tropical zones across the globe (Den Hartog, 1979; Short et al., 2007). The vast Indo-Pacific, where Tanzania is situated, stands out for the highest seagrass diversity in the world (Short et al., 2007).

In relation to human food and nutritional needs, seagrass meadows provide a number of supporting and provisioning services that enables consumption of seafood. Through their supporting services, seagrass meadows provide nursing grounds, habitats and shelter for hundreds of species of finfish and invertebrates (Green and Short, 2003; Jackson et al., 2001; Moberg and Rönnbäck, 2003; Unsworth et al., 2018a). While many species utilise multiple habitats, seagrass meadows provide a three dimensional, or structured, habitat, which provide better protection for juvenile aquatic vertebrates and invertebrates compared to sand and mud flats (Lefcheck et al., 2019). Together with mangrove ecosystems, seagrass meadows stands out for having the highest juvenile density amongst structured habitats (Lefcheck et al., 2019). Some invertebrates, including sea urchins, also graze on seagrasses (Eklöf et al., 2008; Gullström et al., 2012). Through their supporting services, seagrass meadows also play a crucial role in the provisioning fish production (de la Torre-Castro and Rönnbäck, 2004; Green and Short, 2003; Unsworth et al., 2018a). There are estimations that they support one fifth of the world’s largest fisheries (Unsworth et al., 2018b). With 746 species recorded to utilise seagrass meadows, the Indo-Pacific region has the highest number of seagrass-associated fish in the world. These species contribute to both industrial and small-scale fisheries (Unsworth et al., 2018 b). In Zanzibar, more than 270 species are targeted through seafood gleaning from seagrass meadows (Nordlund et al., 2010), and there is an increasing awareness of the significance of seagrass for providing food security (de la Torre-Castro et al., 2014; Nordlund et al., 2010; Quiros et al., 2018; Unsworth and Cullen-Unsworth, 2017). Thanks to all their ecosystem services (Figure 1), seagrass meadows are considered to be one of the most productive ecosystems on earth (Duarte and Chiscano, 1999). Seagrass contribute clear economic benefits to humans and there have been several attempts to
demonstrate this in monetary terms (Barbier et al., 2011; Costanza et al., 1998; Tuya et al., 2014; Vassallo et al., 2013).

**ECOSYSTEM SERVICES PROVIDED BY SEAGRASS**

<table>
<thead>
<tr>
<th>Provisioning services</th>
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<th>Regulating services</th>
<th>Recreational services</th>
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<td>Fin fish</td>
<td>Nutrient cycling</td>
<td>Climate regulating</td>
<td>Aesthetical</td>
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<td>Invertebrates</td>
<td>Soil formation</td>
<td>Disease regulating</td>
<td>Spiritual</td>
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<td>Compost fertiliser</td>
<td>Erosion control</td>
<td>Water purification</td>
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<td>Fish nursing grounds</td>
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**Fig. 1:** Examples of some supporting, provisioning, regulating and cultural ecosystem services provided by seagrass (Nordlund et al., 2016)

### 2.2.1. Seagrass-associated gleaning and food security

The food provisioning role of seagrass meadows are often stressed to raise global awareness of seagrass ecosystems (Cullen-Unsworth and Unsworth, 2013; Nordlund et al., 2018; Unsworth et al., 2018a) and to urge for much needed conservation measures (Unsworth et al., 2018b; Unsworth and Cullen, 2010). But there are only a few articles that assess the significance of seagrass-associated fishery for providing food security in individual households (e.g. Quiros et al., 2018). Such information is important, since rural communities can be highly dependent on seagrass meadows and these have become increasingly recognised as a coupled social-ecological system (Cullen-Unsworth et al., 2014; de la Torre-Castro, 2006; de la Torre-Castro and Rönnbäck, 2004). Gleaning in seagrass meadows is one example of social-ecological interactions between humans and seagrasses (Cullen-Unsworth et al., 2014).

The concept of “gleaning” dates back to Biblical times, when farmers were encouraged to leave some produce in the fields for travellers and the poor. This freely available and accessible food could enhance both the quality and quantity of food that was accessed amongst individuals and households, thus contributing to their food security (Hoisington et al., 2001). Present day gleaning takes place both in the Southern and Northern hemisphere, and may besides subsistence and potential income purposes be pursued for religious, charitable and civil purposes, in both rural and urban settings (Hoisington et al., 2001; Marshman and Scott, 2019). The specific gleaning that takes place in seagrass is usually performed in intertidal areas when tides are low and seagrass meadows are easily accessed. The Indo-Pacific Seagrass Network (IPSN) defines gleaning activities as: “collection on foot in shallow water using bare hands or very simple gear. These simple gears include (but not limited to) rock, knife, stick, sharp stick, rake. [...] Gleaners typically target invertebrates (e.g. mussels, octopus, sea cucumbers) but sometimes also collect fish, algae and seagrass.”(Nordlund and Cullen-Unsworth, 2018).
Fig. 2: Gleaning activities in Kaole, Tanzania. To the left, woman walks home with catch on her head, accompanied by her children. To the right, invertebrate gleaning in a seagrass meadow (photo: Johanna Lauritsen, 2019).

Similar to other small-scale fisheries, gleaning of invertebrates generally goes unreported, and gleaning activities have several features that enhance the risk of overlooking its potential significance. As proposed by the above-mentioned definition of gleaning, it requires no boats or gears, which are usually associated with fishing (Figure 2). In Tanzania and other places in the East Africa, this activity is mostly conducted by women and children (Cullen-Unsworth et al., 2014; de la Torre-Castro and Rönnbäck, 2004; Fröcklin et al., 2014; Jiddawi and Öhman, 2002; Nordlund et al., 2010; Semesi et al., 1998) and there is a tendency that gleaning of invertebrates is not seen as real fishing (Guzman, 2019; Shalli, 2017). Yet, there are several studies indicating that seagrass-associated invertebrate gleaning may provide an important source of protein to poor coastal communities (Cullen-Unsworth et al., 2014; de la Torre-Castro and Rönnbäck, 2004; Nordlund et al., 2010; Quiros et al., 2018), particularly in the Tropical Indo-Pacific bioregion (Nordlund et al., 2018).

An increasing significance of seagrass-associated invertebrate gleaning has been reported from some locations across the globe (Cullen-Unsworth et al., 2014). Research in two Indonesian communities found that invertebrate gleaning in seagrass had gone from being a supplementary and recreational food source to being the main source of protein (Cullen-Unsworth et al., 2014; Unsworth et al., 2014). In Zanzibar, Tanzania, the number of gleaners who gleaned for subsistence purposes were reported to have increased between 2005 and 2010 (Fröcklin et al., 2014). In several locations, including Fiji, low-income families have been found to collect almost anything edible in the intertidal seagrass areas (Cullen-Unsworth et al., 2014). Also in the Caribbean, seagrass-associated invertebrates were found to be important to support households’ protein requirements. Particularly poor communities, with high unemployment rates, were found to fish near shore, in accessible seagrass meadows, to sustain themselves (Baker et al., 2015; Cullen-Unsworth et al., 2014). In a study on two coastal communities in the Philippines, it was further found that women’s participation in intertidal gleaning activities could augment the adaptive capacity of households by providing additional food and income. The study, which included different kinds of small-scale fishery, also found that the communities varied in their vulnerability and response to resource decline. The community closer to an urban centre that provided salaried income was, for instance, less socially vulnerable to disturbance in the seagrass resource (Quiros et al., 2018).
Whilst seagrass-associated invertebrate gleaning plays an important role in providing food in several places, there are also reports of invertebrate declines (e.g. Fröcklin et al., 2014; Nordlund et al., 2010; Semesi et al., 1998). Two different studies from Zanzibar, which both had 2010 as a baseline, found that the number of invertebrates had declined over the last five (Fröcklin et al., 2014), as well as ten (Nordlund et al., 2010), years. The constant pressure from gleaners may have a negative impact on the catch (Fröcklin et al., 2014). Biological surveys of seagrass and associated invertebrates have found that inaccessible areas without gleaners may have considerably higher invertebrate abundance and species richness compared to areas commonly gleaned (Nordlund et al., 2010; Nordlund and Gullström, 2013). These examples illustrate how the strive for food security on the local level may exert pressure on surrounding ecosystem services (Poppy et al., 2014). It also reminds about the importance to incorporate such understandings into food security assessments.

2.2.2. Threats towards marine invertebrates

Marine invertebrates are exposed to multiple human induced stressors (Collier et al., 2016). Besides over-fishing, invertebrates are threatened by pollution, constructional developments, shipping lanes, invasive species and climate change (Collier et al., 2016). The climate change effects include elevated sea temperatures and ocean acidification, which may have a negative effect on invertebrates (Collier et al., 2016; O’Donnell et al., 2009). Invertebrates are also exposed to loss of habitats (Collier et al., 2016). Considering seagrass meadows, they may annually lose as much as 7% of their global distribution (Waycott et al., 2009). Over-exploitation through 1) logging, over-fishing and damage from trawling; 2) increased sedimentation due to logging, farming and development; 3) chemical and nutrient pollution arising from untreated sewage, industry waste, agriculture and several other sources; and 4) coastal construction, where seagrass may be removed in favour of infrastructure developments are all examples of human induced threats towards seagrass (Orth et al., 2006; Wilkinson and Salvat, 2012). Besides these local threats, climate change and invasive species may pose further stress to seagrass meadows (Orth et al., 2006; Waycott et al., 2009; Wilkinson and Salvat, 2012). Geologic stressors, such as earthquakes and tsunamis; climatic and meteorological stressors, including storms and extreme temperatures of hot or cold; and extreme low tides are other examples of mainly natural factors that may degrade seagrass (Orth et al., 2006; Wilkinson and Salvat, 2012). Storm-related seagrass losses have for instance been reported from Tanzania (Cullen-Unsworth et al., 2014). Rising poverty, growing populations and potential displacement from land are additional risks of increasing pressure on seagrass meadows and their provisioning services, resulting from more people using coastal resources for subsistence (Wilkinson and Salvat, 2012). The declining number of invertebrates in Zanzibar, where prime target gastropods and bivalves have reduced in both size and numbers (Fröcklin et al., 2014), coincided with a growing population, increased tourism and inward migration that have caused more coastal constructions and stress on the intertidal area (Cullen-Unsworth et al., 2014). The lack of adequate management of marine resources, missing political engagement as well as coordinated conservation programmes are other factors that often are missing (Wilkinson and Salvat, 2012). This is particularly serious considering that once seagrass meadows are damaged, restoration costs are very high and success rates are usually low (Orth et al., 2006).

In the light of increasing threats and decreasing natural resources, this study now turns to assess the situation in Kaole, Tanzania.

3. Methods

While much seagrass research has been pursued in Zanzibar, less is known about seagrass and their importance for food security along the coasts of mainland Tanzania. Kaole/Bagamoyo was chosen as case study area, since this will be the location on mainland Tanzania for seagrass-related research within the Indo-Pacific Seagrass Network (IPSN). The IPSN is a collaborative research initiative on seagrasses, involving research teams from approximately 20 different countries across the Indo-Pacific. Through collecting similar data in many different locations, the findings will help to identify patterns on large spatial-temporal scales across this geographical area. This thesis aspires to contribute
to the interdisciplinary understanding of the seagrass-associated fishery in the IPSN location in mainland Tanzania. The study was conducted between February 18 and March 8, 2019.

