# EVALUATING SOCIO-ECONOMIC IMPACTS AND COMPLIANCE EFFECTIVENESS OF VOLUNTARY OCTOPUS REEF CLOSURES IN KILWA DISTRICT, TANZANIA

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## ABSTRACT

This study examines the socio-economic impacts of octopus reef closures in coastal Tanzania, with a focus on community participation and compliance. The study was conducted through a comprehensive survey and descriptive analysis across four villages: Namakongoro, Somanga, Songomnara, and Songosongo in Kilwa District. The research investigates how voluntary, temporary octopus reef closures influence local socio-economic conditions, the sustainability of octopus fisheries, and the effectiveness of community participation and compliance. It sought to bridge gaps in the existing literature regarding the socioeconomic impacts and compliance effectiveness of voluntary reef closures. The findings indicate high compliance and widespread support for reef closures among surveyed communities, with significant differences despite a lack of understanding of official voluntary octopus closure guidelines in some villages. The perceived common benefits across the villages include increased income, improved well-being, and strengthened social cohesion. Socio-economic analyses revealed significant impacts on octopus supply and demand, market prices, and overall livelihoods. However, challenges such as price and market fluctuations and resource limitations have been identified. Furthermore, community members overwhelmingly view reef closures as contributing to the sustainability of octopus fisheries in the region. Based on these findings, this study proposes policy recommendations to enhance the effectiveness of octopus reef closures and support sustainable fishery management. The proposed recommendations include continuing to provide capacity building on guidelines and resource support to enhance enforcement, support market resilience, foster community engagement, promote education and awareness, and implement adaptive management strategies. By implementing these recommendations in collaboration with stakeholders, policymakers can support sustainable octopus fishery management and contribute to marine conservation efforts in coastal communities.


**Key words:** Octopus, voluntary octopus reef closure, compliance effectiveness, socio-economic impacts, Tanzania.

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# 1 INTRODUCTION

## 1.1 Background of Tanzania Marine Fishery

Tanzania possesses substantial fishery resources across both marine and inland waters. The marine waters include a territorial sea spanning 64,000 km², an Exclusive Economic Zone covering 223,000 km², and a 1,424 km long coastline teeming with diverse fishing resources (URT, 2015). The coastal fishery comprises multiple species organised into different sub-chains, including reef, small pelagic, large pelagic, prawn, and octopus fisheries. The caught species include mackerel, king fish, scavengers, parrot fish, sardines, rabbit fish, rays, sharks, and crustaceans. However, the primary commercially targeted coastal species consist of prawns, octopus, lobster, crabs, tuna, and tuna-like species. Fishing operations by coastal fishers involve a diverse array of fishing gear and methods, such as gill netting, purse-seining/ring net fishing, longlining, handlining, and trap fishing (Mairi & Mgawe, 2022).

The octopus fishery is crucial for the economy and subsistence fishing of coastal communities in Tanzania (Guard & Mgaya, 2003; Mtonga et al., 2022; URT, 2023). The primary octopus species in Tanzania is the blue octopus (Octopus cyanea), which makes up over 99% of the total landings and contributes to foreign exchange (Silas et al., 2021; Mtonga et al., 2022; URT, 2023). This species is not only an important commercial cephalopod but also contributes significantly to foreign currency earnings (Guard & Mgaya, 2003; Rocliffe & Harris, 2016; Silas et al., 2021; Mtonga et al., 2022).

Research indicates the presence of other species, such as the common octopus (*Octopus vulgaris)* and white-spotted octopus (*Callistoctopus macropus*), albeit in limited numbers, while some octopus species are rare (MLF, 2023; URT, 2023). Generally, the fishery provides employment, income, economy, and economic well-being to communities. Furthermore, the fishery is entirely small-scale, including women, men, and youth, playing a significant role in octopus harvesting, contributing to the estimated 4,600 octopus fishermen in the country (MLF, 2023; URT, 2023).

## 1.2 Fisheries Management (Laws and Regulations)

The fisheries sector in Tanzania is guided by the Fisheries Act. No. 22 of 2003, National Fisheries Policies of 2015, and Fisheries Regulation of 2009 (G.N. No. 308) and its amendments. These legislations provide a clear focus and guidance on the utilisation, conservation, and management of fisheries resources to contribute to food security, nutrition, growth of the national economy, and improvement of the well-being of communities (URT, 2015). However, challenges such as intensive fishing, illegal practices, and ineffective management threaten the sustainability of fishery resources. The government, in collaboration with other stakeholders, has been working to ensure that the regulations are enforced and to find ways to resolve the challenges, thus supporting the newly adopted management measures of temporary octopus closures. According to Oliver et al. (2015), experience indicates that effective governance and social factors play crucial roles in ensuring that fishing activities adhere to the most suitable management measures.

## 1.3 Octopus Fishery in Tanzania

Octopus fisheries are significant for coastal communities in Tanzania; however, their susceptibility to overfishing is exacerbated by inadequate enforcement, limited control mechanisms, and increasing demand in local and international markets (URT, 2023). The octopus fishery in mainland Tanzania is regionally distributed across three zones along the Indian Ocean. Zone 1 covers the Tanga Region, Zone 2 encompasses the Coastal Region (Mafia Island, Mkuranga, and parts of the Kibiti District), and Zone 3 includes the Lindi Region in Kilwa District (from Somanga to Songomnara), Lindi District, and Mtwara Region in the Mnazi Bay area (Figure 1). It involves small-scale fishermen, including both women and men, utilising sticks, iron rods, and spears as fishing gear. Women fish during low tide by walking to the reefs close to the beach, while men dive and locate the octopuses in their dens (Guard & Mgaya, 2003; Sauer et al., 2019; Silas et al., 2022).

The existing management measures for this fishery are stipulated in the Fisheries Regulation of 2009 (G.N. No. 308) and its amendments include licencing of fishers, a minimum size limit of 500 g, closures at neap tides, and export tariffs. However, enforcing size limits poses challenges because the gears used for fishing are size-selective, and estimating octopus weight before capture underwater is not possible.

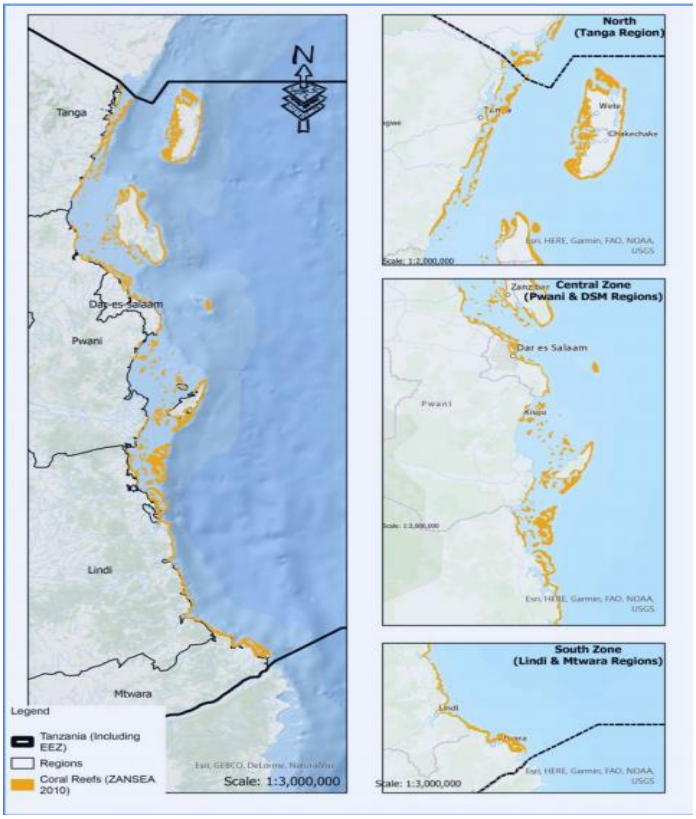


Figure 1: Regions of the octopus fishery in Tanzania mainland (MLF, 2023)

## 1.4 Octopus Reef Closure Practice

Octopus fishing in Tanzania was traditionally conducted by women, children, and the elderly during low tide near the beach. However, with the increasing market value of octopus, men

have joined the fishery, leading to heightened pressure on the resource and subsequent depletion (MLF, 2023). The traditional practice of suspending octopus fishing during neap tides in coastal communities was abandoned as resources dwindled and male involvement increased. Recognising the decline in the annual octopus catch from the late 1950s to 2003, reaching a peak weight of 573 tonnes and subsequently decreasing to 340 tonnes in 2017, as documented by Sauer et al. (2019) and Silas et al. (2022), communities adopted temporary closures of reefs.

The concept of octopus reef closures in Tanzania originated from environmental conservation practices in Southern Zanzibar villages, with seasonal closures, kurimbika pweza," aiming to enhance octopus yields until the late 1980s (MLF, 2023). However, on the Tanzanian mainland, octopus reef closure was pioneered within the Kilwa District in 2017 after WWF-Tanzania supported fishers' trip to Kukuu village in Pemba Island to learn about the traditional octopus reef closure management practice. Nevertheless, inspired by successful initiatives in Madagascar, new voluntary octopus reef closures were introduced in the Somanga village in the Kilwa district.

This practice involves closing the reefs for three months. The three-month duration was determined by the biological traits of the octopus, which is known for its rapid growth and short lifespan, completing its life cycle within a year (Oliver et al., 2015). This allows for shorter optimal closure periods to be achieved. The practice gradually spread to 15 other villages across different districts as of December 2022, with Kilwa District being a leader in terms of the number of villages and closure cycles (MLF, 2023). The implementation varies, but common factors include a three-month closure period, BMU and community responsibility for guarding reefs, and data collection to evaluate ecological and livelihood impacts.

Recognising community acceptance, to support the endeavour the government, in collaboration with NGOs, established voluntary octopus reef closure guidelines. This guide for managing octopus reef closures has been created to improve and enhance the implementation of the reef closure concept as a strategy to sustainably manage octopus fisheries for the benefit of both present and future generations. The guidelines provide the timing for closing, criteria, steps, and stakeholder roles, and address the quality and safety of octopuses and their products. The criteria stipulated in the guide, among others, serve as the basis for selecting reefs for closure. The criteria for reef selection include the ecology, size of the reef area, accessibility, and ease of management of the reef. Additionally, local information and scientific studies and research on the life cycle, recruitment, and growth were considered.

Despite community acceptance and positive impacts on human well-being and management success (Silas et al., 2022), it is important to understand the socioeconomic impact, community participation, and compliance levels of voluntary octopus reef closures. Therefore, this study aims to evaluate these aspects, including factors influencing compliance, in the Kilwa District to contribute to ongoing efforts in collaborative fisheries management.

## 1.5 Rationale

This study has substantial implications for communities, academia, and fisheries management practitioners. The effectiveness of voluntary octopus reef closures relies primarily on the level

of community involvement, adherence, and comprehension of socio-economic factors that contribute to community compliance. By conducting a comprehensive assessment of socioeconomic impacts and community participation and compliance effectiveness within the context of voluntary octopus reef closures in the Kilwa District, this study endeavours to bridge a crucial gap in the existing literature. Beyond unravelling the nuanced interactions between closures and socio-economic conditions, this study aims to delve into the socio-economic factors and the level of compliance, acknowledging their interconnectedness and impact on the success of such management practices.

The findings of this study are anticipated to provide guidance for evidence-based policy decisions, shape resource management strategies, and contribute to the sustainability of the octopus fishery in Tanzania. Furthermore, the study's focus on compliance delves into an unexplored aspect, establishing a foundation for targeted interventions to improve adherence to fisheries management measures and ensure the lasting vitality of octopus resources in the Kilwa District. By presenting recommendations to enhance the effectiveness of voluntary octopus reef closures, this study not only addresses compliance issues, but also provides insights into broader considerations for sustainable fisheries management, thereby contributing to conservation efforts and the overall well-being of fishing communities in the region. Moreover, it addresses SDG 14 (life below water), particularly target 14.2, which protects and restores ecosystems, and 14.7, which increases the economic benefits of the sustainable use of marine resources, as well as SDG 3 (good health and well-being). Therefore, this study focuses on three objectives.

i. To evaluate the effectiveness of community participation and compliance with voluntary octopus reef closures in the Kilwa District.

ii. To assess the socio-economic impact of voluntary octopus reef closures on local communities in Kilwa District; and

iii. To identify socio-economic factors influencing compliance and non-compliance with voluntary octopus reef closure practice in Kilwa District.

# 2 LITERATURE REVIEW

## 2.1 Octopus Fishery in the Western Indian Ocean (WIO)

The octopus fishery is a vital resource for coastal communities across the Western Indian Ocean (WIO), particularly in Tanzania, Madagascar, Rodrigues, and Mozambique (Guard & Mgaya, 2003; Rocliffe & Harris, 2016; Sauer et al., 2019). Moreover, octopuses are highly traded seafood products because of their nutritional value, including high-quality protein, omega-3 fatty acids, and low-fat content (Siero et al., 2006; Fabinyi et al., 2016; MLF, 2018; Silas et al., 2022). According to the FAO, 1,397 tons of octopus were caught in this region in 1990, increasing to 2,517 tons in 2015, contributing 0.75% to global octopus production (Sauer et al., 2019) (Figure 2). This fishery has been dominated by *O. cyanea* and *O. vulgaris,* especially in Seychelles, with Tanzania being a prominent player in the WIO region, annually exporting over 1,500 tons valued at approximately US$6.8 million (Rocliffe & Harris, 2016; Silas et al., 2022) (**Error! Reference source not found.**).