3.1. Study area - Kaole (Bagamoyo)

Kaole is a small coastal village 4.5 kilometres southeast of Bagamoyo town. Bagamoyo is situated 75 kilometres northwest of Dar es Salaam, Tanzania, on the coast of the Western Indian Ocean (Figure 3). It is an old trading town and used to be a site for ivory and slave trade between the East African inland and the sultanate in Zanzibar. Besides trading, the population have lived from fishing and farming. Due to its historical and cultural heritage, Bagamoyo is today a UNESCO World Heritage Site (UN Human Settlements Programme, 2009).

In the 21st century, agriculture and animal husbandry are the main components in the Bagamoyo economy, involving around 90% of population in the district. Other important livelihoods include fishing, hunting, industrial development, commerce, artisan and informal activities as well as tourism (UN Human Settlements Programme, 2009).

Bagamoyo has had a higher population growth compared to the national average in Tanzania. In 2009, approximately two thirds of the population lived in unplanned settlements and many people lack access to water and sanitation. The unplanned settlements have had a negative impact on the local environment with untreated wastewater polluting different water sources. (UN Human Settlements Programme, 2009). Earlier research on coastal resources in the area also discovered mounting environmental pressure and conflicts deriving from the tourist sector. Beach hotels had locked artisanal fishermen out from beach areas in front of their hotels and cleared mangrove areas, resulting in beach erosion. Poverty, increased competition over natural resources, poor institutional arrangements and policy failures, as well as lacking infrastructure, were identified as the main reasons for mismanagement and overuse of coastal resources in the area (Semesi et al., 1998). In recent years, there have been plans to build what is supposed to be Eastern Africa’s biggest port, 10 kilometres outside Bagamoyo town, past Kaole village. The port is sponsored by Chinese and Omani investors and will host several hundred industries (Ndalu, 2018). Despite a presidential inauguration in 2015, the construction has not yet begun.

Intertidal gleaning activities in the area are mainly performed in and around Kaole. The coastal topography favours gleaning in this location by providing a larger intertidal area than outside Bagamoyo town. Kaole is a small fishing village with approximately 250 people, divided into 50-60 households. The village has similar challenges as the rest of Bagamoyo. Only some households are connected to a sewage system and less than 25% of the households have electricity supply (Personal communication, ISPN Location Survey Kaole, 2019).
3.2. Ethical concerns

Prior to the fieldwork, research permission was applied for and granted by Tanzania Commission for Science and Technology (COSTECH). The permit was collected at the Commission offices after arrival in Dar Es Salaam. Once in Bagamoyo, the research was introduced to the local Fisheries office, which also kept a copy of the permission. The research was also introduced to the two secretaries of the Kaole community, one from the upper parts of the village and one from the lower area, closest to the ocean. In addition, the research permit was showed to representatives of the Kaole ruins museum. Visitor’s books were signed in all places. At the point of departure, all representatives were revisited and visitor’s books were signed out.

The structured interviews were held with above 18 year olds only. All participants were informed about the purpose of the study, their anonymity and that they could withdraw at any time (Appendix A).

3.3. Multi-strategy research design

The research question was addressed using a multi-strategy, or mixed methods, design, using both quantitative and qualitative methods. While this can be done in many different ways, this study used a *sequential explanatory design*. This means that the collection and analysis of quantitative data is followed by collection of qualitative information (Robson and McCartan, 2016). The quantitative data consisted of a questionnaire followed by qualitative data collection, through two focus group discussions. While the quantitative data from the questionnaire was prioritised, the qualitative data from the focus groups was planned to help explain, visualise and triangulate some of the findings (Robson and McCartan, 2016). Although the study was predominately social sciences based, it also involved interdisciplinary, and natural sciences, elements through identification of some invertebrate species. Since Swahili is the predominant language in Tanzania, a translator was required for the fieldwork. The translator was a person who teaches marine sciences at University of Dodoma, in Tanzania.

Questionnaires/structured interviews

Measuring food security or food consumption involves many methodological challenges (Fabinyi et al., 2017), and as indicated in the background section there are no indicators that capture all four dimensions of the concept. The aim in this thesis was not to determine the actual level of food security/food insecurity in individual households by using one of the measurements in place, since that mainly would have captured the *access or utilisation* aspect of food security. It would also have focused on the total access to all kinds of food in the households, while the interest here was on invertebrates and their role in providing food and protein to the households, as well as assessing the availability and stability of this food source. A similarly broad application of the food security framework has previously been applied in a review on the significance of small-scale poultry for providing food security in poor settings (Wong et al., 2017).

The quantitative data thus consisted of a self-developed questionnaire to address the significance of seagrass-associated gleaning for providing food security amongst gleaners in Kaole village. Some questions were similar to the gleaning landing survey used to interview gleaners within the IPSN research (IPSN, 2018), asking for what purpose the interviewees glean, what they do with the catch and how many hours are spent gleaning. The gleaning survey also asks detailed questions about what gears are used, which habitat (coral reef, deep water, mangrove, mud, sand, seagrass, algae, other) is most preferred, most profitable and visited on the day of survey, as well as weighs and assesses invertebrate landings. To make this study complementary and bring it closer to food security, this questionnaire instead added questions relating to availability, alternative incomes, alternative protein sources and stability over time (Appendix A). The results from this questionnaire may be a complement to the coming results from the local gleaning landing surveys.
Two researchers with significant experience in socio-ecological seagrass research and sound knowledge of local conditions gave feedback on the questionnaire, prior to the fieldwork. The questionnaire included both closed and open questions. Once in the field, two pilot interviews were conducted. After some minor amendments, all questions were translated into Swahili (Appendix B).

Since several respondents were illiterate all questionnaires had to be read out loud to the interviewees following the exact Swahili wording, rather than being distributed to them to fill in. There are both disadvantages and advantages with collecting data this way. The data may be affected by interviewers’ skills, as well as by interactions between interviewer and interviewee, where different class and ethnic background may affect the results. Respondents may also feel that their replies are not anonymous (Robson and McCartan, 2016). To tackle this, we took good care to dress appropriately, as well as to remind the interviewees that they could withdraw from the study at any time and that all answered would be treated anonymously. On the positive side, it may encourage participation and provide an opportunity to assess whether questions are treated seriously. The interview style also provides an opportunity to clarify questions (Robson and McCartan, 2016). Although this is a positive aspect, some respondents may still misinterpret what you mean or be too shy to ask for clarifications. In this study, the interviews offered an opportunity to identify knowledgeable key informants, which were suitable to invite to the focus group discussions.

During the pilot interviews it was discovered that the interviews easily could attract other community members, who involved themselves in discussions around the interview questions. To avoid this situation, which could affect both the answers given as well as compromising on anonymity, it was decided that the interviews would be held in the respondent’s household or in a separate outdoor area.

In total, 30 women in Kaole village answered the questionnaire. Five of the interviewees had stopped their gleaning activities, but were still included in the data collection since they could provide relevant knowledge to many of the questions. The use of a standardised questionnaire allowed for data collection from more respondents, compared to what would have been possible through semi-structured interviews. Compared to merely gathering data through focus group discussions, the questionnaire also allowed for better information on the role invertebrate gleaning plays in the individual households. A sample of 30 respondents from a location is furthermore often regarded as sufficient for statistical analysis regardless of population size (Bailey, 1994). In the case of Kaole, with 50 to 60 households in the village, around half of the households were represented in the study. Each interview lasted for approximately 30 minutes, but some took longer.

Focus group discussions

After initial analysis of the structured interviews, two focus groups discussions were organised, one with male fishers (primarily targeting finfish) and one with female fishers (invertebrate gleaners). The overarching aim of the focus groups was to add more information on the ecosystems and their food provisioning services over time. Considering preliminary results from the questionnaire, participants were asked to describe historical changes in invertebrate and finfish catches, status of seagrass and mangrove ecosystems, status of climate change, population pressure and marine protection.

One known challenge with continuous environmental degradation is that people’s tolerated thresholds for environmental conditions are constantly being lowered. Without past experience or information of historical conditions of the natural environment, each new generation accept the environmental situation in which they are raised as being normal. This sociological and psychological phenomenon is called ‘shifting baseline syndrome’ (SBS) (Pauly, 1995). SBS is increasingly being seen as the main obstacle to addressing environmental challenges across the globe (Soga and Gaston, 2018). By inviting key informants and in particular elders to the focus group discussions, this study aimed to diminish the risks of SBS and provide a more comprehensive overview of environmental conditions in the area. This is of particular importance since there is no historical research or data on seagrass distribution in the area.
There are different recommendations on how big focus groups should be (Robson and McCartan, 2016; SCB, 2019). In general, they can involve between four to 12 participants (Hakim, 2000). In this study, the female group involved six participants, while the male group only involved four participants. The division into two same sex groupings was following local advise that female participants would be more comfortable to talk by this separation. It also provided an opportunity for additional triangulation of data (Salkind, 2010). The female informants were easily identified through the questionnaire interviews, were it became apparent who had long experience and/or sound knowledge of the area. The male participants were identified with help from the village secretary. The oldest and most knowledgeable male participant was above 60 years of age and had spent most of his life fishing in the village.

Each group received a long piece of paper with a timeline divided into the different presidential periods since Tanzania’s national independence in 1964. Following local advise, this would be the easiest way for participants to relate to different time periods. The timeline was thus divided into five different time periods; 1) President Nyerere, 1964 - 1985; 2) President Mwinyi, 1985 - 1995; 3) President Mkapa, 1995-2005; 4), President Kiwete, 2005 - 2015; and 5) President Magufuli, 2015 - on-going. Four pens were distributed to group members at each session. The male group did, however, prefer that the local facilitator and translator wrote down their contributions. In the female group, one of the younger and most educated participants took on the role as group secretary. In addition to the documented timelines, the discussions were recorded with a voice recorder (Hakim, 2000). The focus groups lasted for one hour each. Both groups had identical results (Appendix C).

**Invertebrate identification**

A common method applied in several studies to assess the dependency on seagrass-related fish in an area is to assess fish landings from fishers, gleaners or both (see for instance Fröcklin et al., 2014; Nordlund et al., 2010; Quiros et al., 2018). Since many species occur in multiple habitats one may also need to ask questions in which particular habitat (e.g. seagrass, sandflats, mud, mangrove) gleaners and fishers have fished in on that particular day. This is the method used in the IPSN gleaning landing form (Nordlund and Cullen-Unsworth, 2018). Given time constrains and the fact that the gleaning season was just about to begin when this study took place, the questionnaire was designed to only focus on seagrass-associated gleaning and respondents were asked to mention what species they glean in the seagrass. The names were given in Swahili and old shells from dead animals were shown to further specify which species they were referring to. With this data it was, together with an earlier study from the area (Semesei et al., 1998), possible to identify some of the species and their preferred habitat using the book by Richmond (2011) (Appendix D). In connection to the IPSN data collection, there were also four gleaning landings from seagrass, which helped the identification.

**3.4. Timing of the study**

Since gleaning activities mainly takes place during spring low tides, the fieldwork was adjusted to fit the tidal cycle that changes daily. With nearly three weeks to dispose, the fieldwork was planned to take place between February 18 and March 8, 2019, which would allow for two weeks of spring low tides. This provided the most possible time for observations of both gleaning activities and seagrass meadows, in addition to interviews and focus groups. The study was also adjusted to converge with the mentioned data collection by the local IPSN team, who would perform habitat, ecological and some gleaning landing surveys in the area during 4 – 7 March 2019.

**3.5. Limitations**

While the initial plan was to randomly approach gleaners on the beach, the gleaning season was just about to begin and there were only a few gleaners around. Instead, the village secretary contacted gleaners and organised an interview schedule for those interested, so it is plausible that some bias may have entered here in terms of the individuals selected for interviews. Every one of the interviewees was also female, due to the female-dominated nature of gleaning activities in Kaole.
Since there were no previous studies assessing food security and gleaning in the village, it was not possible to assess and compare past and present gleaning patterns from a food security perspective. While the focus group discussions provided a timeline of the overall situation, they did not reveal the significance of gleaning in individual households over time. The number of interviewed women was also relatively low. The results from these kind of studies become more significant, not at least for policy-makers, when scaled up and undertaken simultaneously in several coastal communities.

4. Results

All of the 30 interviewees that took part in the structured interviews were women living in Kaole village. One person did not know her age, but the age of the remaining 29 people ranged from 19 to 57 years, with a median age of 34 years and a mean age of 34.8 years. All but four women had attended different levels of formal education, but no one had attended higher education.

The interviewees had performed gleaning for one to 25 years, with a median of five years and a mean of seven years. Some women added that they had moved to Kaole after marrying men from the village, to explain why they were relatively new to invertebrate gleaning. Of the 30 people interviewed, 24 were still gleaning in seagrass and one was about to resume the activity after some years of inactivity (83%, n=25). The remaining five people (17%, n=5) had stopped all their gleaning activities. Two of them stopped due to physical problems. The other three gave no particular reason for giving up the activity, but one of them now had a small food business as well as an administrative, income bringing, role in the village. The other two lived in households where the other income earner was a boat engineer and a business entrepreneur respectively.

The interviewees had no coherent view of how many gleaners are currently active in invertebrate gleaning in Kaole and the replies varied between four to 60 gleaners. Some added that there are 50 to 60 gleaners during the kusi season. Besides the 25 active women that were interviewed, additional people were later observed gleaning in the area and there are at least 30 people active in gleaning, probably more.

Of all 30 respondents that are active in gleaning or had participated in gleaning in the past, 18 respondents (60%, n=18) glean(ed) invertebrates to provide both income and food to the household. The second most common answer, stated by eleven women (37%, n=11), was to provide only food for the household. One person (3%, n=1) gleaned for income purposes only.

Nearly all women (97%, n=29) were also gleaning invertebrates in the mangrove area, or had done so while still engaging in gleaning activities. Mangrove was also the most preferred ecosystem to glean invertebrates in, favoured by fourteen women (47%, n=14). Seagrass-associated areas were preferred by ten women (33%, n=10), while five people (17%, n=5) liked to glean invertebrates in both ecosystems. One person (3%, n=1) stated that the ecosystem preferences depend on the seasons (Figure 4).

\footnote{Kusi is the southeast monsoon, which stretches from June to August each year, while the northeast monsoon, Kazkasi, stretches from December to February each year. The periods in between are transition periods, partly associated with rainfalls (Okoola, 1999). According to the explanations from the gleaners, they seem to include both the transition periods into their definition of kusi.}
Twelve of the 14 women (47%, n=14) who preferred gleaning their invertebrates in the mangrove area, explained that there are plenty of invertebrates in the mangroves and they are easy to find. The remaining two favoured the mangroves because you find invertebrates there during all seasons, compared to the seagrass areas where you mainly collect during the kusi season, which they described as the period stretching from March/April to November/December\(^2\). Of those ten women (33%, n=10) who preferred to collect their invertebrates in seagrass meadows, eight stated that the seagrass is easier to access compared to the mangroves, where you have to walk through knee-deep mud. One respondent preferred seagrass areas because “there were plenty of invertebrates before” and one person gave no reason why seagrass was preferable.

The preferences for where to glean for invertebrates looked slightly different when taking age into account. Amongst those seven respondents (23%, n=7) who were above 40 years old (>40), four preferred invertebrate gleaning in seagrass, two favoured gleaning in the mangrove ecosystem and the last one was the respondent who said it depends on the seasons.

### 4.1. Availability

#### 4.1.1. Availability: results from structured interviews

When asked what species they glean in the seagrass, the respondents mentioned in total 18 different invertebrate species that they collect or had collected while still gleaning. The most mentioned variety, stated by 28 (93%, n=28) of the women, was *Vijino* (*Volema sp*). *Volema* species are both sand and seagrass-associated. Some of the other mentioned species that were possible to identify mainly live in sand habitats (see Appendix D).

A majority of the women (77%, n=23) believed that the variety of different invertebrate species have changed over time. When asked to describe how it has changed, it became evident that they interpreted the question differently. While seven respondents (23%, n=7) said that the variation in different invertebrate species has decreased over the years, another twelve respondents (40%, n=12) mainly referred to seasonal changes. They described that different invertebrates may be collected during different time periods, throughout the *kusi* harvesting season. Another two respondents (7%, n=2)

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\(^2\) As described in the previous footnote, *Kusi* is the southeast monsoon, which stretches from June to August each year, while the northeast monsoon, *Kazkasi*, stretches from December to February each year. The periods in between are transition periods, partly associated with rainfalls (Okoola, 1999). According to the answers from the gleaners, they seem to include both the transition periods into their definition of *kusi*. 
believed that invertebrates vary in available amounts, but did not say anything about variation in species. An additional two people (7%, n=2) gave no explanation.

Most women (93%, n=28) believed that invertebrate catches have decreased during the years they have performed gleaning in the area, while two respondents (7%, n=2) thought catches have increased. Amongst those respondents who said that invertebrate catches have decreased, the most common reason why was an “increased number of gleaners” or “I do not know”. The question was open, allowing for multiple answers, and two respondents stated both an “increased number of gleaners” and “climate change” as the main reasons for the decreasing availability of invertebrates (Table 1). Of those two respondents who thought invertebrates have increased, one respondent had only gleaned in seagrass in the last two years, which allowed for limited knowledge of changes over a longer time period. She was also one of the gleaners without any education. However, there were no such parameters concerning the second gleaner who thought that invertebrates have increased. She had formal education, had been gleaning in the area for 15 years and was still doing so.

**Table 1**: Of the interviewed women, 28 thought that invertebrate catches have decreased during the years they have performed gleaning in the intertidal area in Kaole, Tanzania. The table displays their responses to why catches have decreased (multiple answers possible). The percentage displays the share of the total number of responses (n=30).

<table>
<thead>
<tr>
<th>Invertebrates have decreased, because...</th>
<th>(n=30)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased number of gleaners</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>I do not know</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>No answer (N/A)</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Changes or disturbances in the ocean</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Strong winds</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Climate change</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Illegal fishing gear destroy seagrass</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Increased demand</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>The sun is too hot</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Availability depends on tides and waves</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>God’s will</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Concerning the question whether the number of gleaners have increased, decreased or remained the same during the years gleaning have been performed in the area, 21 respondents (70%, n=21) thought that the number of gleaners have decreased, six respondents (20%, n=6) thought the amount of gleaners have increased, while three respondents (10%, n=3) thought the number of gleaners had remained the same. Even these answers depended on the number of years people had performed gleaning in the area. Those who thought that the number of gleaners had decreased had generally been gleaning in the area over a longer period of time; between two to 25 years, with a median time of 5 years and mean time of 8.7 years. Five of these 21 respondents were women who stopped gleaning themselves. Conversely, those who thought that the number of gleaners had increased had only been gleaning in the area between 1 to 15 years, with a median time of 1.5 years and mean time of 3.7 years. Those who thought that the number of gleaners had remained the same had been gleaning in the area between 2 to 3 years. The majority of those who believed that gleaners have decreased saw the decrease in available invertebrates as the main reason for this (Table 2).
Table 2: Of all interviewed women, 21 thought that the number of gleaners has decreased during the years they have performed gleaning in the intertidal area in Kaole, Tanzania. The table displays their responses to why gleaners have decreased (multiple answers possible). The percentage displays the share of the total number of responses (n=21).

<table>
<thead>
<tr>
<th>Gleaners have decreased, because...</th>
<th>(n=21)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invertebrates have decreased</td>
<td>16</td>
<td>76.0</td>
</tr>
<tr>
<td>Limited knowledge amongst new gleaners (“who do not know that catches vary and do not come after some bad catches”)</td>
<td>1</td>
<td>4.8</td>
</tr>
<tr>
<td>Decreased customer demand</td>
<td>1</td>
<td>4.8</td>
</tr>
<tr>
<td>Gleaning restrictions</td>
<td>1</td>
<td>4.8</td>
</tr>
<tr>
<td>New generation is less interested in gleaning</td>
<td>1</td>
<td>4.8</td>
</tr>
<tr>
<td>I do not know</td>
<td>1</td>
<td>4.8</td>
</tr>
</tbody>
</table>

4.1.1. Availability: results from focus groups discussions

Results from the two focus group discussions reveal that seagrass-associated gleaning activities in Kaole were initiated during the Mwinyi presidency (1985-1995), as a result of increased costs of living. During that time, there were plenty of accessible invertebrates to collect in the area. The number of gleaners then increased during president Mkapa (1995-2005) and people came from other areas to collect invertebrates in Kaole. The demand for sea cucumber was high and one could make good business collecting and selling the specimens. As a result of increasing collection, invertebrates began to decline and the collection of sea cucumber decreased during the end of the Mkapa presidency as well as during the first years of the succeeding President Kikwete (2005-2015). During the current president (from 2015 and onwards), gleaners have moved into the mangrove areas for invertebrate collection (Appendix C).

4.1.2. Availability: results from observations and gleaning landings

Field observations and preliminary findings from the IPSN gleaning landing survey showed that the mollusc specie *Volema pyrum* represented 90-95% of the total catches, which were weighed and observed in early March 2019. The gleaning landings and observations also revealed that seven kilograms was a good, and well above average, catch from the seagrass and sand associated areas, while catches of the mollusc specie *Terebralia palustris*, from the mangrove area, nearly could be as big as one could manage to carry.

4.2. Accessibility

4.2.1 Accessibility: results from structured interviews

Concerning the accessibility of invertebrates, the women usually walk between half an hour and five hours to find their invertebrates when gleaning in seagrass, with 3 hours being the median length. Many women added that they often start the gleaning activity early in the morning, before the sun gets too hot. The respondents gave different answers concerning in which area you find the best invertebrates and some gleaners mentioned two areas. The most common answer was “towards Bagamoyo town” (43%, n=13). Other areas that were mentioned were “outside Kaole village” (33%, n=10), “near the mangroves” (20%, n=6), Mbegani area (17 %, n=5), “in the whole area from the

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3 One person explained: “Around 2005, there was a high demand for sea cucumber from rich people and people came from different places to glean them. They were collected day and night (using a torch). The lifestyle got better. By 2009 the collectors had increased and the catch of sea cucumber was decreasing. The government then prohibited the collection.”
mangroves to Bagamoyo town” (3%, n=1) and “during high tides, at night” (3%, n=1), (Figure 5). Two respondents (7%, n=2) thought that “it varies” and one person (3%, n=1) thought that good invertebrates are “nowhere” to be found. All but one person answered that they can access their preferred gleaning location and that they do so by foot. The only person who cannot access her favoured area was the respondent who mentioned high tide gleaning during night-time.