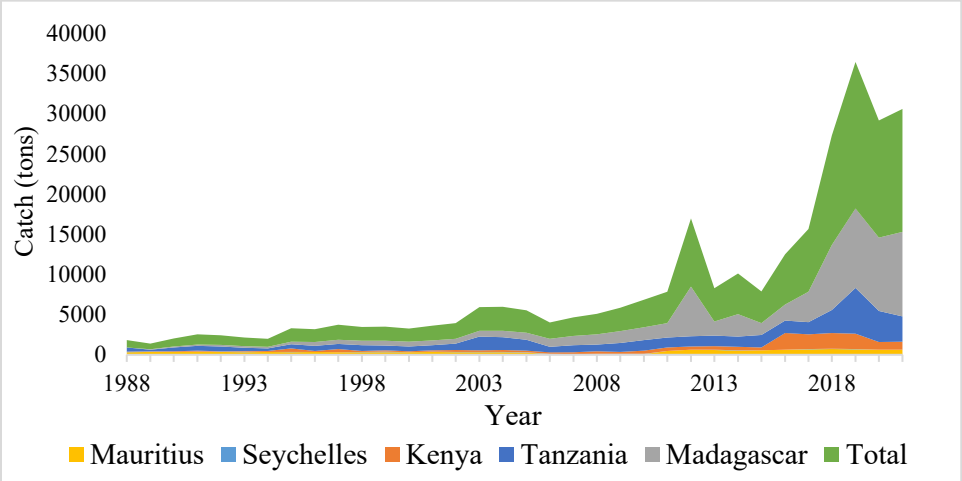


Figure 2: The trend of octopus fishery in West Indian Ocean Region (FAO, 2021)

In the WIO region, octopus fisheries are a crucial economic activity for coastal communities, traditionally dominated by women and children. However, with increased international demand and income opportunities, men have become more involved in the industry (Rocliffe and Harris, 2016). The region now sees the operation of domestic and foreign-owned trading and collection companies, responding to the growing demand from European and Far Eastern markets, where octopus prices are higher (Guard and Mgaya, 2003; Rocliffe and Harris, 2016). Major importers of octopus from the WIO region include China, Morocco, Portugal, Italy, France, Mauritius, India, Peru, Vietnam, and Spain (Rocliffe & Harris, 2016; Silas et al., 2022; FAO, 2022). Tanzania stands out as a dominant export player in the WIO region, annually exporting half of the total octopus exports in terms of both weight and value (**Error! Reference source not found.**). With an average price of US$4.45 per kilogram, Tanzania's octopus exports constitute a substantial portion of the region's trade (Rocliffe and Harris, 2016; Silas et al., 2022).

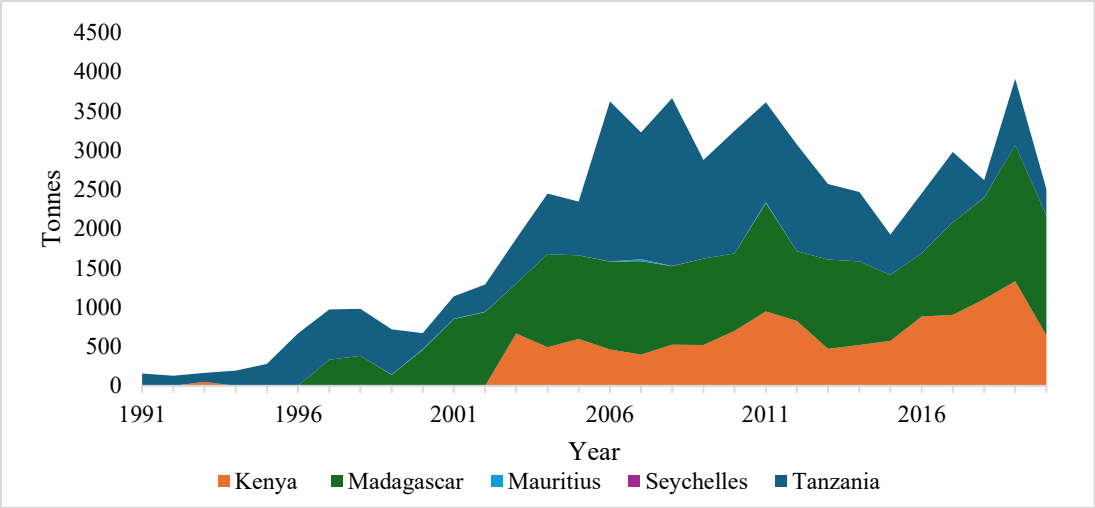


Figure 3: Octopus export trend in West Indian Ocean (WIO) (FAO, 2021)

## 2.2 Reproductive Dynamics and Ecological Role of *Octopus cyanea*

*Octopus cyanea*, a reef species, is commonly found in the shallow tropical waters of the Indian and Pacific Oceans. It inhabits intertidal reefs and resides in small holes and crevices hidden by rubble and shell fragments (Guard & Mgaya, 2003). With a potential weight exceeding 6000 grams, this substantial benthic species has a lifespan of 12 to 15 months known as a fast growing and short-lived species (Guard & Mgaya, 2003; Silas et al., 2022; Oliver et al., 2015). Reproductive processes involve males transferring seeds to females, and females brood only once in their lifetime, barricading their dens and caring for the eggs until they hatch. From this time onwards, the female octopus does not feed and gains her energy requirements from the breakdown of somatic proteins. This irreversible process concludes with the female's demise a few days after the eggs hatch (Heukelem & W, 1973; Guard & Mgaya, 2003).

Therefore, the survival of female octopuses is crucial for successful reproduction, emphasising the need for effective management strategies to sustain reproductive output and decrease fishing pressure during peak brooding periods (Guard & Mgaya, 2003; Nair et al., 2018; Silas et al., 2022). As female octopuses typically attain reproductive status at larger sizes, substantial decreases in the size range may significantly impede reproductive output, resulting in diminished recruitment and, ultimately, a reduction in stock size (Guard & Mgaya, 2003).

The ecological importance of octopuses is highlighted by their role as predators and potential prey for larger fish, such as sharks and some neritic tuna (Silas et al., 2021). This ecological role underscores the significance of managing octopus fisheries for the overall health of marine ecosystems.

## 2.3 Octopus's Fisheries Management

Despite the vital role of octopus catches in providing sustenance and socio-economic benefits to the WIO region's populace and their ecological significance, the species faces alarming overexploitation in recent times (Silas et al., 2021). Notably, previous studies have highlighted a decline in the mean harvestable size and weight of landed octopus catches in the West Indian

Ocean region (Guard & Mgaya, 2003; Rocliffe & Harris, 2016; Silas et al., 2021). Globally, the proportion of stocks fished within biologically sustainable levels continues to decrease, necessitating stringent management actions (Rocliffe & Harris, 2016; Silas et al., 2022). According to Silas et al. (2022), the octopus share of global trade is increasing over time but is facing risks due to poor management.

Tanzania has recognised octopus as one of its top 10 valued products, accounting for approximately 10% of the total catch and serving both local and export markets (Rocliffe & Harris, 2016). The historical trajectory of octopus catches in Tanzania indicates an increase from the late 1990s until 2003, reaching a peak of 1,700 tons, followed by a subsequent decline, with a reported catch of 703 tons in 2016, and then booming again in 2019 with a catch of 5687 tons (FAO, 2019). Existing management measures for the octopus fishery include licencing of fishers, a minimum size limit of 500 g, closures at neap tides, and export tariffs. However, the enforcement of size limits poses challenges, especially considering non-size-selective fishing methods and dynamite fishing in some areas (Silas et al., 2022). In the WIO region, octopuses are collected using one of three methods: i) walking along the lower sections of intertidal reef flats at low tide actively seeking octopus dens (small holes often identified by small piles of stones and fragments of shell), spearing, or jerking up and down with sticks; ii) snorkelling or diving along the periphery of the reef edge; or, less frequent occasions iii) sighting octopuses from pirogues during periods of remarkably transparent water (Rocliffe & Harris, 2016).

In the WIO, size-limit management varies between regions, with Tanzania enforcing a 500 g limit and Kenya setting limits at 10.8 cm for females and 10.5 cm for males, measured using dorsal mantle length (DML) (Kivengea et al., 2014). Female octopuses reach first maturity ($DML_{50\%}$) at a length of 10.8 cm and males at 10.5 cm. Minimum size limits are set at 1 kg in Comoros and 350 g in Madagascar, applying to both female and male octopus (Rocliffe & Harris, 2016; Silas et al., 2022).

The octopus fishery in Tanzania, like those in other countries in the WIO region, is small-scale and open to access. According to the Fisheries Regulation 2009, fishers are required to catch octopuses above 500 g, posing challenges due to non-size-selective fishing methods, making the estimation of octopus weight underwater difficult (Guard & Mgaya, 2003; Sauer et al., 2019; Silas et al., 2022). Although the use of pots is suggested as a selective and sustainable method, current practices still involve the use of sticks and spears (Sobrino et al., 2011; Sauer et al., 2019; Silas et al., 2022).

Traditionally, Tanzanian fishers were restricted from capturing octopuses during neap tides, unlike in other WIO regions, such as Madagascar, where closed seasons for octopus are implemented and sales are prohibited during specific periods (Rocliffe and Harris, 2016). These closures have shown economic, social, and fishery benefits, as evidenced in Seychelles, where a licencing scheme, annual catch quota, and periodic fishery closures were established after initial attempts at temporary closures proved inadequate (Oliver et al., 2015; Rocliffe & Harris, 2016; Mtonga et al., 2022).

## 2.4 Octopus Reef Fishery in Kilwa District

The octopus fishery plays a pivotal role in the economic activities of Kilwa District, with a population of approximately 29,700, contributing significantly to the livelihoods of local communities and the nation at large (URT, 2023). Situated in the Lindi Region, Kilwa District boasts a vast expanse of Tanzania's coastal waters, covering 1,221 square kilometres and teeming with valuable marine resources.

The octopus fishery supports over 7,000 people directly or indirectly employed along the value chain, with women comprising approximately 30% of octopus fishers in Tanzania (URT, 2023). This highlights the significant socio-economic impact of the octopus fishery in Tanzania, particularly in terms of employment and gender representation. Furthermore, female participation underscores the importance of gender equity and inclusivity within the fishing industry, adding to the uniqueness of the imperative for sustainable management measures.

The Kilwa District encompasses more than 20 villages with approximately 32 octopus landing sites. Kilwa is a leading district in octopus production among the coastal districts (Figure 4), with Songosongo Island emerging as a major contributor to octopus catches compared to other sites in Kilwa District (MLF, 2020; URT, 2023). Despite challenges in obtaining precise data, the Ministry of Livestock and Fisheries (MLF) estimated that octopus production in Kilwa District reached 174.02 metric tons in 2020, with over 90% of the catch being sold to large traders and companies, primarily in Dar es Salaam, for export to international markets during the COVID-19 pandemic.

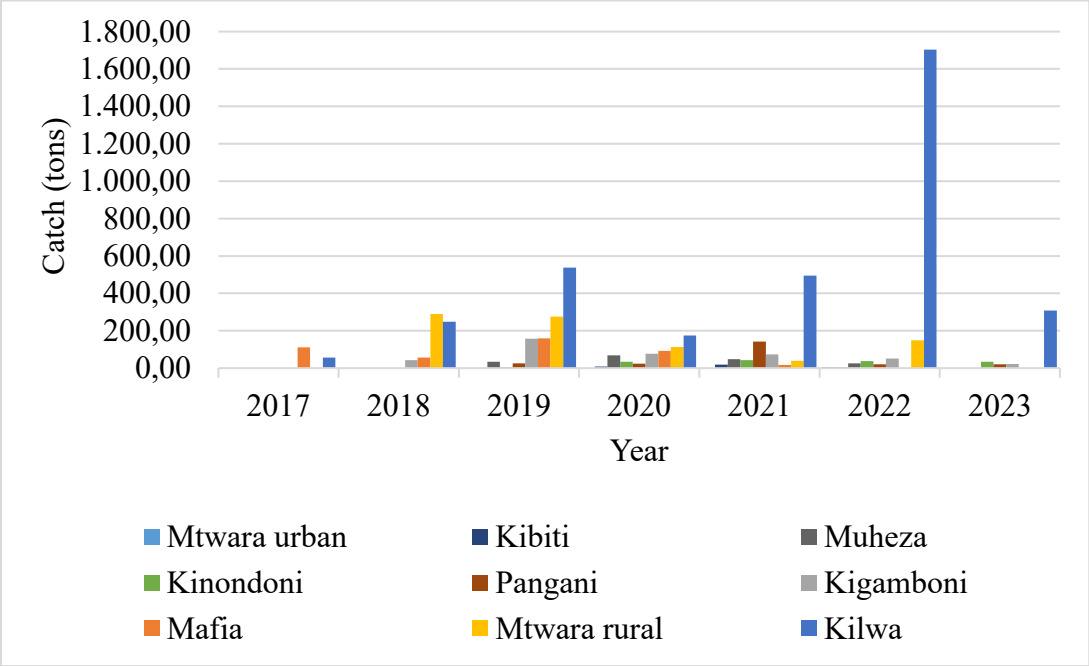


Figure 4: Trend of octopus production in the coastal districts of Tanzania (MLF).