Fig. 5: Satellite photo of the coastal area where the gleaning takes place (Google Maps, 2019b). Kaole village is situated to the left of the Kaole ruins, where the mangrove area begins/ends. Bagamoyo town begins by the Funky Squids Hotel.

A great majority of the women (90%, n=27) thinks that it is difficult or dangerous to perform gleaning in seagrass. The most common reason, which was stated by 21 respondents (70%, n=21), was that you might get cut, pierced, chased or grabbed by different invertebrates or fish. In addition to this, three women find the hot sun is challenging, two stated that you have to dig with your hands to find invertebrates, two thought that you have to walk far and mentioned that you might fall into holes in the seabed. Of those women who did not see any difficulties with seagrass gleaning (10%, n=3), one person added there are some challenges, but they are not significant.

Of those 24 women who are currently active in gleaning, and the one who is returning to this activity (total n=25), a majority (64%, n=16) would glean in another place if they could no longer access the seagrass related gleaning areas. All but one specified that this other place would be in the mangroves. Eleven of the women (44%, n=11) who would glean in another place (mangroves) would combine this with another activity. Nine of the women (36%, n=9) would stop all gleaning and merely try another activity (Figure 6).
Of those 20 respondents (80%, n=20) who would try another activity either in combination with or instead of gleaning, a small food business was the most common answer given by thirteen women. Four respondents would do another, non-food related, small business, while three women would engage in agriculture. In addition to this, one person would focus on chicken farming, one would become a fish vendor and one would make mats. A couple of respondents would combine several activities, which is why the total number of activities exceed 20. As revealed by the question on alternative livelihoods, all but one woman who replied that they would engage in another activity already had such activity going, either fully (n=12) or partly (n=7). The question on alternative livelihoods also revealed that of all active gleaners (total n=25), most of them (88%, n=25) already had alternative incomes (Table 3).

Table 3: Of all interviewed women in Kaole, Tanzania (total n=30), 25 were still active in gleaning. Amongst those active gleaners, 22 stated that they have alternative livelihoods besides gleaning. The table displays the alternative livelihoods of those 22 active gleaners.

<table>
<thead>
<tr>
<th>Additional incomes (gleaner)</th>
<th>n=22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small food business (not specified)</td>
<td>4</td>
</tr>
<tr>
<td>Small food business (selling fish and poultry)</td>
<td>1</td>
</tr>
<tr>
<td>Small food business (cooking and selling porridge)</td>
<td>1</td>
</tr>
<tr>
<td>Small food business (cooking and selling samosas)</td>
<td>1</td>
</tr>
<tr>
<td>Small food business (roasting and selling groundnuts)</td>
<td>1</td>
</tr>
<tr>
<td>Small food business (baking sweet bread)</td>
<td>1</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2</td>
</tr>
<tr>
<td>Small business (selling clothes)</td>
<td>2</td>
</tr>
<tr>
<td>Small business (cleaner)</td>
<td>2</td>
</tr>
<tr>
<td>Small business (laundry)</td>
<td>1</td>
</tr>
<tr>
<td>Small business (mat making)</td>
<td>1</td>
</tr>
<tr>
<td>Small business (gaming, mobile credits, product promoter)</td>
<td>1</td>
</tr>
<tr>
<td>Small business (hairdresser)</td>
<td>1</td>
</tr>
<tr>
<td>Small business (selling washing powder)</td>
<td>1</td>
</tr>
<tr>
<td>Small business (collecting and selling wood)</td>
<td>1</td>
</tr>
<tr>
<td>Small business (not specified)</td>
<td>1</td>
</tr>
</tbody>
</table>

Of those women who were still gleaning in seagrass or would uptake this activity (total n=25), ten women (40%) were living in households where the other income earner (husband, son, brother or
other relative) also depends on the ocean, either by being a fisherman or by being a fishmonger. In three households, the other income earner engaged in two different activities, which is why the total number exceeds 25 (Table 3). In those five households where the gleaner had stopped gleaning, there were no other income earners that depended on the ocean.

Table 4: Of all interviewed women in Kaole, Tanzania (total n=30), 25 were still active in gleaning. The table shows additional incomes from other family members in those 25 households that are active in gleaning in Kaole village, Tanzania. The percentage indicates the share of responses from the 25 active gleaners (multiple answers possible)

<table>
<thead>
<tr>
<th>Additional incomes (husband/other family member)</th>
<th>(n=28)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisherman</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Construction work</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>No other income earner</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Traditional doctor</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Service sector</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Animal farming</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Fishmonger</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Small business</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Concerning the overall access to different protein sources amongst those women who were still active in gleaning (total n=25), all but two gleaners had everyday access to at least one protein source and a majority of the women (64%, n=16) had everyday access to two or more protein sources. The two women who did not have everyday access to any of the protein sources, still had access to finfish, invertebrates and legumes a few days a week. This suggests that they in total are likely to have daily access to at least one protein source. One of them also had access to tree nuts a few times a week. The two respondents without everyday access to any of the different protein types were both single women, one with children and five people to feed in the household, the other woman lived with her brother, working as a fisherman, but whose boat was confiscated due to illegal fishing activities.

The most commonly accessed and consumed protein sources were finfish and legumes, which all women had access to and 16 respondents (64%) would have those proteins on an everyday basis. Although being accessible to all respondents, invertebrates were consumed to a lesser extent and some interviewees would add that they cannot eat invertebrates daily, since they want dietary variation (Figure 7).
Fig. 7: The diagrams show how frequently the 25 interviewed women, which were still active in gleaning in Kaole village, Tanzania, could access different protein sources. The diagrams display access to a) finfish protein, b) invertebrate protein, and c) legumes protein.
By summarising the total amount of days a week\(^4\) or month a certain protein is accessed by all active gleaners in Kaole (total n=25) on an annual basis, one can get a rough overview of which proteins are most frequently consumed. The results indicate that eggs and invertebrates are accessed at a similar proportion (Figure 8). However, eggs were not accessible to all respondents in the same way as invertebrates are. Three women had no access to eggs and three had only access to eggs once or twice a month. Of the total amount of consumed animal sourced protein, approximately 55\% were fish sourced (finfish or invertebrates). Looking at all protein sources, fish sourced proteins constituted nearly 39\% of the accessed protein. These calculations are only rough estimations. The questionnaire did not reveal if any gleaner would consume some protein types on several occasions during the same day, nor how much of each protein was consumed at each occasion.

![Pie chart showing protein sources](image)

**Fig. 8**: The pie diagram shows the proportion of the total access to different protein sources amongst those interviewed women who were still active gleaners (n=25) in Kaole village, Tanzania. The numbers displayed within the pie diagram indicate the total number of times that each protein was accessed by all active gleaners on an annual basis (12 month period).

### 4.3. Utilisation

#### 4.3.1. Utilisation: results from structured interviews

Of those women who were still active in gleaning (total n=25), 16 were gleaning for both home consumption and income purposes. The most common investment for incomes generated from seagrass-associated gleaning was to buy other foods or pay for costs related to children’s education (Figure 9).

\(^4\) In this calculation "a few days a week" was counted as three days a week. A control calculation, where "a few days a week" was translated into two days a week did not show any significant difference on the total share in percentage of how often the different proteins were consumed.
Concerning sanitation and food safety, all but two women of those who were still gleaning or would uptake the activity (total n=25) said they could store their seagrass-associated invertebrates for later consumption, using a combination of different techniques. The most common way to store invertebrates was cold storage (68%, n=17). Other techniques that were mentioned were boiled (52%, n=13), sundried (36%, n=9), salted (4%, n=1) or smoked (4%, n=1) invertebrates. Some women who used cold storage, to keep their invertebrates for later consumption, explained that they rent storage space in a neighbour’s fridge, for a fee. Those two women who did not store their invertebrates both said that the catch is too small to store. One respondent added that invertebrates from the mangroves are easier to store. If being isolated from freshwater, they can be stored in a sack for up to a month.

4.4. Stability over time

4.4.1. Stability over time: results from structured interviews

Concerning stability over time, 29 (97%, n=29) of the present and past gleaners (total n=30) thought that the invertebrate catches vary over the northeast monsoon (*kaskazi*) and southeast monsoon (*kusi*). The majority of the respondents (80%, n=24) think that you get the best catch during the southeast monsoon and see that as the season for invertebrate gleaning in seagrass. Another three respondents (10%, n=3) believed that the catch varies with the seasons, without describing how. Two women (7%, n=2) believed that the northeast monsoon is the main season for gleaning in seagrass. The remaining person (3%, n=1) did not believe that there is much difference between the seasons and stated “you find them in both seasons if determined”.

Gleaning in seagrass is something the women do between nil to seven days a month, which was the span given by 23 of the total 25 respondents, who were still gleaning or would uptake the activity. The median amount of days amongst those women was five days a month and the mean was 3.5 days a month. Of the remaining two women, one replied that it depends on the target she sets and the other replied “everyday”. Everyday is, however, impossible since the gleaning activity requires low tides.

Amongst all present and past gleaners that participated in the interviews (total n=30), climatic conditions/weather was the most common factor believed to pose a threat to seagrass-associated invertebrates. Two gleaners did not identify any threat towards the ecosystem and invertebrates

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5 As described in footnote 1 and 2, *Kusi* is the southeast monsoon, which stretches from June to August each year, while the northeast monsoon, *Kaskazi*, stretches from December to February each year. The periods in between are transition periods, partly associated with rainfalls (Okoola, 1999). According to the answers from the gleaners, they seem to include both the transition periods into their definition of *kusi*.
themselves, but rather identified the cost of the newly introduced gleaning licence of 20 000 TZS\(^6\) per ecosystem, as well as official patrolling to prevent illegal fishing in the area, as threats to the gleaning activity itself (Table 5).

Table 5: The table indicates what threats all interviewed gleaners (total n=30) in Kaole village, Tanzania, identify towards seagrass-associated invertebrates (multiple answers possible). The percentage indicates the share of responses (n=41) from the interviewees.

<table>
<thead>
<tr>
<th>Threat to invertebrates</th>
<th>(n=41)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climatic conditions/weather</td>
<td>13</td>
<td>43</td>
</tr>
<tr>
<td>I do not know</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>Waste water</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>Other: fishing gear</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Other: environmental pollution</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Industry</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Tourism</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Too many gleaners</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Plastic</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Ecological changes that decrease the invertebrates</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Other: the ocean itself is changing</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Other: not everyone can afford the gleaning licence</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Other: patrolling to prevent illegal fishing frighten gleaners</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Of all interviewed women (total n=30) a majority (70\%, n=21) thought that there are things one should do to protect the invertebrates for future generations. To reduce collection was the most common suggestion, mentioned by eight respondents (27\%, n=8). The second most common answer was relating to fishers, who should be strictly patrolled and prevented from using illegal fishing techniques as well as being careful not to destroy breeding sites (17\%, n=5). Other suggestions to protect the invertebrates were to “stop collection” fully (3\%, n=1), “protect invertebrates by strict laws” (3\%, n=1), “introduce fishing permissions” (3\%, n=1) “initiate aquaculture” (3\%, n=1), and “introduce better conservation policies that are integrated with mangrove and fishery conservation” (3\%, n=1). The remaining three people (10\%, n=3) thought they should be protected but did not know how.

Five respondents (17\%, n=5) thought that invertebrates do not need to be saved for future generations. Two of them (7\%, n=2) explained that it is difficult to conserve them when most people in the village depend on the ocean. One person (3\%, n=1) thought that they “reproduce on their own”, another respondent (3\%, n=1) gave no explanation to her answer and the last person (3\%, n=1), thought that “there is no deal with the seagrass related invertebrates because they are so few and it is better to glean in the mangrove”. This was the person who gleaned most frequently of all respondents. She was also the only person without any other income generating activity. The remaining respondents (13\%, n=4) had no opinion on whether or not one should protect seagrass-associated invertebrates for future generations.

\(^6\) Approximately 8.6 USD per 10 April 2019
The final question in the questionnaire asked gleaners to rate the importance of seagrass-associated invertebrates for providing food to the household. Amongst those women who were still gleaning in seagrass and the person who were about to uptake the activity (total n=25), the vast majority (80%, n=20) described this activity as very important (44%, n=11) or important (36%, n=9) to provide food/protein to the household, either by direct consumption or indirectly by providing income to buy other foods. One respondent who rated the gleaning activity as “very important” explained; “sometimes you have nothing to eat in the household and only 500 TZS available”. Another person added that it is “very important”, since “my husband had an accident”. Of those respondents who thought that gleaning in the seagrass was either “not so important” or “not important at all”, they were all married and all but one had other income generating activities. The one who had no other income-bringing activity had been gleaning in the seagrass for 25 years and explained that “gleaning is our culture”, and hence saw no other option than gleaning in the mangrove ecosystem. She had tried to organise groups for gleaning in the mangrove, but explained that there are not so many interested or “they are lazy”.

4.4.2 Stability over time: result from focus groups discussions

Results from the focus group discussions indicate that many potential stressors to the marine area and the gleaning activities appeared during the Mkapa presidency (1995-2005). Besides the increase in gleaners, illegal and destructive fishing gear, such as dynamite fishing, dredging nets, plant-based poison, seine fishing close to the shore and trawling, were introduced. It was also the time era when gleaners and fishers began noticing rising water temperatures, as a possible effect of climate change. If both mangrove and seagrass ecosystems were dense and of good status the first three decades after national independence, the focus group discussions revealed that both mangrove forests and seagrass meadows began to decline during President Mkapa, and have thereafter continued to do so. The increasing pressure on natural resources over the last decades have coincided with an increasing population, increasing costs of living, lack of alternative livelihoods and poor transport network, as well as establishment of some hotels in the area. The demand for mangrove trees, for charcoal making, has increased, and in the last years there have been illegal fishing activities taking place during night-time (Appendix C).

The focus groups further revealed that there have over time been different measurements to control and protect fisheries and the marine environments, but those have been of limited success. Protective laws concerning the mangrove areas as well as fishing licences were in place already during the first presidential era (1964-1985), but have generally not been strictly followed and enforced. During President Kikwete (2005-2015) a Marine Protection Area (MPA) was introduced, but failed during the same presidential period. While there have been no particular measures exclusively aimed to protect local seagrass ecosystems, there are now new regulations in place that require licenses for gleaning, both in the seagrass and in the mangroves (Appendix C). These licenses cost 20 000 TZS/year. A few key informants further raised questions whether it would be possible to initiate seagrass restoration in the area.

5. Discussion

Observations revealed that both seagrass and sand habitats are gleaned on the same occasion. While the most gleaned invertebrate is found to be both seagrass and sand associated, the initial invertebrate identification indicates that respondents also included invertebrates from sand habitats when asked about what invertebrates they fish in seagrass. Similar to the findings in de la Torre-Castro and Rönnbäck (2004), further investigation is hence needed on the degree these species rely on seagrass meadows. The results from the local ecological survey of seagrasses and invertebrates (Eklöf et al., 2018), conducted by the local IPSN team, will shed more light on this. The survey includes comparisons between seagrass vegetated and un-vegetated areas. The additional gleaning landing

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7 500 TZS was worth approximately 0.22 USD per 10 April 2019
8 Seine fishing is a fishing method where you use a fishing net called a seine
9 Approximately 8.6 USD per 10 April 2019
surveys (Nordlund and Cullen-Unsworth, 2018), which are planned within IPSN, will also be helpful by better connecting gleaned invertebrates to either sand or seagrass habitats.

With this limitation in mind, this study reveals that a great majority of the gleaning women in Kaole regard seagrass-associated gleaning as “important” or “very important” for providing food to the households. They rate it as important or very important despite a decline in seagrass-associated invertebrate gleaning, increased gleaning activities in the adjacent mangrove area and the fact that a majority of the women have alternative incomes. The findings are here discussed along the food security concept and connected to other research and debates. Since availability, accessibility, utilisation and stability over time are highly interlinked, some of the results are discussed in relation to several of these components. The potentials and problems relating to aquaculture, marine protection, alternative livelihoods and seagrass restoration as means to enhance food security and ease pressure on ecosystem services are given particular focus.

5.1. Availability

Similar to studies in Zanzibar (Cullen-Unsworth et al., 2014; Fröcklin et al., 2014; Nordlund et al., 2010), the decline in available invertebrates in the seagrass-associated areas in Kaole has coincided with a number of anthropogenic stressors, such as over-fishing and an increasing number of people using the resource. According to the focus group discussions, the decline in invertebrates has also been concurrent with degrading seagrass meadows. Besides destructive fishing techniques that may result in seagrass loss (e.g. Orth et al., 2006; Wilkinson and Salvat, 2012), there are several studies indicating that trampling on seagrass beds also may deteriorate their status (Eckrich and Holmquist, 2000; Garmendia et al., 2017; Travaille et al., 2015). The gleaning activities themselves may hence stress the meadows. Whilst the results indicate that gleaning activities peaked sometimes around 2005, when business was still profitable and gleaners came from surrounding areas, declines in sea cucumber and other invertebrates were reported from the Bagamoyo area already in 1998 (Semesi et al., 1998). The discrepancy in the results from the focus group discussions and this previous study of Bagamoyo’s coastal resources could perhaps be an indication of the shifting baseline syndrome (Pauly, 1995).

Sea cucumbers have traditionally not been part of the local diet, although it was reported in the late 1990s that some locals had begun to eat them (Semesi et al., 1998). The Tanzanian trade in sea cucumber has rather been directed towards Asia (Jiddawi and Öhman, 2002; Semesi et al., 1998), where Chinese demand increased in the late 20th Century (Eriksson et al., 2012). The increased demand has often been met by unsustainable fishing rates and resulted in closure of many sea cucumber fishing activities across the globe (Anderson et al., 2011). In Kaole, the declining invertebrate abundance of both sea cucumber and other invertebrate species has resulted in a decreasing number of people that engage in gleaning activities, at least for commercial purposes. Amongst the respondents, there was only one person who gleaned for income purposes only. If sea cucumber had been sustainably collected, it could perhaps have continued to generate incomes to Kaole and benefit food security indirectly. This rise and fall of local sea cucumber collection also reminds about the importance to map who benefits from ecosystem services in space and time, if one wants to meet the multiple goals of food production, ecosystem integrity and resilience (Poppy et al., 2014).

When productive ecosystems or fish stocks are degraded or overfished, the capacities to deliver food security may be reduced (HLPE, 2014). In the face of degraded seagrass meadows and decreasing invertebrate catches, this study finds that gleaners in Kaole have moved some of their gleaning activities into the adjacent mangrove area, where invertebrates still are abundant. Whilst seashell collection in Bagamoyo’s mangrove ecosystem is no new phenomenon (Semesi et al., 1998), it is only in the last four years that the interviewed women in Kaole have shifted their activities to include that area. Similar trends have previously been reported from Zanzibar, where mangrove-associated invertebrate gleaning had become increasingly important by 2010 (Fröcklin et al., 2014).

Like seagrass meadows, mangrove ecosystems are highly productive ecosystems (Moberg and Rönnbäck, 2003; Rönnbäck, 1999). These ecosystems are dominated by tropical mangrove trees (Field, 1999) that also provide three-dimensional, structured, habitat for aquatic species. Like seagrass,
they hence offer better protection for juvenile aquatic vertebrates and invertebrates than sand and mud flats (Lefcheck et al., 2019), and are important ecosystems for food provisioning (Rönnbäck, 1999). The whelk species *Terebralia palustris* is plentiful in the mangrove area and gleaners can harvest as many animals as they manage to carry. In the short term, fishing in mangrove may hence ease some of the human pressure on the seagrass-associated ecosystems, as well as add positively to the food security of the gleaning households, by offering a high invertebrate abundance. At the same time, the newly initiated gleaning in the mangrove area raises questions on future availability. Will the problems associated with over-fishing only be displaced into a new area, in particular since the demand for mangrove trees for charcoal making also is increasing and populations are growing? The demand for charcoal and timber has in some places in Zanizbar been reported to degrade mangrove ecosystems (Nchimbi and Lyimo, 2019), hence increasing the risk of habitat loss. A study in South Africa found that *Terebralia palustris* had declined or disappeared from areas where they previously had been recorded in the 1960s, probably due to habitat degradation (Raw et al., 2014).

While only one respondent suggested aquaculture as a mean to provide invertebrates for future generations, this is commonly seen as having the potential to fill the gap between increasing demands from a growing population, on the one hand, and fish stocks that are limited by ecosystem’s productivity, on the other hand (HLPE, 2014; Merino et al., 2012; Willett et al., 2019). Similar to gleaning, which in places like Kaole and Zanzibar has a clear gender aspect to it (Fröcklin et al., 2014), aquaculture may also be a homestead based livelihood (Jahan et al., 2010). It could hence integrate well with prevailing cultural norms in countries where women primarily involve in household activities (Jahan et al., 2010). However, it is often better off households that benefit from aquaculture (Béné et al., 2016; Nguyen et al., 2016) Low education levels, limited incomes and missing access to information and finance, along with lacking access to water and land, are generally obstacles for poor households to run their own aquaculture farms (Béné et al., 2016). Many gleaners in Kaole live on very limited resources, lack savings, electricity and market access to Bagamoyo town, which would be valuable assets for any aquaculture business. Another potential problem with aquaculture is that increasing fish supplies can keep fish prices down and instil competition with wildly caught fish (Béné et al., 2016). This mainly benefits consumers who buy fish, while fishermen and gleaners, who may not find employment in aquaculture, may face decreasing incomes. Although the research on sustainable aquaculture is rapidly evolving, it also struggles with significant environmental challenges (Troell et al., 2014; Willett et al., 2019). Both traditional aquaculture (Herbeck et al., 2014) and lower impact seaweed farms can have negative effects on adjacent seagrass meadows (Eklöf et al., 2005; Lyimo et al., 2007).

If aquaculture has the potential to increase the availability of fish based protein, both globally and locally, it does not provide the kind of freely accessible food as gleaning activities do (Hoisington et al., 2001).