The escalating demand in both local and international markets exerts pressure on the fishery, making it vulnerable to overfishing. However, the fishery faces challenges related to insufficient enforcement and minimal control mechanisms, despite the presence of legalised

management measures (URT, 2023). Perry et al. (1999) and Mtonga et al. (2022) proposed three management strategies: catch regulation, size/sex limits, and fishing control, to safeguard cephalopod fisheries. However, implementing effective management is challenging because of the artisanal nature of the octopus fishery, which involves hundreds of fishers, most of whom are illiterate and use primitive gear. Therefore, it is recommended to adopt a combination of these three strategies (Mtonga et al., 2022).

Notably, the Kilwa District, starting with the Somanga village, embraced octopus reef closure after a noticeable decline in catches in 2017. Following the closure's initial trial, the villages observed increased catches, weight, volume, and income; however, the catches were associated with post-harvest losses (WWF, 2019; WWF, 2020; WWF, 2022; MLF, 2023). Since 2016, the Ministry of Livestock and Fisheries, in collaboration with WWF, has been promoting the reef octopus closure program and managed to introduce the program at Songosongo Island in late 2017, inspiring other fishing communities (WWF, 2022; MLF, 2023). As of 2022, the Kilwa District has 13 villages implementing octopus reef closures, including Somanga, Songosongo Island, Songomnara, Namakongoro, and Kilwa Kivinje (MLF, 2023). During open reef periods, data on catch, fishing effort, fishery stock, and economic benefits were recorded. Furthermore, the Marine Stewardship Council (MSC) and Blue Ventures have been promoting sustainable fisheries in collaboration with the octopus fishery in Kilwa District toward MSC certification for over a decade (WWF, 2020; URT, 2023).

Several studies in Kilwa indicate that reef closures have resulted in increased catch and income in the communities (This study aims to assess the participation and compliance effectiveness of the community during reef closure, the socioeconomic impacts of closure, and the interconnectedness of socioeconomic factors on compliance and non-compliance.

Table 1) (WWF, 2019; Mtonga et al., 2022). Silas et al.,(2022) reported that reef closures enhance octopus mean weight, catch rates, and volumes landed, although short-term benefits were observed. The study revealed a surge in catch within the first three days of closure opening. In Songosongo Island, the catch before closure ranged between 15 and 18 tons, while after closure, the collected catch soared to 37 tons in 2019 and 41 tons in 2023 (WWF, 2019; Silas et al., 2022). This emphasises the significant contribution of three days of a single reef-opening event, surpassing what would have been collected over several months (Table 1). Silas et al., (2022) highlighted the community's involvement in resource management through octopus reef closure and the positive economic benefits. However, it is important to have information on the behaviour of fishers during closure and the socio-economic influences on compliance with closure practices, rules, and regulations. This study aims to assess the participation and compliance effectiveness of the community during reef closure, the

socioeconomic impacts of closure, and the interconnectedness of socioeconomic factors on compliance and non-compliance.

Table 1: Trend of octopus landings for three days of reef closure-opening in Songosongo village

| S/N | Closing date | Opening date | Catch (tons) |
|---|---|---|---|
| 1. | 20 November 2017 | 20 February 2018 | 9.82 |
| 2. | 30 April 2018 | 11 August 2018 | 19.94 |
| 3. | 20 November 2018 | 23 March 2019 | 14.79 |
| 4. | 01 July 2019 | 29 September 2019 | 37.60 |
| 5. | 01 January 2020 | 08 May 2020 | 9.21 |
| 6. | 01 June 2021 | 22 September 2021 | 15.30 |
| 7. | 05 March 2022 | 15 July 2022 | 18,491 |
| 8. | 10 June 2023 | 16 September 2023 | 41.314 |

# 3 METHODOLOGY

This study used a survey to obtain quantitative and qualitative data through questionnaires and interviews physically collected by interviewing participants from communities that are implementing voluntary octopus reef closures.

## 3.1 Study design.

The study collected quantitative and qualitative data on socioeconomic factors and compliance levels through a series of questionnaires and interviews using the KoBo Toolbox software over five consecutive days, from 13 March to 17 March 2024. The designed questions for both the questionnaire and the interview were input into the KoBo Toolbox software and deployed for data enumerators to access through their Android phones. This software was chosen for its familiarity among the enumerators and the convenience of being able to use it on Android phones. Enumerators were provided with the URL for the server, along with a username and password, enabling them to access the project forms. Data were submitted in real time and accessed on the server. To authenticate the data and verify the exact location of the study, enumerators were required to fill in the GPS coordinates of respondents' locations.

The questionnaire was administered to participants from diverse backgrounds, including fishers (men, women, and youth), fish vendors, processors, business owners, and community members. Various parameters were explored within this group, such as community participation, awareness, understanding, adherence, and the economic and socio-economic impacts of voluntary reef closure. Additionally, group interviews were conducted with Beach Management Unit (BMUs) leaders, village leaders, and fisheries officers to gain nuanced perspectives on the socio-economic impacts and factors influencing compliance. The focus was on exploring various aspects of the practice, including awareness, management, decision-making, enforcement, perceptions, and attitudes within the community regarding reef closure practices.

Participants from communities that practiced voluntary octopus reef closures were randomly selected. The combination of questionnaires and interviews with different participant groups provided a comprehensive understanding of community sentiments toward the practice, highlighting the divergent viewpoints across groups and villages. This study aimed to assess the overall impact of the practice on the community, evaluate community participation and compliance with established rules, and discern the reasons behind the observed behaviours within these dimensions.

### 3.2 Study tools.

A structured questionnaire featuring closed-ended questions was used for quantitative data collection across various participant categories, including fishers, processors, vendors, small business owners, and members of the local community (Annex 1). The questions covered a range of topics, including community participation, awareness of voluntary octopus reef closures, and socio-economic impacts. For example, participants were asked about their awareness of octopus reef closures, frequency of participation in community meetings regarding closures, adherence to closure rules, factors influencing compliance, changes in income from octopus fishing since the implementation of closures, and their beliefs regarding the overall benefits of closures to the community.

In addition to the questionnaire, group discussions were conducted using a set of open-ended questions as an interview guide with a group of 12 participants to gather qualitative data (Annex 2). These questions were designed to explore various aspects of the community's practices, including decision-making and management processes, enforcement and compliance measures, effectiveness and awareness of closures, support and collaboration, and factors influencing community-led initiatives and compliance. Sample questions included enquiries about the duration of octopus reef closures, stakeholders involved in the closure process, challenges faced in ensuring community compliance, motivators for community participation in closure initiatives, awareness of voluntary closure guidelines, utilisation of guidelines during closures, and observations of non-compliance or resistance within the community.

### 3.3 Study area.

This study aimed to comprehensively assess the socioeconomic impact and compliance effectiveness of voluntary octopus reef closures, with the Kilwa District chosen as the research

site. This district was selected because of its abundance of valuable marine resources and its direct relevance to the research objectives.

Moreover, Kilwa District stands out as a pioneer in voluntary octopus reef closure practices, with approximately 11 out of 15 villages and 33 out of 47 closures (MLF, 2023). Additionally, it leads in terms of production and value among the coastal districts of the Indian Ocean in Tanzania (**Error! Reference source not found.**).

For this research, four villages, namely Somanga, Songosongo, Songomnara, and Namakongoro, were randomly selected. The selection process considered factors such as the frequency of reef closures, number of reef closure instances, quantity of reefs, their sizes, and the consistency of closures. These factors are deemed influential in socioeconomic aspects and compliance levels, ensuring comprehensive findings on the impact and effectiveness of octopus closures.

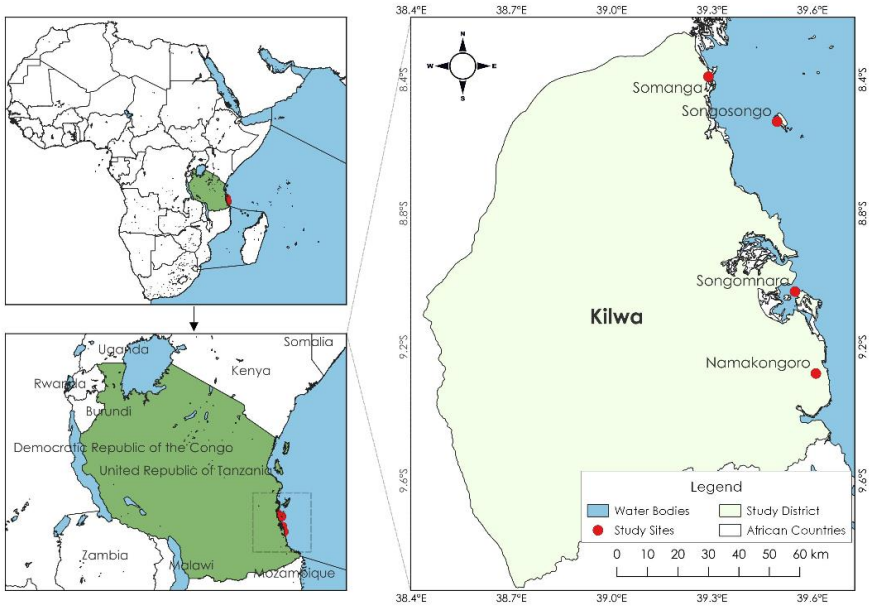


Figure 5: Map of the coastal areas of Tanzania showing the study site.

### 3.4 Sample size and sampling procedures.

The study engaged a diverse array of stakeholders, including fishers (men, women, and youth), fish vendors, processors, village leaders, Beach Management Unit (BMU) leaders, fisheries officers, small business owners, and members of the local community. A total of 144 individuals from these groups across the four villages participated in the study.

Each focus group comprised three individuals to ensure a comprehensive representation and ample opportunity for individual participation. During the study, randomly selected participants from each village were brought together and divided into two groups: one for questionnaire administration and the other for interviews.

The first group, designated for questionnaire administration, included participants from the groups of fishers, vendors, processors, small business owners, and local community members,

totalling 96 for four villages, each having 24 respondents. Enumerators sequentially asked questions to each participant.

The second group consisted of village leaders, BMU leaders, and fisheries officers, with 48 participants in eight groups. Different sets of questions were tailored for each group to capture their diverse perspectives. The number of participants in each group is shown in (**Error! Not a valid bookmark self-reference.**).

Prior to conducting the survey, formal communication was initiated through the district fisheries officer, who informed participants via their village leaders about the survey objectives and obtained their consent to participate.

Table 2: Number of participants for the study

| Number of groups | Group of participants | Number of participants |
|---|---|---|
| 1 | Fishers (men, women, and youth) | 46 |
| | Fish Vendors and Processors | 26 |
| | Small Business Owners and Local Community | 24 |
| 2 | Village Leaders, BMU Leaders, and Fisheries Officer | 48 |
| | **Total number of participants** | **144** |

### 3.5 Data analysis and presentation

After the completion of data collection, the data obtained from the field were thoroughly cleaned. This involved scrutinising the responses to ensure accuracy and consistency, aligning them with the assigned sections, namely community awareness and participation, adherence to rules and decision-making, perception of the importance of compliance, and socio-economic impacts, and documenting the findings in an Excel spreadsheet. The quantitative data collected were aggregated and analysed using Microsoft Excel to identify patterns and trends within the dataset. The chi-square statistical test was used to compare the percentages between villages. Statistical tests were conducted at a 5% significance level.

For qualitative data, a content analysis approach, as employed by Kakama (2019), was used to extract meaningful insights from the Key Informants responses. This involved systematically reviewing and categorising qualitative information to identify recurring themes and patterns. The results derived from the quantitative analyses were then synthesised and presented in tabular format and charts, facilitating a clear and concise representation of the findings. The qualitative results from the Key Informants were used to interpret and complement the quantitative analysis and provide more insight into the practice.

# 4 RESULTS AND DISCUSSION

## 4.1 Community Awareness and Participation in Octopus Reef Closure

### *4.1.1 Awareness of community to the existence and reasons for implementing octopus reef closure*

The survey results revealed significant levels of community participation and awareness of octopus reef closures. When respondents were asked about their awareness of the closures and the reasons behind their implementation, 99% reported being aware, with 96% also demonstrating knowledge about the practice (Education and awareness training activities are being actively conducted by Beach Management Units (BMUs), local and central government authorities, and NGOs to further enhance awareness levels within the community. These results demonstrate statistically significant differences across the villages, proving that Namakongoro, Somanga, and Songomnara would benefit from additional education and awareness-raising training. This training should target both Beach Management Units (BMUs), village government leaders, and the local community to enhance their understanding of the significance of octopus reef closure practices. ). Significant differences were found in the awareness of the community regarding the closure after residence ($\chi^2$ (3, n = 96) = 12, $p < 0.05$). Notably, only one individual (1 %) residing in Somanga village stated that they were not aware of the closures, while 4% of respondents, including 12% from Namakongoro and 4% from Songomnara, were not aware of the reasons for implementation.

Table 3: Percentage of community awareness of the existence and reasons for implementing octopus reef closures.

| **Percentage of Awareness (%)** | **Overall** | | **Namakongoro** | | **Somanga** | | **Songomnara** | | **Songosongo** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Are you aware of the presence of octopus reef closure? | 99 | 1 | 100 | 0 | 96 | 4 | 100 | 0 | 100 | 0 |
| Are you aware of the reasons for implementing octopus reef closures? | 96 | 4 | 88 | 12 | 100 | 0 | 96 | 4 | 100 | 0 |

The results indicate significantly widespread awareness across the surveyed villages, suggesting that most community members are well-informed about the octopus reef closure initiative. Such extensive awareness is crucial for the successful implementation and effectiveness of conservation measures, indicating positive engagement and understanding within the community regarding the necessity of reef closures to protect octopus populations and sustain the fishery. The significant awareness level might be the reason for the community's compliance with the octopus closure practice.