### 5.2. Accessibility

Although most women point to difficulties and dangers connected to seagrass-associated gleaning, the study confirms earlier findings (Cullen-Unsworth et al., 2014; de la Torre-Castro and Rönnbäck, 2004; Fröcklin et al., 2014; Nordlund et al., 2010) that seagrass-associated gleaning generally is an accessible food source, mostly conducted women and sometimes children. While nearly all respondents also glean in the mangrove forest and this ecosystem is more preferred, due to its high invertebrate abundance, observations revealed that gleaning in this area is challenging and less accessible than seagrass-associated areas. Because of mangrove stems and knee-deep mud, it is easy to get hurt and challenging to bring the harvest home (Figure 10). These conditions make the mangrove-associated gleaning less accessible to those with small children to care for, as well as for potential gleaners with physical disabilities or elderly, population groups that are at risk to be more vulnerable to food insecurity than others (Ellis, 2003; Lamidi, 2019). The difficult conditions may also explain why this area is less popular amongst respondents above 40 years of age.
The results further show that most gleaners think that measures should be taken to protect invertebrates for future generations. Reduced gleaning and better control of illegal fishing were the most common suggestions, and one person thought that gleaning should stop completely. The focus groups gave no insight into the design and reasons of past failures of marine protection in Kaole. Marine Protection Areas (MPAs) have, however, been a common approach to protect marine areas from exploitation and sustain marine biodiversity in Tanzania and elsewhere (e.g. Jones, 2011; Kamat, 2014; Kamukuru et al., 2004; Sesabo, 2007). In relation to seagrass loss caused by increasing anthropogenic pressures, there has also been an increasing number of MPAs that include seagrass ecosystems, monitoring and restoration projects across the globe (Orth et al., 2006). Yet, there are several studies suggesting that MPAs may have limited effect on the status of seagrass meadows, since successful programs also need to tackle land use and water quality issues, which often are missing (Orth et al., 2006; Quiros et al., 2017). MPAs may also have a negative effect on local food security, by potentially reducing the ability of coastal communities to access food (Kamat, 2014). Approximately 55% of the total amount of animal sourced protein accessed amongst gleaners in Kaole was either finfish or invertebrates. This is remarkably higher than the global average and compares with levels in small island developing states, as well with countries like Bangladesh, Ghana and Sierra Leone (FAO, 2016). The results also showed that 72% of incomes generated from seagrass-associated gleaning were invested in different household needs, with food purchases being the most common expenditure. Marine protection hence risks to restrain both the direct access to marine sourced protein and limit the access to other foods (Kamat, 2014), if not initiated correctly.

Another common approach to protect species, habitats or other natural resources from poverty-driven and degrading human activities is Alternative Livelihood Projects (ALPs). The basic idea is to reduce pressure on ecosystems through the provision of food or income substitutes that provide corresponding benefits (Wright et al., 2016). This has been applied to prevent people from consuming bushmeat (Wicander and Coad, 2015), but has also been used to reduce unsustainable pressure on natural resources in coastal regions (Ireland et al., 2004; Katikiro, 2016). While ALPs might sound promising, there are limited evaluations of such projects and its effectiveness for nature conservation is not always monitored (Roe et al., 2015; Wicander and Coad, 2015). Wright et al., (2016) warn that ALPs tend to be based on flawed assumptions that providing alternatives will diminish people’s need to
exploit natural resources. New incomes risk becoming supplementary and destructive resource contraction may continue. Most active gleaners in Kaole (88%) already have alternative incomes and there is a risk that ALPs only become incorporated into the overall mix of different livelihood activities, rather than replacing the existing resource degrading activity (Roe et al., 2015). There is also a tendency that communities are seen as homogenous in the design of ALPs, ignoring social and political structures on the local level that usually control access to resources. Even if the right individuals are targeted, it does not guarantee that this will scale up and reduce impact on natural resources from the community as a whole. Alternative incomes for one household member may only result in reallocation of labour and increased effort by another household member to use the targeted resource (Wright et al., 2016). The results from Kaole village indicate that most gleaners engage in different alternative livelihoods, which are not competitive with one another. This is important since most women lack access to larger markets in Bagamoyo town and most products are sold within the community. This is an example of local social and economical structures that any potential ALP would need to consider. In relation to the inward migration to the Bagamoyo area and the predicted population growth in Tanzania as a whole, there is also a risk that the potential gains from alternative incomes may be diluted by births and inward migration. This was the case of a seaweed project in the Central Philippines that aimed to decrease pressure on exploited fisheries (Hill et al., 2012).

Whilst the before-mentioned, seagrass-associated, study in the Philippines found that proximity to a major urban city and alternative incomes can decrease people’s vulnerability to degrading seagrass resources, those were salaried jobs (Quiros et al., 2018). Such incomes can probably not compare to the alternative livelihoods amongst gleaners in Kaole, where the food or goods are produced and sold from home. This can perhaps explain why most gleaners rate the seagrass-associated gleaning as “important” or “very important” for providing food to the household, despite having alternative incomes. Some respondents accordingly expressed concerns that seagrass protection would be difficult since everyone in the village depend on the ocean. One person also identified the newly introduced gleaning license as a threat to the gleaning activity itself, since not everyone can afford this fee.

5.3. Utilisation

The seagrass-associated invertebrate gleaning in Kaole is used for direct consumption as well as for indirect access to foods and other needs in the household. Besides consumption, the shells may also be sold and used for interior decoration, jewellery and construction purposes. In addition to giving indirect access to other foods, the money generated from seagrass-associated gleaning was also invested in children’s education and other household needs. While this study gave no assessment of how local men spend their incomes, there is much evidence that women and men, in many parts of the world, tend to spend money differently. Women are more likely than men to spend incomes they control on healthcare, children’s education and food (Meinzen-Dick et al., 2011; UN Women, 2017). Earlier findings suggest that women generally invest as much as 90% of the income in the household, while men’s share is less than half of that (OECD 2009, referenced in Wong et al., 2017). Even if gleaner’s investment in the Kaole households were lower, with 72% being invested in household needs or 78% if one includes savings, the findings confirms earlier studies that women’s income bringing activities may play an important role for families wellbeing.

The results also show that there are many different techniques to process and store invertebrates in Kaole. Preservation and storage is particularly important concerning seafood, which is a versatile food that can spoil more rapidly than other foods (FAO, 2018), particularly in tropical environments (Akinintola and Fakoya, 2017). These techniques can prevent post-harvest losses and keep invertebrates for consumption on other days than harvesting day. Although many gleaners lack electricity there are several possibilities to pay a fee and store invertebrates in neighbouring houses with fridges available. Invertebrates can also be collected and consumed by households in a single meal, removing the need for storage, which would be needed for animal sourced protein from large livestock animal species.

It is well known that marine invertebrates are highly nutritive food as concerns proteins, vitamins, minerals and essential fatty acids (Venugopal and Gopakumar, 2017; Zarai et al., 2011), which may be difficult for people in developing countries to access in other ways (Béné et al., 2015; Willett et al.,
2019). But there is no available data that can give the exact nutrient composition for the seagrass-associated *Volema Pyrum*. This was found to be the most commonly fished invertebrate in the area, at least in early March when this study was conducted. Nor is there any data for the mangrove-associated *Terebralia palustris*, which could allow a comparison between their nutritional content. Although the FAO/INFOODS (2016) database include composition estimations of 152 crustaceans and 114 mollusks, there are more than 1000 crustaceans and 50 000 species of mollusks in the ocean (Venugopal and Gopakumar, 2017), and only the most commonly consumed and commercially valuable invertebrates are included in the data.

Considering the nutritional benefits it might not be surprising that invertebrates and finfish are considered as important complements to other protein sources (Béné et al., 2015), such as legumes, which are highly consumed in Kaole. At the same time, food safety risks could potentially represent a barrier to frequent consumption of wild fish (Henchion et al., 2017). Besides process-related hazards, there are a number of environmental hazards, such as microbial pathogens, parasites, biotoxins, heavy metals, pesticides and other chemical pollutants from their habitats, which pose a potential risk to consumption of invertebrates (Venugopal and Gopakumar, 2017). Studies on risks versus benefits have, however, concluded that the nutritional benefits clearly overshadow the risks among the general population, when a variety of shellfish is consumed (Venugopal and Gopakumar, 2017). In communities with limited food options, seagrass-associated fishery may also remain a major food source, despite official warnings not to eat shellfish (Cullen-Unsworth et al., 2014).

5.4. Stability over time

The results indicate that seagrass-associated gleaning is a seasonal activity. Although other studies (e.g. de la Torre-Castro and Rönnbäck, 2004; Hockey and Bosman, 1986) describe gleaning as an activity that usually takes place during low spring tides, gleaners in Kaole mention that you find invertebrates from March to November. Two gleaners also suggested that you could glean and find invertebrates in all seasons, if determined. Even so, it does not seem to be a reliable food source for the whole year around. The questionnaire gave no insight into how the low season may affect gleaners’ incomes and food security, if they live on alternative incomes or if they have enough invertebrates stored from high season. Two respondents who preferred to glean in the mangrove ecosystem mentioned that one might glean there the whole year around. This is in line with an earlier study in the area that found that the mangrove-associated *Terebralia palustris* invertebrate is available all year (Semesi et al., 1998). The findings suggest that the mangrove area hence could be a more reliable food source around the year.

The results further showed that many globally identified threats towards seagrass ecosystems (Orth et al., 2006; Wilkinson and Salvat, 2012) are also found in Kaole. While climate change needs to be handled on the global scale, some key informants in the village raised questions concerning the feasibility of seagrass restoration in the area, as a mean to improve ecosystem services and improve the chances of future food security. While there are ongoing projects, for example in Australia, aimed to restore seagrass meadows, costs are generally high and outcomes uncertain (Orth et al., 2006). Although success rates may be higher in some locations, earlier studies have indicated that seagrass transplantation and restoration only is successful in approximately 30% of the cases (Fonseca et al. 1998). In a recent review of nearly 1800 seagrass restoration trials, seagrass survival was recorded in 37% of the cases, with large-scale planting increasing survival rates. The study also confirmed that removal of threats is crucial prior to replantation. Reduced water quality, mainly through eutrophication, as well as construction activities were identified as more severe threats to successful restoration efforts than local direct impacts, including dredging and natural causes (van Katwijk et al., 2016). These findings are similar to other studies, which conclude that seagrass restoration or conservation efforts must address large-scale problems that affect seagrass meadows. As mentioned above, MPAs may have limited effect on the status of seagrass meadows, as long as they do not include land use practices and water quality (Orth et al., 2006; Quiros et al., 2017).

Most restoration projects have exclusively been pursued in the Northern hemisphere (van Katwijk et al., 2016), or in so called developed countries, and there seems to be limited experience on how such projects would work in coastal regions, where people are dependent on these ecosystems for their day
to day food security. After removing significant threats, any restoration project should, however, be weighed against the seagrass capacity to recover naturally (Orth et al., 2006). A restoration project requires careful site selection and application of appropriate techniques (van Katwijk et al., 2016).

5.5 The way forward

Considering that most gleaners perceive seagrass-associated invertebrate gleaning as important or very important for providing food and income to their household, and that a majority of the women believe that this food source should be protected for future generations, there seem to be momentum amongst gleaners to initiate sustainable change. The identified problems in connection to aquaculture, marine protection, alternative livelihoods and seagrass restoration do not imply that such measures can’t be tested. It is rather a reminder that there are no easy solutions available when trying to maintain both ecosystem integrity and food security in rural communities with high reliance on local natural resources, and there will most often be trade-offs (Poppy et al., 2014).