These results align with the information gathered from Key Informants (KIs), highlighting the inclusive nature of the process involving local communities and other stakeholders, such as Village Government Authorities, researchers, academics, and Non-Governmental Organizations (NGOs). Moreover, the findings underscore the significance of awareness-raising efforts and community engagement initiatives related to octopus reef closures in the Kilwa District.

Education and awareness training activities are being actively conducted by Beach Management Units (BMUs), local and central government authorities, and NGOs to further enhance awareness levels within the community. These results demonstrate statistically significant differences across the villages, proving that Namakongoro, Somanga, and Songomnara would benefit from additional education and awareness-raising training. This training should target both Beach Management Units (BMUs), village government leaders, and the local community to enhance their understanding of the significance of octopus reef closure practices. Furthermore, regular monitoring by local and central government authorities should be conducted to ensure that the initiative is progressing positively and to address any emerging challenges that the community faces.

#### *4.1.2 Sharing of information about the seasons of octopus reef closure, rules, and regulation*

The survey aimed to explore the communication channels utilised for sharing information about the opening and closing of octopus reefs and the rules and regulations of the practice. This investigation sought to understand how information is disseminated within the community and whether these channels are conducive to all stakeholders.

Overall, the survey findings indicate that the respondents employed a variety of communication methods. Approximately 40% reported receiving information through traditional channels, such as word of mouth, community leaders, or public announcements, while 35% obtained information from village assembly meetings, 18% from local authorities or fisheries officers, and 6% from written notices or posters.

Upon closer examination, it became apparent that the distribution of communication channels varied significantly across villages ($\chi^2$ (9, n = 96) = 91, $p < 0.05$). In Namakongoro, for instance, 70% of respondents rely on traditional communication channels, while 30% prefer village assembly meetings. In Songosongo, 47% of respondents favour village assembly meetings, followed by 29% who rely on traditional communication channels and 20% who receive information from local authorities. Similarly, in Songomnara, 50% of respondents utilise village assembly meetings, 31% rely on traditional communication channels, and 17% obtain information from the local authorities. Conversely, in Somanga, 42% of respondents utilised traditional communication channels, 17% preferred village assembly meetings, 28% obtained information from local authorities, and 13% relied on written notices or posters (Figure 6).

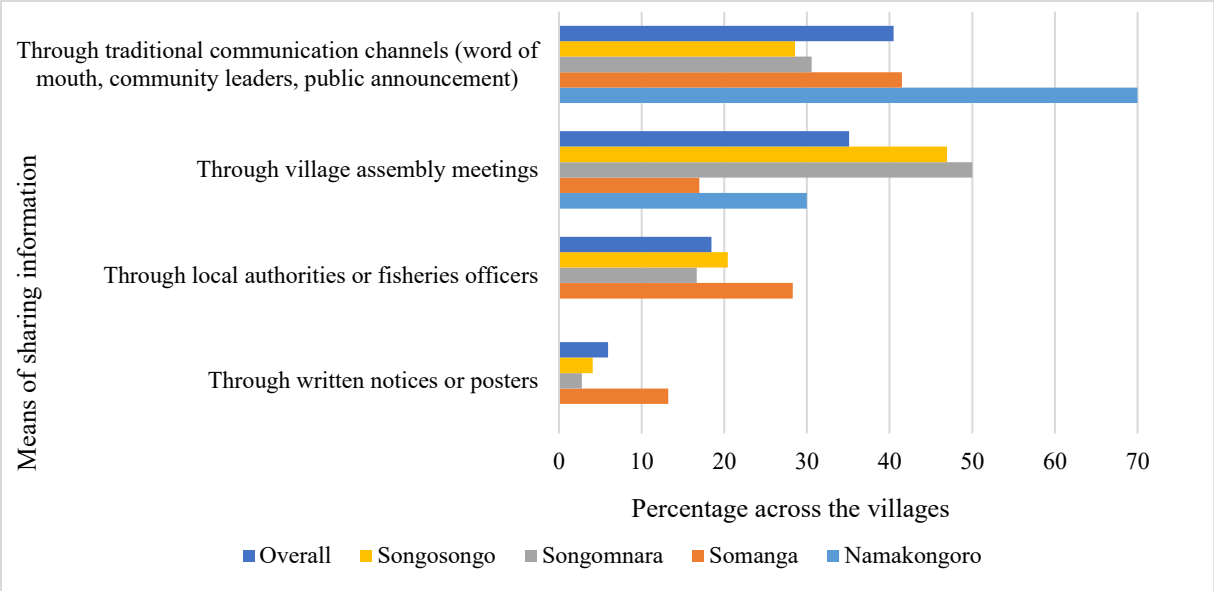


Figure 6: Sharing of information about the seasons of octopus reef closure, rules, and regulations.

The significant difference in communication channels may be attributed to the geographical and social characteristics of each village. For instance, Songosongo and Songomnara, being small island villages, may find village assembly meetings more practical because of their close-knit communities and limited access to alternative communication methods. In contrast, Namakongoro and Somanga, with their larger and possibly more dispersed communities, may rely more heavily on traditional communication methods and written notices or posters.

Nevertheless, the results indicate that both traditional communication and village assembly methods are used across different villages. This signifies a multifaceted approach to information dissemination, proving the diverse needs and preferences of community members. Such diversity in communication channels emphasises the importance of ensuring inclusivity and accessibility in information-sharing processes within communities.

### *4.1.3 Participation of community in meetings regarding octopus reef closures*

The survey results revealed varying levels of community participation in village meetings, with approximately 26% of respondents occasionally attending, 24% frequently attending, 21% always attending, 18% rarely attending, and 11% never attending. However, when analysed across villages, there was a statistically significant difference ($\chi^2$ (12, n = 96) = 123.87, $p <$ 0.05). In Songosongo, for instance, approximately 54% of community members always participate in village meetings, with 29% frequently attending, 13% occasionally attending, and only 4% rarely attending. This contrasts completely with Somanga, where 52% of respondents occasionally attend meetings, compared to 25% in Namakongoro and 17% in Songomnara. Conversely, only 4%, 8%, and 17% of respondents from Somanga, Namakongoro, and Songomnara, respectively, reported that they always attended village meetings. In Namakongoro and Songomnara, a significant percentage of respondents (29% and 13%, respectively) reported never attending meetings (Figure 7).

These findings are supported by insights from Key Informants (KIs), who confirmed the participation rates in village assemblies: approximately 95% for Songosongo, 55% for Somanga, 40% for Namakongoro, and 20% for Songomnara. The high turnout rate in Songosongo may be attributed to its status as an island community, where approximately 80% of residents rely solely on fisheries, primarily octopus fishing, for their livelihoods, as highlighted by Silas et al.(2022). Thus, issues related to fisheries management, including compliance with octopus reef closure measures, are of utmost importance, leading to active participation in village meetings. During interviews with KIs, it was reported that village meetings and discussions revolved around determining which reefs should be closed, the duration of closures and openings, modalities for conducting patrols, enforcement strategies, by-laws, and funds needed to support the closures.

Conversely, lower participation may be attributed to several reasons. For instance, in Somanga, the village's proximity to the main road between Dar es Salaam and Mtwara results in a bustling environment with diverse economic activities, leading to busy schedules for residents. This may pose challenges in gathering high attendance rates at the village meetings. Similarly, Namakongoro, despite being distant from the main road, experiences lower participation rates, possibly due to a combination of factors such as economic activities, illiteracy level, and geographical factors.

In the case of Songomnara, while sharing similarities with Songosongo in terms of being an island community, they do not implement reef closures on the entire reef but instead focus on closing specific holes adjacent to the reef. The proximity of the reef to the beach allows for easy patrolling, potentially diminishing the perceived importance of regular attendance at village meetings.

The survey findings revealed significant differences in community participation across the studied villages, with Songosongo particularly standing out for its high turnout rate, driven by its reliance on fisheries for livelihoods and the importance of fisheries management discussions. In contrast, Somanga, Namakongoro, and Songomnara exhibit lower participation rates due to factors such as economic activities, geographic location, and variations in reef closure implementation. Navigating these complexities requires a nuanced understanding of socioeconomic dynamics and community engagement within each village.

Tailored strategies are essential to promote increased involvement in decision-making processes related to octopus reef closures and broader fishery management initiatives. These strategies include community outreach and education programs, capacity building for community leaders and Beach Management Units (BMUs), incentivising community participation, and fostering partnerships and collaboration among stakeholders. Recognising and addressing these differences is crucial for the effective implementation of targeted interventions to promote sustainable resource management practices within coastal communities.

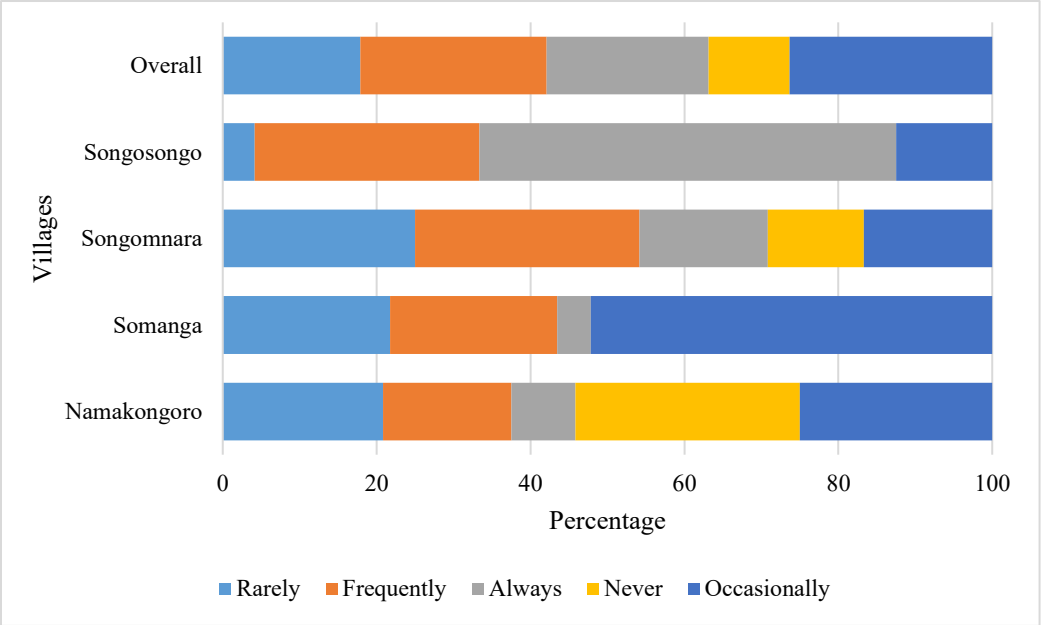


Figure 7: Frequency of community participation in meetings regarding octopus reef closures across villages.

*4.1.4 Roles played by the community in octopus reef closures.*

The survey aimed to investigate the roles played by communities, Beach Management Units (BMUs) leaders, and village leaders in octopus reef closures. Overall, the findings revealed diverse roles undertaken by community members, with approximately 40% reporting their involvement in reporting individuals who violate closure regulations, 21% conducting community awareness campaigns, 12% educating on sustainable fishing practices, 11% participating in BMU/Collaborative Fisheries Management Areas (CFMA) meetings, 4% cleaning the beach and landing site, 3% participating in patrols, 1% data collection, and 7% reporting others (Figure 8).

Chi-square analysis across the villages indicates a significant difference in the distribution of roles among community members ($\chi^2$ (21, n = 96) = 162, $p < 0.05$). In all villages, a significant proportion of respondents reported playing a key role in reporting violators of closure bylaws and regulations. For example, 63% of respondents in Songomnara, 43% in Somanga, 39% in Songosongo, and only 14% in Namakongoro were involved in this aspect. Conducting community awareness campaigns emerged as another common role across all villages, with 34%, 26 %, 20 %, and 7% of the respondents from Namakongoro, Somanga, Songosongo, and Songomnara, respectively, undertaking this responsibility.

Remarkably, Songosongo stood out for its high involvement in reporting violators of closure bylaws and regulations, potentially influenced by the richness of octopus in closed reefs and surrounded by neighbouring villages with unfertile reefs frequently trespassing the closed areas, as reported by Key Informants (KIs). In Songomnara, the task of reporting violators seemed relatively straightforward because of the proximity of the closed area to the beach, facilitating easy monitoring. In Somanga, the high involvement in reporting violations may be attributed to the incentives provided as motivation for taking risks.

It has been reported that KIs noted several violations, with fishers being caught, subsequently fined, and prohibited from fishing during the opening periods. As a result, announcements of these violations were disseminated to the community. The community reacted by expressing fear of trespassing in closed areas as the perpetrators face financial penalties and lose income by not participating in fishing, hence, demonstrating increased compliance with closure rules and regulations. This indicates that enforcement actions and public announcements effectively influence behaviour change, fostering greater adherence to management measures.

In Namakongoro, conducting awareness campaigns emerged as a predominant role, followed by educating on sustainable fishing practices. Approximately 31% reported involvement in educational practices, while about 17% indicated no specific role, mainly among local communities and small business owners.

Furthermore, the survey also shed light on the significant roles played by KIs, primarily BMU leaders, village leaders, and fisheries officers, in managing the closure process. These individuals undertook a range of responsibilities, such as organising meetings, formulating regulations and strategies, preparing budgets, monitoring compliance, enforcing regulations, conducting surveillance, including patrols, collecting data, researching markets, setting prices, and managing revenue collection. Notably, BMUs and village leaders in Songosongo demonstrated a higher level of understanding than their counterparts in other villages, as reflected in the quality and comprehensiveness of their reports.

However, despite their common roles across villages, the execution of these responsibilities varied significantly. For instance, patrols in Somanga and Namakongoro were primarily conducted by BMU leaders alone, probably because they perceived that the patrol incentives offered may not suffice if shared. In contrast, in Songosongo and Songomnara, both BMUs and local communities participated in patrols, and the allowance was shared among all participants. In Songosongo, patrols were rigorously conducted for 90 consecutive days, covering approximately 3,977 hectares of reef, as reported by KIs. This vigilant surveillance involves four individuals rotating weekly to ensure round-the-clock protection and monitoring. The high compliance level in Songosongo can be attributed to this intensive surveillance, coupled with the abundance of octopuses on the reef. Notably, this practice is crucial because of the presence of neighbouring villages that lack regulations on reef access. Additionally, the Songosongo BMU operates a dedicated patrol boat to enhance its monitoring efforts.

The survey findings indicate the varied roles of communities, BMU leaders, and village leaders in octopus reef closures. Community members are actively engaged in reporting violations and conducting awareness campaigns, although there are significant differences across villages. For instance, Songosongo exhibits high involvement in reporting violations, likely due to frequent trespassing by neighbouring villages. Conversely, Namakongoro prioritises awareness campaigns, reflecting a tailored approach to community engagement. The pivotal roles of Key Informants (KIs), such as BMU leaders and fisheries officers, highlight the significance of leadership and coordination in closure management. Notably, the execution methods differ, with Songosongo employing intensive surveillance measures, including round-the-clock patrols and a dedicated patrol boat.

These insights underscore the need for tailored strategies, such as communication and information-sharing channels and adaptive management approaches, emphasising effective leadership, community engagement, and collaborative efforts in octopus reef closure initiatives. Nevertheless, other villages can benefit from adopting the best practices observed in Songosongo. Despite differences in geographical location, these exemplary practices can be implemented in other villages.

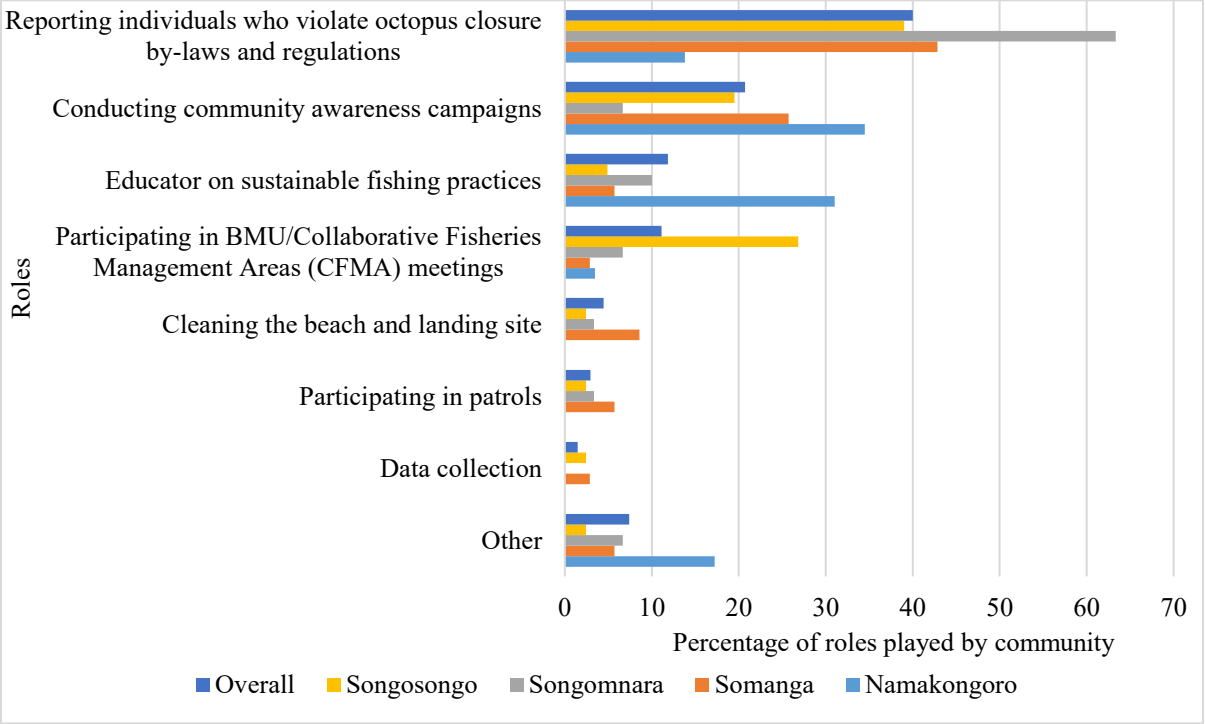


Figure 8: Roles played by the community in octopus reef closures.

## 4.2 Adherence to Rules and Decision-Making Involvement

### *4.2.1 Awareness of the communities to the octopus reef closure rules and regulation*

Despite the bottom-up management approach inherent in community-led initiatives, establishing rules and regulations is essential for ensuring compliance and success of practices such as octopus reef closures. Each community develops its own set of rules, often referred to as by-laws, to govern the implementation of these practices within the community. To further bolster these efforts, the Ministry of Livestock and Fisheries (MLF) has developed official guidelines to assist communities in effectively carrying out the process (MLF, 2023).

The survey aimed to gain insight into the rules existing across villages, the level of community awareness, adherence to these rules, and knowledge of the official guidelines. KIs confirmed the variation in rules across villages, although certain commonalities were also observed. Among these common rules were prohibitions on fishing in closed areas, fines and penalties for violators, and the requirement for fishers to pay tariffs to the BMU and village authorities for each kilogram of octopus caught.

For example, in Somanga, violators may face a fine of 300,000 TZS or six months' imprisonment, whereas in Namakongoro, the penalty is 200,000 TZS. Similarly, in

Songomnara, the fine is 60,000 TZS, and in Songosongo, it is 300,000 TZS for fishers and ranges from 300,000 to 1 million TZS for boat owners. Additionally, rules stipulate that no one is allowed to fish juvenile octopuses weighing below 500 g, a regulation also outlined in the Fisheries Regulations of 2009 and its amendment. Other regulations include the requirement to obtain a fishing license, with outsider fishers required to pay a fishing fee in villages such as Somanga and Songomnara. These regulations, set by the communities, influence compliance with closures and are highly effective. For instance, before the closure, enforcing a size limit of over 500 g was reported to be challenging because of non-selective gear. However, the implementation of octopus reef closures has addressed this issue, as octopus caught during the opening season ranges between 3.5 and 8 kilograms. KIs reported that violators were penalised with fines and prohibited from participating in fishing during the opening periods.

When surveyed about their awareness of these rules, 92% of respondents indicated being aware, with only 8% reporting unawareness, primarily from Namakongoro District. However, analysis across villages revealed that, apart from Namakongoro, 100% of the community members were aware of the closure rules and regulations (Figure 9). The Chi-square test indicates a significant difference in awareness between Namakongoro and the other three surveyed villages ($\chi^2$ (3, n = 96) = 109.09, $p < 0.05$). The high level of awareness among communities likely contributes to their high compliance with the practice, given the stringent penalties associated with the rule violations.

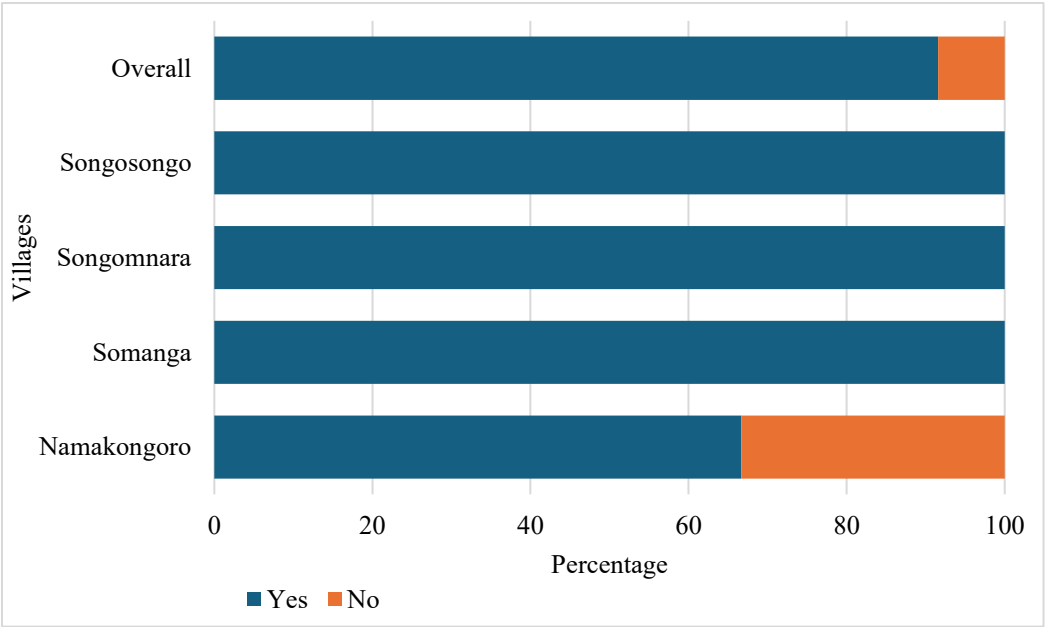


Figure 9: Community awareness of octopus reef closure rules and regulations.

Regarding knowledge of the official guidelines from the MLF, all KIs across the villages acknowledged awareness of their existence. However, only Songosongo and Somanga reported possessing the guidelines, with Songosongo actively implementing them and reporting positive results. In Somanga, although the guidelines are available, challenges exist in comprehending their contents, despite being written in Swahili. In contrast, Namakongoro and Songomnara do not possess guidelines.

Despite Songosongo implementing the guidelines, KIs highlighted discrepancies in adherence to the suggested timing. Scientific evidence indicates that the high recruitment period for octopuses occurs between March and August, peaking from May to July, as documented by Silas et al. (2021). Ideally, the closure should take place during this period, as juveniles recruited during November-December enter the fishing grounds, weighing no more than half a kilogram (MLF, 2023). Conversely, to promote juvenile octopus growth, the best opening time is August and September. The guidelines' recommended timing is not consistently followed by all villages, which could potentially improve the benefits of the closure if adhered to uniformly.

These findings emphasise the need for the MLF to formally distribute guidelines to all villages involved in octopus fishing. Moreover, training sessions should be provided for BMUs and community members on the guidelines' contents and how to effectively utilise them to ensure common understanding and implementation. Nevertheless, the MLF should translate the guidelines into simple language for ease of understanding by the communities and conduct regular monitoring to ensure the implementation of octopus reef closure guidelines in these villages.

### *4.2.2 Adherence of communities to the closure rules and the specified closure periods*

The survey aimed to provide insights into closure practices, rules, and periods across villages, as well as the level of adherence to these regulations. Villages consistently closed the same reef despite having access to multiple options. This tendency may be attributed to resource limitations, particularly the capacity to conduct monitoring, control, and surveillance activities. For example, in Songosongo, patrols are conducted throughout the closure period, with participants receiving compensation of 12,000 TZS per day and the need to hire boats to transport supplies. While closing more reefs could incur additional expenses, it could also lead to enhanced outcomes in terms of octopus conservation and resource sustainability.

Furthermore, the closure period spans three months for all villages, with the reef typically being open for three consecutive days. During this brief window, BMUs collect vital data on catch, pricing, number of fishers and boats, and revenue distribution among fishers, BMUs, and village authorities.

However, the actions taken after the initial three-day period vary among villages. For instance, in Namakongoro, the reef was promptly closed again. In contrast, the Songosongo, Somanga, and Songomnara reefs do not immediately re-close and lack a specific timeframe for resuming closure activities. This variance was verified by insights from the KIs and findings from previous research (Silas et al., 2022). Notably, Songosongo expressed intentions to adopt Namakongoro's approach for future seasons, citing positive outcomes from a previous season in which the official opening lasted five days instead of three. Re-closing the reef after three days of opening will allow for a robust recovery of the octopus population from fishing mortality, thereby ensuring the opportunity for long-term sustainability, as supported by Oliver et al. (2015).

The decision-making behind these approaches seems to be influenced by the favourable results observed in certain villages. For instance, Songosongo reported a significant catch of approximately 41,314 tons valued at about 202,357,500 TZS after a three-month closure period.

This is interpreted by a noted revenue distribution, with 161,886,000 TZS allocated to fishers, 20,235,750 TZS to BMU revenue, and another 20,235,750 TZS to boat owner fees, surpassing the previous season's results of 18,491.3 tons, valued at 96,621,500 TZS.

Regarding adherence to closure rules and specified periods, the survey found that 92% of respondents reported strict compliance, with only 8% indicating non-adherence, primarily from Namakongoro (Figure 10). However, analysis across villages revealed full compliance with closure rules and specified periods, with a significant difference for Namakongoro, where some non-compliance cases were reported, notably instances of theft during the night ($\chi^2$ (3, n = 96) = 109.09, $p < 0.05$). In contrast, Songosongo showed no cases of non-compliance or resistance, likely attributed to the village's robust economic impact and improved well-being, which incentivised strict adherence to practices.