As already proposed in so many other studies (e.g. Poppy et al., 2014; Semesi et al., 1998; Unsworth et al., 2018b), sustainable management and conservation of local marine ecosystems require interdisciplinary approaches that are sensitive to both social and ecological needs. The local community and its characteristics must be integrated into marine management (Sesabo, 2007) and one must find sustainable solutions for small-scale fishery (de la Torre-Castro et al., 2014). Whilst this paper did not provide any deeper assessment of why different conservation and management efforts have failed in the past, the general impression is that such measures mainly have been a top down process and not fully integrated with one another. Considering the moderate success of past management efforts of small-scale fishery, it would also be worth trying new governance approaches that include previously excluded actors, such as women, into the process (de la Torre-Castro, 2019). Several of the interviewed women had ideas on how to protect the seagrass-associated resource base and as one gleaners expressed, “one should introduce better conservation policies that are integrated with mangrove and fishery conservation”

6. Conclusion

This case study has showed that a great majority of the women that engage in seagrass-associated gleaning in Kaole rate this activity as important or very important for providing food to the household. The seagrass-associated gleaning activities were perceived as important, despite the fact that most women also glean in the mangrove area and that almost all women have alternative incomes. Seen through the food security lens, it is, however, questionable how significant this activity is for food security. Availability has decreased and it is not a food source that is stable throughout the year. In these respects, the mangrove area seems to provide a higher sense of food security. Invertebrates are abundant in the mangrove area and the mollusc Terebralia palustris seems to be available throughout the year. The findings also suggest that the mangrove-associated Terebralia palustris may be easier to utilise, considering that you can store it in a sack, without being kept cold. At the same time, gleaning in the mangrove area is less accessible to potential gleaners with small children, elderly and people with physical disabilities. The study further found that the decline in seagrass-associated gleaning activities have coincided with a number of human stressors and deteriorating seagrass meadows.

More research is needed to determine the nutritional content and potential toxic contents in the most fished invertebrate species. Coming studies will also shed better light on the exact proportion of seagrass-associated invertebrates extracted from the intertidal area. Even if seagrass associated gleaning presently seems to be of decreasing significance for providing food security, a majority of the women rate this fishery as important or very important and wants to protect it for future generations. Against this background, immediate action should be taken to sustainably preserve this provisioning resource. Bearing in mind the fine balance between ecological and food security needs, conservation measures need to be interdisciplinary and involve different community members, as well as other stakeholders.
7. Acknowledgements

My biggest gratitude goes to my supervisor Dr. Lina Mtwana Nordlund. Without her enthusiasm and support in arranging the fieldwork, this study would never have happened. She was always available when needed. I also extend my deepest thank you to the Tanzanian team; Dr. Mariam Hamisi, who kindly assisted me with the research permit and to get me out to Kaole; my local supervisor Dr. Liberatus Dominick Lyimo, who came with valuable input on one of my drafts; and Amina Asiya Nchimbi, who assisted me with both translations and her marine knowledge in the field. I would also like to deeply thank my subject reviewer Dr. Johan Eklöf, who gave me much valuable input and recommended some good articles. Any mistakes or misinterpretations in this work are only mine.
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World Bank (2018). Prevalence of undernourishment (% of population) | Data


9. Appendices
Appendix A

Structured interviews: Gleaning and food security in Kaole, Bagamoyo

We study/work at Uppsala and Dodoma universities and are conducting research about the importance of gleaning and food security. We would like to talk to you for a short time and ask some questions about seagrass gleaning (fishing). This interview is totally voluntary, you can decline to take part, and is anonymous. We will not ask your name, the answers cannot be traced back to you. You can cancel the interview at any time and if you want we will delete your answers. Do you agree to participate in this study?

Introductory questions

1. Village/Sex/Age/Education
2. How many years have you performed seagrass gleaning?
3. Do you perform gleaning in any other ecosystem? (which one?)
4. Which ecosystem do you prefer? (and why?)
5. What is the main reason for gleaning in seagrass?
   a. Income
   b. Food for the household
   c. Both
   d. Other, please specify

Availability

6. What kind of invertebrates do you collect in the seagrass?
7. Has the variety changed over time?
   a. Yes. If yes, please describe
   b. No
   c. I do not know
8. During the years you have performed seagrass gleaning in Kaole, do you think that the catch has
   a. increased? Why do you think it has increased?
   b. decreased? Why do you think it has decreased?
   c. remained the same?
   d. I do not know
9. During the years you have performed seagrass gleaning in Kaole, do you think that the number of people that perform gleaning has
   a. increased? Why do you think it has increased?
   b. decreased? Why do you think it has decreased?
   c. remained the same?
   d. I do not know
10. According to your knowledge, approximately how many people in Kaole perform seagrass gleaning?

Accessibility

11. How long do you have to walk during collection? (Hours)
12. If you could no longer access this area, what would you do?
   a. Glean in another place
   b. Stop to do gleaning
   c. Try to do another activity (which one?)
   d. I do not know
13. Is it difficult or dangerous to do seagrass gleaning here?
   a. Yes. If yes, please specify why
   b. No
   c. I have no opinion
14. In your opinion, in which seagrass area do you find the best invertebrates? (e.g. best quality, biggest catch, best value)
15. Can you access that area?
   a. Yes. If yes, please specify how
   b. No. If no, please specify why
   c. I do not know
16. What protein sources (foods) do you have access to?
a. **Beef** (every day/a few days a week/once a week/a few times a month/other)
b. **Lamb/goat** (every day/a few days a week/once a week/a few times a month/other)
c. **Chicken/other poultry** (every day/a few days a week/once a week/a few times a month/other)
d. **Eggs** (every day/a few days a week/once a week/a few times a month/other)
e. **Fish** (finfish) (every day/a few days a week/once a week/a few times a month/other)
f. **Invertebrates** (every day/a few days a week/once a week/a few times a month/other)
g. **Legumes**, e.g. beans, lentils, peas, soy foods, peanuts - (every day/a few days a week/once a week/a few times a month/other)
h. **Tree nuts**, e.g. cashew nuts, (every day/a few days a week/once a week/a few times a month/other)
i. **Bush meat** (every day/a few days a week/once a week/a few times a month/other)
j. **Other**

17. Are there any alternative livelihoods/incomes in your household?
   a. Yes, If yes, please specify which (and who is performing this other livelihood: you, husband, children)
   b. No

**Utilisation and nutrition**

18. What do you do with the catch?
   a. Eat
   b. Sell
   c. Exchange for other foods
   d. Other, please specify

19. If you sell the invertebrate / their by-product, what do you do with the income?
20. How many people do you need to feed in your household?
21. Can you store your catch and eat it later?
   a. Yes
   b. No
   c. I do not know

22. If you can store the invertebrates from seagrass, how is it done?
   a. Smoked
   b. Salted
   c. Sun dried
   d. Boiled
   e. Cold storage: ice/fridge/freezer?
   f. Other

**Stability over time**

23. Does the catch vary over the northeast monsoon (kaskazi) and southeast monsoon (kusi)?
24. How many days a month do you glean in seagrass?
25. How many days a month do you glean in another ecosystem?
26. According to you opinion, is there anything that threatens the provision of seagrass invertebrates?
   a. Industry
   b. Tourism
   c. Too many gleaners
   d. Plastic
   e. Waste water
   f. Climatic conditions/weather
   g. Ecological changes that decrease the invertebrates
   h. Other. Please specify what
   i. I do not know

27. Is there anything one can do to protect the invertebrates for future generations?
   a. Yes. If yes, how do you think it should be protected?
   b. No. If no, why don’t you think it cant be protected?
   c. No opinion/I do no know

28. How important do you think this seagrass gleaning activity is to provide food/protein to your household (either by your own consumption, or through providing income to buy other food/protein)?
   a. Very important
   b. Important
   c. Not so important
   d. Not important at all
Appendix B

Structured interviews: Gleaning and food security in Kaole, Bagamoyo (Swahili version)

Sisi ni wanafunzi kutoka chuo kikuu cha Uppsala Sweden na chuo kikuu cha Dodoma. Tunafanywa utafiti kuhusu umuhimu wa uokotaji wa viumbe baharini na uhakika wa chakula. Tungependa kuvahojo maswali kuhusu akusanyaji wa viumbe vya bahari (uvuvi) kwenye nyasi bahari. Haya mahojiano ni ya kujitolea unaweza kukataa kushiriki. Hatutachukuada mrefu kwenye mahojiano na hatutatoa majibu yako kwa chombo chochote wala mtu yeyeto. Unakabali kua mnoja wa wahoojiwa kwenye hii taftiti ya kinasomo?

Utangulizi

1. Unatokea kijiji gani/Jinsia/Umri/Elimu yako
2. Ni kwa mda gani umefanya hii kazi ya ukusanyaji wa viumbe vya baharini kwenye nyasi bahari?
3. Je unafanya ukusanyaji wa viumbe vya baharini kwenye maeneo mengine? (yapi?)
4. Unapendelea maeneo yapi kwenye ukusanyaji wa viumbe vya baharini na kwa nini?
5. Ni sababu ipi kubwa inayo kufanya ukusanyaji wa viumbe vya baharini kwenye nyasi bahari?  
   a. Kipato
   b. Chakula kwa ajili ya familia
   c. Vyote
   d. Nyinginezo, ainisha

Upatikanaji

6. Ni aina gani ya viumbe bahari mnavyo okota kwenye nyasi bahari?
7. Je aina ya viumbe vya baharini vimebadilika kulingana na muda  
   a. Kama ndio tafadhali elezea
   b. Hapana
   c. Sui
8. Kwa mda uliyofanya ukusanyaji wa viumbe vya baharini kwenye nyasi bahari, unahisi upatikanaji wa hivi viumbi ukoje  
   a. Umeongezeka. Kwa nini unahisi umeongezeka? 
   b. Umepongeuwa. Kwa nini unahisi umepongeuwa? 
   c. Hakuna mabadiliko 
   d. Sifahamu
9. Kwa mda uliyofanya ukusanyaji wa viumbe vya baharini kwenye nyasi bahari hapa Kaole, unahisi idadi ya watu wanao fanya kuchwa kwenye viumbe vya baharini?  
   a. Ongezeka? Kwa nini unahisi wameongezeka? 
   b. Wamepongeuwa? Kwa nini unahisi wamepongeuwa? 
   c. Hakuna mabadiliko 
   d. Sui
10. Kwa ulewa wako unahisi kuna watu wangapi hapa kijijini/ Kaole wanao fanya ukusanyaji wa viumbe vya baharini kwenye nyasi bahari?