Moreover, Songosongo's unique approach involves the strong integrity and transparency of BMU leadership, reinvesting BMU revenue back into the community, and supporting endeavours such as paying contractual teachers' allowances or funding mosque construction. This stands in contrast to other villages, where BMU revenue remains solely within the organisation. These findings underscore the intricate interplay between compliance and socio-economic factors, highlighting the importance of community-driven initiatives and effective resource allocation for sustaining closure practices. Hence, it is crucial for other villages to adopt the best practices from Songosongo, such as reinvesting revenue generated from octopus closures back into the community. Ensuring integrity and transparency within BMU executive committees can enhance acceptance and adherence to the practice, fostering trust in its positive outcomes. Nevertheless, it is important for stakeholders to continue to support these community-led initiatives and explore opportunities arising from such practices.

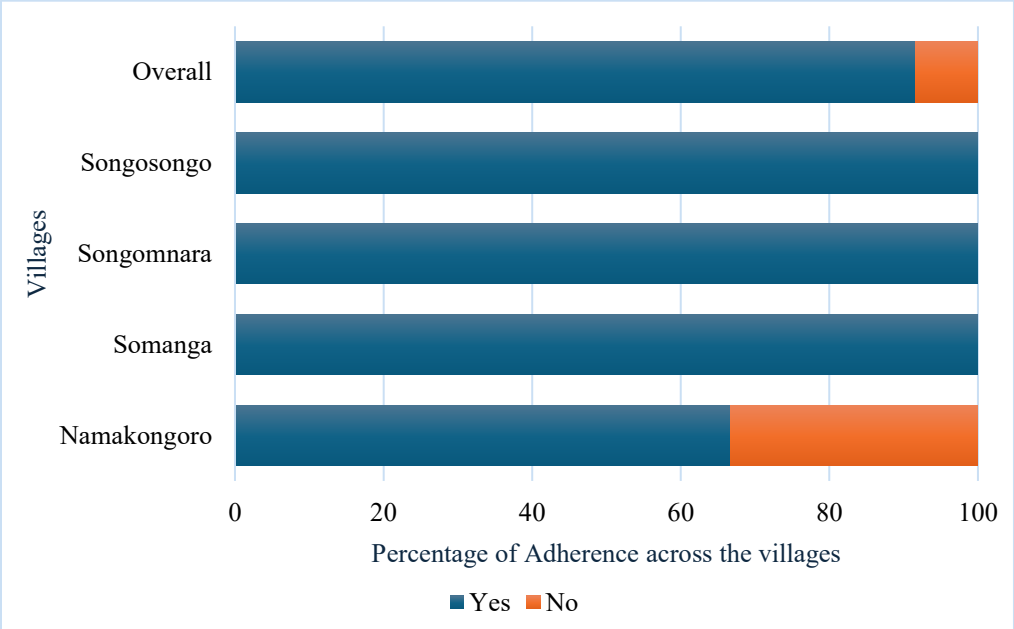


Figure 10: Community adherence to closure rules and specified closure periods.

### *4.2.3 Involvement of communities in the decision-making process regarding octopus reef closures*

The active involvement of communities in decision-making processes concerning their economic welfare and overall well-being is crucial. This highlights the importance of collaborative fisheries resource management and fostering a sense of ownership over shared resources, particularly fisheries such as octopus. Additionally, community involvement enhances compliance with the management practices implemented by these communities.

The survey sought to assess the extent of community involvement in decision-making regarding octopus reef closures and its potential influence on compliance levels across the villages. When respondents were asked about their participation in decision-making, 72% indicated their involvement, while 28% reported otherwise. Analysis across villages revealed significant differences in the scales of community engagement, with notably high levels observed in Songosongo (96%), followed by Somanga (74%), Songomnara (63%), and Namakongoro (54%) ($\chi^2$ (3, n = 96) = 48.16, $p < 0.05$). Remarkably, all villages recorded participation levels exceeding 50% (Figure 11).

The analysis implies that communities with higher levels of involvement in decision-making, such as Songosongo, exhibit greater compliance with octopus reef closure management. This increased compliance may be attributed to the community's active role in decision-making processes, which fosters cohesion and a shared commitment to conservation efforts. These findings underscore the significance of community engagement in decision-making as a driver of compliance, highlighting its importance in sustainable resource management initiatives. Furthermore, local communities support for management initiatives is crucial to effectively protect biodiversity and human livelihoods (Oliver et al., 2015)

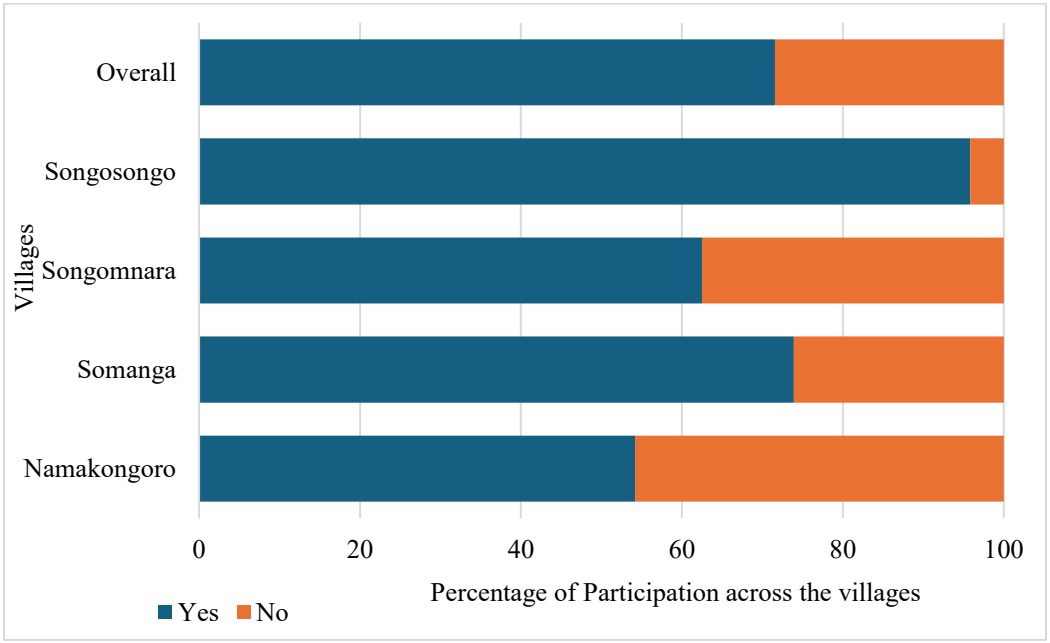


Figure 11: Community participation in the decision-making process regarding octopus reef closures.

*4.2.4 Measures taken by communities to ensure compliance with octopus reef closures, rules and regulations.*

The survey aimed to explore the measures taken by communities to ensure compliance with the octopus reef closures. It is recognised that abstaining from familiar activities or areas can be challenging, necessitating various strategies to facilitate compliance and deter temptations. Octopus reef closures, during which octopuses reach lucrative sizes, pose challenges, with reports indicating the potential temptation to violate regulations (Silas et al., 2022).

The question was, "what measures do you take to ensure compliance with octopus reef closures?" Overall, the findings revealed a range of measures employed by community members to adhere to octopus reef closure rules and regulations. Approximately 25% of respondents reported participating in community meetings, 20% adhering to designated closure periods, 19% educating others about the importance of closure, 8% participating in education and awareness programs, and 7% reporting violators to authorities (Figure 12).

Analysis across villages unveiled statistically significant variations in the measures taken by community members ($\chi^2$ (21, n = 96) = 99.58, $p < 0.05$). In all villages, a significant proportion of farmers participated in community meetings, with notable rates in Songosongo (42%), Songomnara (22%), Somanga (20%), and Namakongoro (16%). Adherence to closure periods was another common practice across villages, with rates of 24% in Songosongo, 23% in Namakongoro, 22% in Songomnara, and 14% in Somanga. Additionally, educating others about the importance of closure was prevalent, with rates of 18%, 29%, 20%, and 15% across the villages. Reporting violators to the authorities was also notable, with rates of 4%, 13%, 24%, and 20% across the villages.

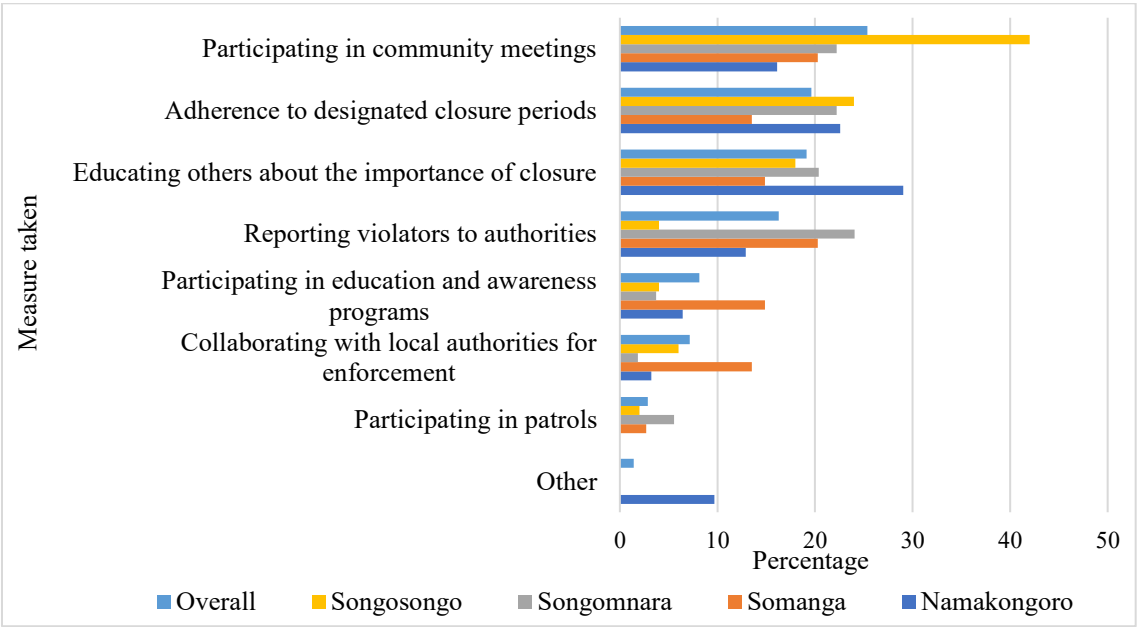


Figure 12: Measures taken by the community to ensure compliance with octopus reef closures.

Songosongo displayed high involvement in community meetings, possibly driven by the fishery's significance to the community, as evidenced by decision-making involvement. In

Namakongoro, high rates of educating others about the importance of closure may compensate for lower participation in meetings and decision-making, enhancing awareness and compliance. In Songomnara and Somanga, reporting violators to the authorities was straightforward, possibly due to proximity to the closed area and provided incentives or strict enforcement measures.

The information from the KIs underscores the importance of strict enforcement measures to ensure compliance with octopus reef closures. These measures include imposing hefty penalties and severe punishments, such as removal from BMU membership or leadership. As highlighted by Oliver et al. (2015), effective enforcement is crucial for realising post-closure benefits, as without it, open-access fishing becomes the most economically rewarding strategy. This emphasises the necessity of implementing enforcement measures that are both applicable and cost-effective to enhance compliance in the future. For instance, in Songosongo, frequent educational and awareness training and patrols have been effective in fostering community compliance, whereas in Namakongoro, Somanga, and Songomnara, compliance may be more difficult to achieve. Despite the presence of strict rules and penalties, continuous capacity building and awareness programs remain essential across all villages, particularly in Namakongoro, Somanga, and Songomnara, to ensure effective management measures.

## 4.3 Perception of Importance of Compliance with Octopus Reef Closure

### *4.3.1 Perception of the communities to the importance of compliance with octopus closure, rules, and regulations*

The survey placed significant emphasis on understanding the community's perception of compliance with octopus reef closure practices and regulations. When respondents were asked about their views on compliance, an outstanding 92% expressed the belief that adhering to closure rules is paramount for ensuring the sustainability of octopus populations and the preservation of marine ecosystems. Meanwhile, 5% remained uncertain, 2% recognised the importance of compliance but cited economic constraints as a challenge to consistent adherence, and 1% acknowledged the importance of compliance but highlighted the presence of other influencing factors (**Error! Reference source not found.**).

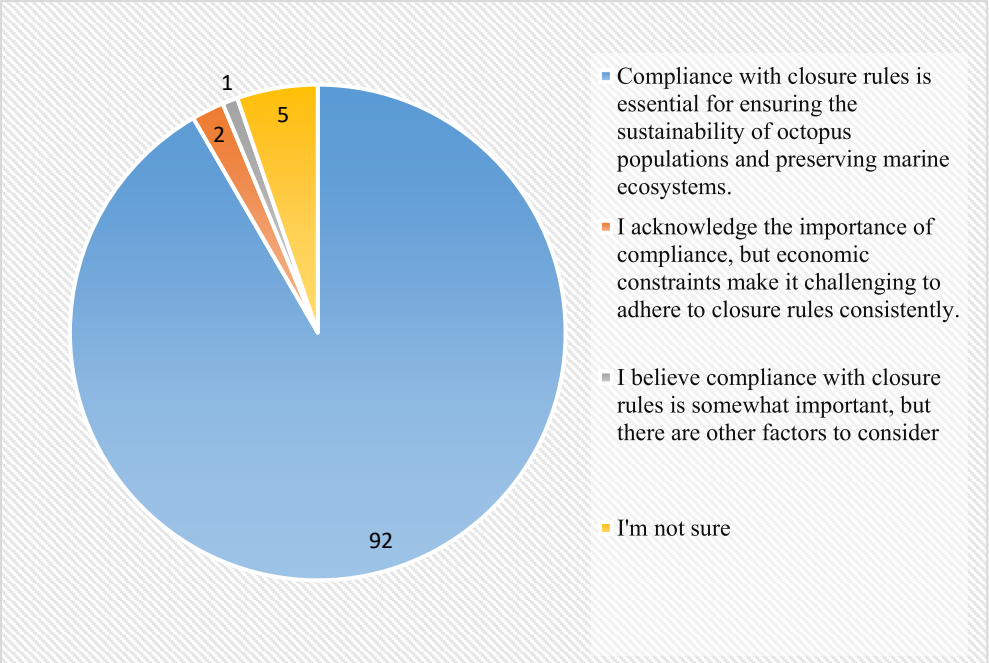


Figure 13: Community perception of the importance of compliance with octopus closure rules.