Ufikaji

11. Unachukua mda gani kutoka nyumbani ladi kwenye maeneo ya nyasi bahari mnako kusanya viumbi vya bahari? (masaa)  
12. Kama hautaweza kutumia hili eneo kwenye kazi za ukusanyaji wa viumbe vya baharini, utafanya nini?  
   a. Ukusanyaji maeneo mengine 
   b. Kuacha ukusanyaji 
   c. Kufanya shughuli nyingine. Taja? 
   d. Sui
13. Kuna uguumu wowote unao pata kwenye ukusanyaji wa viumbe vya baharini kwenye nyasi bahari?  
   a. Ndiyo. Kama ndiyo, tuambie 
   b. Hapana) 
   c. Sina jibu
14. Kwa mtazamo wako unahisi ni maeneo yapi ya nyasi bahari unaweza kupata chaza wazuri? (kwa mfano wenye ubora, wakubwa)  
15. Unaweza kufikia hilo eneo?  
   a. Ndiyo. Kama ndiyo, elezea vipi unafika huko 
   b. Hapana. Kama hapana elezea kwa nini 
   c. Sui
16. Aina gani ya protini una uwezo wa kupata?
a. **Nyama ya ng’ombe** (kila siku/siku chache kwa wiki/ siku chache kwa mwezi/nyingine)
b. **Nyama ya mbuzi** (kila siku/siku chache kwa wiki/ siku chache kwa mwezi/nyingine)
c. **Nyama ya kuku/ aina nyingine ya ndege** (kila siku/siku chache kwa wiki/ siku chache kwa mwezi/nyingine)
d. **Mayai** (kila siku/siku chache kwa wiki/ siku chache kwa mwezi/nyingine)
e. **Samaki** (kila siku/siku chache kwa wiki/ siku chache kwa mwezi/nyingine)
f. **Chaza** (kila siku/siku chache kwa wiki/ siku chache kwa mwezi/nyingine)
g. **Nafaka** (m.f. maharage, njegere, soya,njugu), (kila siku/siku chache kwa wiki/ siku chache kwa mwezi/nyingine)
h. **Karnaga za mti** (m.f. korosho),
i. **Nyama pori** (kila siku/siku chache kwa wiki/ siku chache kwa mwezi/nyingine)
j. **Nyingine**

17. **Unakazi mbadala ya kuigizia kipato familia?**
   a. Ndiyo, taja ni ipi (Ni nani anafanya hii kazi mbadala : wewe, mume , watoto)
b. Hapana

**Utumiaji na lishe**

18. **Unafanya nini na kile ulichos kusanya ?**
   a. Kula
   b. Kuuza. kama unauza , unauza ndani ya Bagamoyo/kijijini au nnje ya Bagamoyo/kijijini
   c. Kubadilishana na aina nyingine ya vyakuala
   d. Nyingine, ainisha

19. **Ukiuza ulicho kusanya,** unafanya nini hela kako?

20. Una watu wa ngapi kwenye kaya yako unao walisha?

21. **Unahifadhi viumbwe vya bahari ulivyovu kusanya kwa kuliwa badea?)**
   a. Ndiyo
   b. Hapana
   c. Sijui

22. **Kama unaweza kutunza/ kuhiifadhi viumbwe vya bahari kutoka kwensi bahari , tueleze unatunzafe?**
   a. Kuchoma
   b. Kuweka chumvi
   c. Anika juani
d. Chemsha
   e. Tunza kwensi jokofu
   f. Nyingine

**Stability over time**

23. **Je upatikanaji wa viumbwe vya bahari unatafautiana kipindi cha kaskazi na kusi?**

24. **Ni siku ngapi kwenye mwezi unafanya zozei la kukusanya viumbwe vya baharini kwenye nyasi bahari?**

25. **Ni siku ngapi kwenye mwezi unafanya ukusanyaji wa viumbwe vya baharini kwenye maeneo mengine tofauti na nyasi bahari?**

26. **Kwa mtazamo wako, je kuna aina yoyote ya tishio kwenye upatikanaji wa chaza kwensi bahari?**
   a. Viwanda
   b. Utalii
c. Waokotaji wengi
d. Plastiki
e. Maji machafu
f. Mabadiliko ya hali ya hewa
g. Mabadiliko ya ekologia/ mazingira
h. Nyingine ainisha
i. Sijui

27. **Je kuna kitu chochote unaweza kufanya kuhifadhi viumbwe vya baharini kwa matumizi ya badae?**
   a. Ndiyo. Kama ndiyo, unahisi utunzaji ufanyikaje?
b. Hapana. Kama hapana kwa nini unahisi tusihifadhi?
c. Sijui

28. **Unahisi ukusanyaji wa viumbwe wa baharini - kwensi nyasi bahari inakupa chakula kwensi familia au inakupa kipato cha kukusaidia kununua aina nyingine ya chakula**
   a. Muhimu sana)
   b. Muhimu
   c. Muhimu kiasi
d. Siyo muhimu
Appendix C

Timeline for status of seagrass, mangrove, fish catch and gleaning of seagrass-associated invertebrates by Kaole village, Bagamoyo. Results retrieved from two focus group discussions with key informants fishermen (men) and key informants gleaners (women), held in February 2019.

<table>
<thead>
<tr>
<th>Period</th>
<th>Status of mangrove &amp; seagrass</th>
<th>Status of gleaning &amp; fisheries</th>
<th>Surrounding conditions/ probable reasons for these status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1964-1985</strong></td>
<td>Dense mangrove forest cover. Tall mangrove tree species present. Status was very good. Dense seagrass meadows with very good status. <strong>Laws governing mangroves already existing (but not being reinforced)</strong> No laws /by-laws governing seagrass ecosystems. No existence of marine protected areas (MPAs)</td>
<td>High invertebrate abundance (in numbers and species variations) A lot of Sea cucumber <strong>High fish catch and availability</strong> <strong>Fishing licenses were introduced, but not strictly followed by fishermen.</strong> <strong>Gleaning had no license</strong></td>
<td>Population size was small, hence less demand on mangrove trees and other natural resources. Invertebrates were consumed at a very small rate The importance and market for sea cucumbers was not known. Not easy to notice signs of climate change at this time No hotels constructed</td>
</tr>
<tr>
<td><strong>1985-1995</strong></td>
<td>Dense mangroves Dense seagrass meadows <strong>No laws /by-laws governing seagrass ecosystems.</strong> No existence of marine protected areas (MPAs)</td>
<td>High invertebrate abundance (in numbers and species variations) <strong>Introduction of gleaning activities conducted by women in Kaole</strong> High fish catch and availability. Increase in fishing boats and fishermen. <strong>Licensing of fishing boats was in place, but not strictly followed by the fishermen</strong> <strong>Gleaning had no license</strong></td>
<td>Population size increased Introduction of hotels led to demand on mangrove trees Increased living costs forced women to conduct gleaning activity to increase incomes No illegal fishing gear in use.</td>
</tr>
<tr>
<td><strong>1995-2005</strong></td>
<td>Decrease in mangrove forest at fast rate</td>
<td>The demand for sea cucumber was high and was good business for a while.</td>
<td>Increase in population size</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------</td>
<td>-----------------------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>(President Benjamin Mkapa)</td>
<td>Decrease in seagrass meadows</td>
<td>Increase in gleaners both from within and outside Kaole (from Ukumi, Kilome, Morogoro, Buma and Kiwangwi).</td>
<td>Increase in hotels</td>
</tr>
<tr>
<td></td>
<td>No MPAs</td>
<td>Invertebrates, including sea cucumber, began to decrease</td>
<td>Increase in water temperature and occurrence of Tsunami effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decrease in fish catch</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gleaning activity had no license</td>
<td></td>
</tr>
</tbody>
</table>

| **2005- to 2015** | Decrease in mangroves | Decrease in invertebrates, due to the increase in the number of gleaners who collect for selling and eating | Rapid increase in population size, increased costs of living, lack of alternative valuable livelihood, poor transport network system, community engage in mangrove charcoal making activities. | The use of illegal fishing gears such as drag net fishing increased |
| (President Jakaya Kikwete) | Decrease in seagrass meadows | Decrease in sea cucumber collection\(^\text{10}\) | Increase demand for mangrove trees | Increase in water temperature, resulting from climate change? |
| | Introduction of MPA (Kifumbani Kaole). | Decrease in fish catch. Increase in fishing boats and fishermen | Increase in hotels | |
| | The introduced MPA failed | Gleaning activity had no license | | |

<table>
<thead>
<tr>
<th><strong>2015 to Date</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Seagrass meadows have decreased</td>
</tr>
<tr>
<td>Increase in demand/use of mangrove trees</td>
</tr>
<tr>
<td>No MPA</td>
</tr>
<tr>
<td>Decrease in the number of gleaners</td>
</tr>
<tr>
<td>Gleaners have moved to the mangroves to do gleaning</td>
</tr>
<tr>
<td>Introduction in 2019: Gleaners need to have license to conduct gleaning activity in the mangroves and seagrass (TZS 20 000/per annum)</td>
</tr>
<tr>
<td>Fish catch have decreased, decrease in number of fishermen</td>
</tr>
<tr>
<td>Illegal fishing conducted during night hours, due to increase in unemployment rate</td>
</tr>
<tr>
<td>Increase in population size and increasing costs of living</td>
</tr>
<tr>
<td>Increase in tourism</td>
</tr>
<tr>
<td>Experienced increase in water temperature and disappearance of some invertebrates, maybe due to climate change</td>
</tr>
</tbody>
</table>

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\(^{10}\) One participant explained: “Around 2005, there was a high demand for sea cucumber from rich people and people came from different places to glean them. They were collected day and night (using a torch). The lifestyle got better. By 2009 the collectors had increased and the catch of sea cucumber was decreasing. The government then prohibited the collection.”
Appendix D

Table 6: The table shows the 18 different invertebrate species that gleaners stated that they glean in Kaole, Tanzania. The percentage indicates the share of responses from the 30 interviewees (multiple answers possible). The most mentioned variety, stated by 28 (93%) of the 30 respondents, was Vijino (Volema sp).

<table>
<thead>
<tr>
<th>Swahili name</th>
<th>English name</th>
<th>Latin name</th>
<th>Habitat</th>
<th>(n)</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vijino</td>
<td>Volema sp</td>
<td>Eulittoral sand and seagrass beds</td>
<td>28</td>
<td>93.3</td>
<td></td>
</tr>
<tr>
<td>Kombe</td>
<td>Probably Anadara sp</td>
<td>Eulittoral. Buried in sand/mud.</td>
<td>17</td>
<td>56.7</td>
<td></td>
</tr>
<tr>
<td>Chaza</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>33.3</td>
</tr>
<tr>
<td>Vinyama</td>
<td></td>
<td></td>
<td></td>
<td>9</td>
<td>30.0</td>
</tr>
<tr>
<td>Nyaluale</td>
<td>Probably Strombus sp</td>
<td>Shallow sand</td>
<td>5</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>Vikora/Kola/Kikora</td>
<td>Murex brevispina</td>
<td>Sheltered shallow soft sediments/seagrass beds</td>
<td>4</td>
<td>13.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crabs</td>
<td></td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>Mpanga</td>
<td>Family PINNIDAE</td>
<td>Eulittoral sand/seagrass bed</td>
<td>2</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sea cucumber</td>
<td>Holothuria sp</td>
<td>In sand, lower eulittorial and deeper</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>Simbi</td>
<td>Probably Oliva episcopalis</td>
<td>Shallow sands</td>
<td>2</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Visharifu</td>
<td>Probably Zeuxius olivaceus</td>
<td>Shallow sands</td>
<td>2</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Dome</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>Mbaramwezi</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>Kaa</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>Nigisi</td>
<td>Calamari</td>
<td></td>
<td></td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>Nyeupe</td>
<td>Polinices mammilla</td>
<td>Sandy bottoms in shallow waters</td>
<td>1</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Ushumba/Uduvi</td>
<td>Shrimps</td>
<td></td>
<td></td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>Vikuze</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>3.3</td>
</tr>
</tbody>
</table>
Vijino, *Volema Sp*

*Volema Pyrum*, identified through gleaning landing

*Nyaluale*, could be identical with *Strombus Sp*
Nyeupe, *Polinices mammilla*

Kombe, could be identical with *Anadara Sp*

Visharifu, could be identical with *Zeuxius olivaceus*
Kola (Vikora could be an alternative local name), *Murex Brevispina*

Simbi, could be identical with *Oliva episcopalis*

Sea cucumber, *Holothuria sp*