Upon analysing responses across villages, significant variations in perception were revealed, with Songosongo (96%) and Namakongoro (71%), while all communities in Somanga and Songomnara collectively perceived compliance as crucial ($\chi^2$ (9, n = 96) = 106.44, $p < 0.05$). This collective perception emphasises the recognition of the vital role of compliance in preserving octopus populations and marine ecosystems. The high value placed on compliance by these communities can be attributed to the tangible benefits derived from closure practices, as evidenced by the reported outcomes.

In Songosongo, 96% of community members acknowledged the essential nature of compliance, emphasising its role in ensuring the sustainability of octopus populations and marine ecosystems. However, 4% of respondents expressed nuanced views, indicating that while they recognised the importance of compliance, they believed that other factors must also be considered. These factors may include a deeper understanding of the ecological significance of closures, the provision of incentives or benefits for compliance, and access to alternative livelihood opportunities.

The widespread perception of compliance emphasises its significance in the community. This positive perception can be attributed to the reported benefits of closure practices, including increased income, enhanced well-being, sustainability, improved marine environments, and more robust data collection efforts, as corroborated by the insights from the KIs.

### *4.3.2 Factors influencing community compliance with octopus reef closures.*

This study aimed to explore community perceptions of the importance of complying with octopus reef closure practices, rules, and regulations, and sought to delve deeper into the factors influencing their decisions to adhere. Therefore, the survey inquired about the factors influencing community compliance decisions to understand the relationship between these variables.

When communities were questioned "what factors influence your decision to comply with octopus reef closures?" Of the respondents, 41% cited the influence of their understanding of the ecological importance of closures, 23% mentioned economic incentives or benefits for compliance, 10% expressed fear of penalties or enforcement measures, 9% emphasised the perception of the long-term benefits of closure, 6% highlighted trust in the effectiveness of closure measures, 5% mentioned social pressure from the community or peers, and 3% attributed compliance to personal ethics or values regarding sustainable fishing and access to alternative livelihood opportunities (Figure 14).

Analysis across villages revealed significant variations in the factors influencing community compliance ($\chi^2$ (21, n = 96) = 118.97, $p < 0.05$). Understanding the ecological importance of closure emerged as a common factor across all villages, with significant proportions in Songosongo (49%), Songomnara (47%), Somanga (43%), and Namakongoro (29%). Economic incentives or benefits for compliance were also prevalent across villages, with rates of 31% in Namakongoro, 16% in Songosongo, 16% in Songomnara, and 11% in Somanga. In Namakongoro, Somanga, and Songomnara, fear of penalties or enforcement measures and the perception of the long-term benefits of closure were important factors, as hefty fines and the belief in the enhancement of closure for long-term sustainability were reported by KIs. In contrast, in Songosongo, social pressure from the community or peers and trust in the effectiveness of closure measures emerged as significant factors, likely influenced by previous positive results.

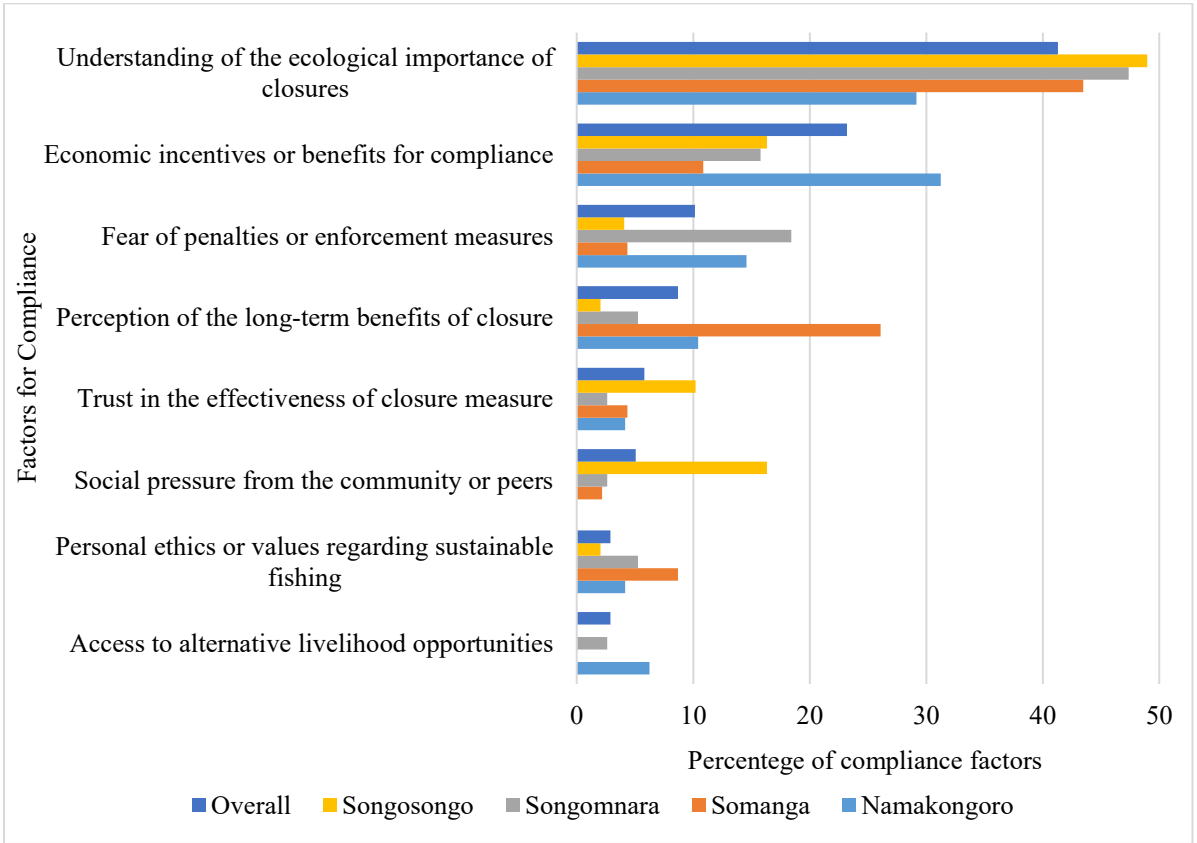


Figure 14: Factors influencing community compliance with octopus reef closures.

Furthermore, understanding the ecological importance of closure emerged as a prominent factor across villages, possibly due to the increased catches observed since the closure implementation, coupled with increased income and support from NGOs such as Blue Ventures, Sea Sense, and WWF. KIs reported receiving funding and support for processing facilities, data collection, patrol equipment, training, and guidance during the closure periods. These factors likely played a significant role in community compliance, emphasising economic well-being, livelihood security, and resource sustainability. Nevertheless, common theory suggests that communities are more inclined to adhere to and participate in management practices when they believe that the anticipated advantages surpass the perceived drawbacks of such management (Oliver et al., 2015).

Hence, compliance with octopus reef closure is significantly influenced by socio-economic factors, highlighting the need for ongoing support from the MLF, Local Government Authorities (LGAs), and other stakeholders to the community. The support may include funding for patrols, provision of training, processing facilities, data collection equipment, and development of infrastructure such as landing sites and markets.

## 4.4 Socio-Economic Impacts of Octopus Reef Closure on Local Communities

### *4.4.1 Changes in income of community from octopus fishing since the implementation of reef closures*

The survey aimed to explore the socioeconomic impact of octopus reef closures on local communities. Specifically, we sought to understand whether there have been any changes in community income since the implementation of the closure measures. Overall, 85% of the respondents reported observing changes in their income, while 15% noted no significant difference. Upon analysing responses across the villages, no significant differences were observed ($\chi^2$ (3, n = 96) = 3.30, $p > 0.05$). Similar trends emerged, with 89% in Somanga, 8, 86 %, 85 %, and 80% of the Somanga Songosongo, andSongomnara communities' observing income changes, respectively (Figure 15).

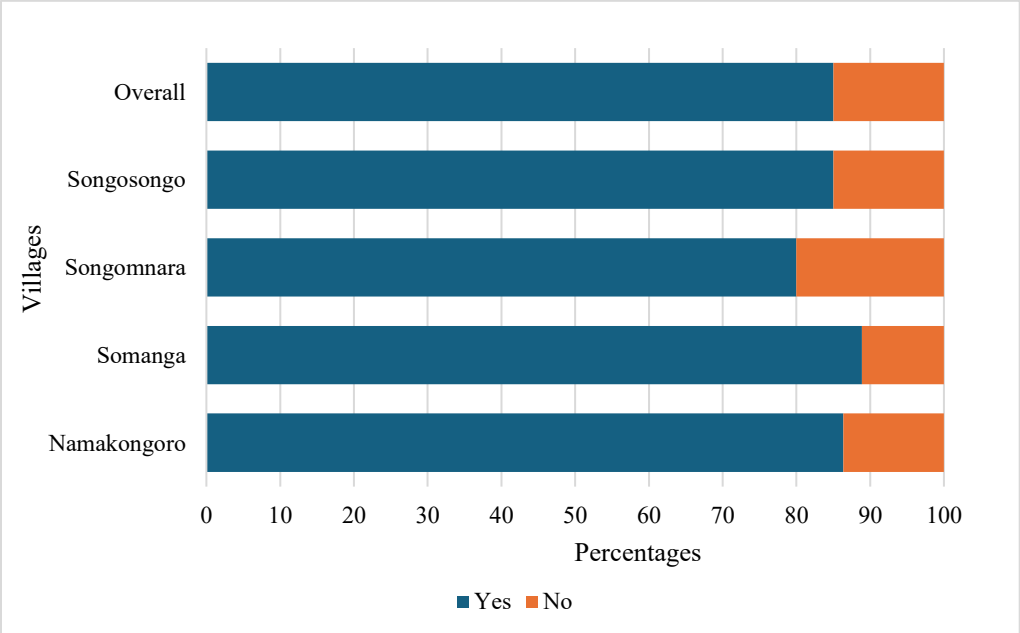

Figure 15: Changes in community income from octopus fishing since the implementation of reef closures.

Furthermore, we investigated the specific changes experienced by different community members, including fishers, vendors, and processors. A remarkable 80% of respondents reported a significant increase in income, 19% noted a slight increase, and only 1% indicated a decrease (Figure 16). The Chi-square analysis across the villages revealed significant differences in the scale of changes in income experienced by the community ($\chi^2$ (6, n = 96) = 47.88, $p < 0.05$). Notably, Songosongo stood out, with 94% of respondents reporting a significant income increase, consistent with findings from Key Informants and previous research (Silas et al., 2022; Oliver et al., 2015).

Similarly, other villages also reported high proportions of respondents noting significant income increases: Songomnara (88%), Somanga (69%), and Namakongoro (68%). These findings underline the positive impact of octopus closure management measures, not only in terms of octopus population increase but also in enhancing community income levels and economic prosperity, despite occasional reports of reduced prices during opening periods.

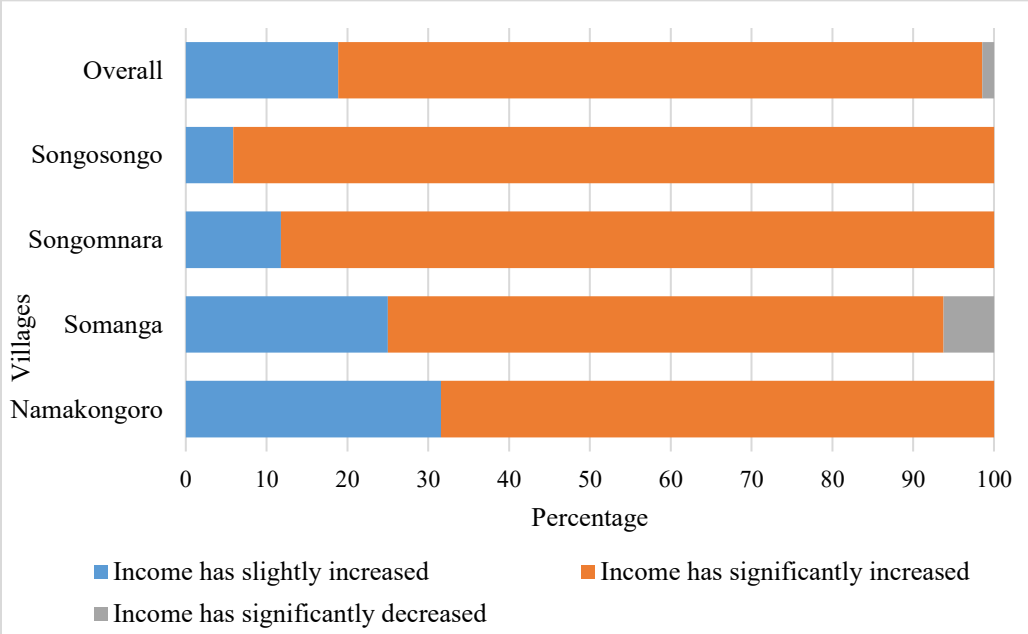


Figure 16: Changes in income experienced by the community since the implementation of the octopus reef closure.

The observed significant variations in income changes across villages may be attributed to differences in catch volumes and the size of reefs subject to closure. For instance, Songosongo closes a single reef spanning 3,977 hectares, yielding substantial catch volumes, whereas Namakongoro closes smaller reefs totalling approximately 4 hectares, resulting in comparatively lower catch volumes. Similarly, Songomnara and Somanga close two adjacent holes and two reefs, respectively, with corresponding differences in the catch volumes. The lower catch volumes might be due to either the small size of the reef closed, high fishing pressure, long open periods, or high fishing intensity during opening periods which do not support robust recovery from fishing mortality, as reported by Oliver et al. (2015). This

highlights the importance of considering the size and characteristics of the closed reef, as well as the timing of opening and fishing intensity, to achieve significant results.

Overall, these findings indicate a significant correlation between compliance with closure measures and socioeconomic impacts, particularly income increases. Moving forward, it will be important to continue monitoring income trends and devise interventions to address the identified income-related challenges while maximising the benefits of octopus reef closures for local communities. These interventions might include economic diversification initiatives aimed at providing alternative sources of income for communities, expanding market access and value-added opportunities, enhancing capacity through training programs, and strengthening enforcement and compliance mechanisms through strategic investment in resources and infrastructure. By addressing the challenges faced by local communities and maximising the potential benefits, these measures can ensure the economic development, long-term success, and sustainability of octopus reef closure endeavours.

### *4.4.2 Octopus reef closure benefits for overall well-being of the community*

The survey aimed to assess the impact of octopus reef closure on community income and sought to understand its broader effects on overall community well-being. Specifically, the survey investigated whether community members believed that reef closures contributed to their overall well-being.

The findings revealed that an overwhelming majority (96 %) of respondents believed that octopus reef closures improved their overall well-being, while only 4% expressed doubts. Across villages, this sentiment was consistent, except for Namakongoro, where 83% of respondents acknowledged the positive impact ($\chi^2$ (3, n = 96) = 52.17, $p < 0.05$) (Figure 17). These communities reported experiencing changes in their welfare due to reef closures.

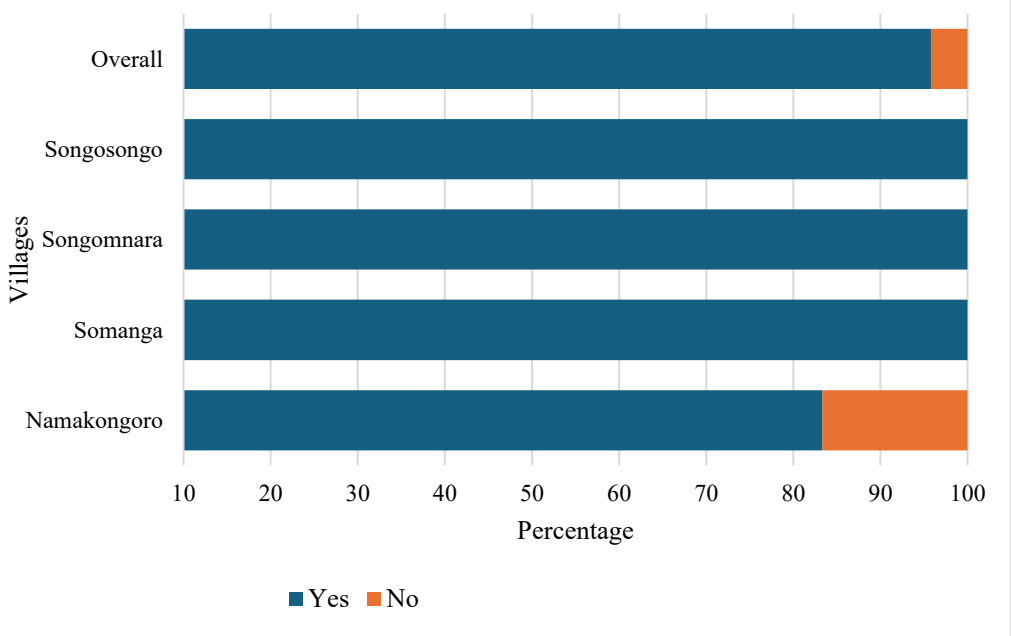


Figure 17: Community belief in the contribution of octopus reef closures to overall well-being.

The survey findings displayed a widespread belief among community members that octopus reef closures have positively impacted overall well-being, addressing SDG 3 (good health and well-being). With an overwhelming majority (96 %) expressing this sentiment, it emphasises the significance of reef closures beyond mere economic benefits. While this belief was consistent across most villages, it is noteworthy that Namakongoro showed a slightly lower but still substantial acknowledgement at 83%. These results affirm the broader positive effects of reef closures on community welfare, highlighting the importance of conservation measures for holistic community development.

### *4.4.3 Conflicts within the community regarding octopus reef closures*

In any societal context, conflicts are inevitable because of the diversity of views and opinions. This is true for practices such as octopus reef closures, which directly impact people's livelihoods and resource sustainability. The survey aimed to uncover whether conflicts existed within communities regarding octopus reef closures and gauge the level of cohesion and cooperation among community members.

Overall, 73% of the respondents reported no conflicts, while 27% indicated otherwise (Figure 18). Among those who acknowledged conflicts, 81% described them as minor, involving occasional disagreements or tensions that were quickly resolved without significant impact. The remaining 19% reported moderate conflicts, leading to noticeable tensions that were manageable and did not escalate significantly ($\chi^2$ (3, n = 96) = 104.23, $p < 0.05$) (Figure 18). Major conflicts were generally absent in these communities.

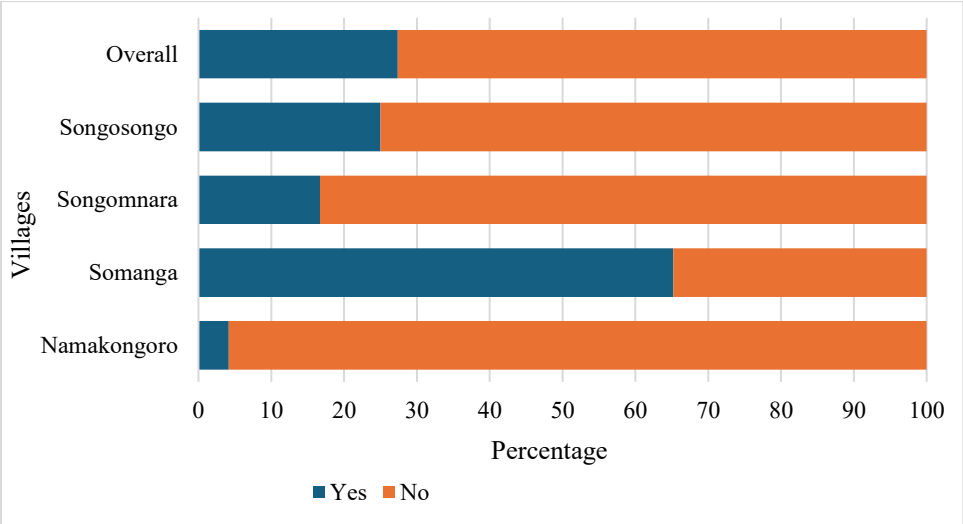


Figure 18: Conflicts within the community regarding octopus reef closures.

However, analysis across villages revealed significant differences in the scale of conflicts, with Somanga experiencing notable minor (80%) and moderate (20%) conflicts ($\chi^2$ (3, n = 96) = 69.23, $p< 0.05$) (Figure 19). This could stem from its geographical location and occasional instances of non-compliance, necessitating that community members report to the authorities. Moreover, the exclusion of BMU members and local communities from patrol activities by the BMU executive committee may contribute to tensions. A similar scenario was observed in Songosongo, with 67% minor and 33% moderate conflicts, possibly due to rigorous monitoring and surveillance during the closure period, leaving fewer loopholes for violators.

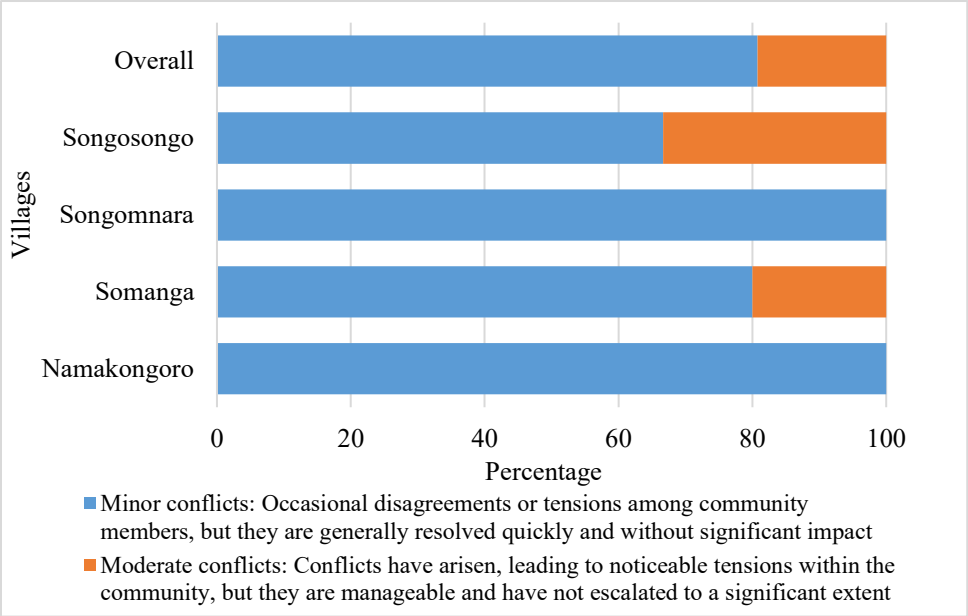


Figure 19: Scale of conflicts within the community across villages.

Nevertheless, despite minor conflicts, octopus reef closures have strengthened community cohesion and cooperation. Overall, 78% of respondents noted strengthened cohesion and cooperation, while 14% reported the maintenance of existing levels, and 3% noticed no impact (Figure 20). Across villages, significant differences emerged, with Somanga (87%), Namakongoro (42%), and all communities in other villages recognising enhanced cohesion and cooperation ($\chi^2$ (6, n = 96) = 160, $p < 0.05$). In Namakongoro, moderate levels might result from its diverse population and socioeconomic activities, with only the BMU executive committee involved in monitoring and conducting surveillance. A similar trend was observed in Somanga, although with slightly reduced cohesion, likely due to the presence of the Octopus Fishers Association, which resolves conflicts more efficiently.

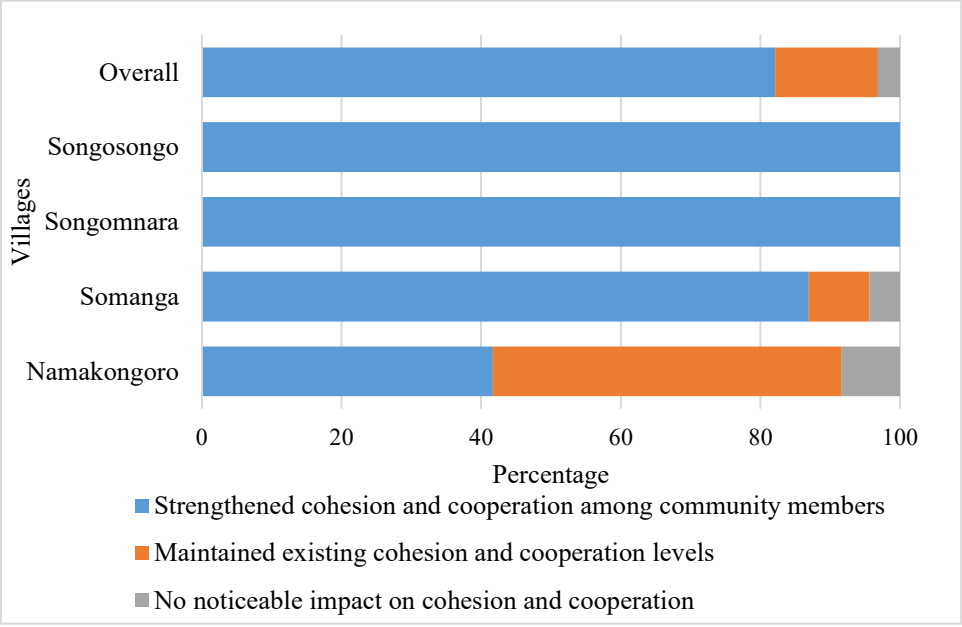


Figure 20: Impact of octopus reef closure on community cohesion and cooperation.

In Songosongo and Songomnara, community cohesion and cooperation were significantly high, possibly due to the importance of fisheries, a high level of community engagement, and positive outcomes. This underscores the importance of stakeholder engagement and forming fishers' unions to address community interests. Such high levels of cohesion and cooperation contribute to the success of octopus reef closure measures, enhancing the socioeconomic well-being of the community.

## 4.5 Economic Effects of Octopus Reef Closure on Local Economies

### *4.5.1 Effects of octopus reef closure on quality and price of octopus in the market*

The survey aimed to gauge community perceptions regarding the impact of octopus reef closures on the quality and market price of octopuses, recognising their direct influence on local economies, livelihoods, and resource sustainability. Respondents were asked about their observations regarding the changes in quality and price resulting from these closures and how these changes affected community livelihoods.

Overall, 89% of respondents acknowledged the influence of octopus reef closures on quality and market price, while 11% had different views. Moreover, 76% reported fluctuations in octopus prices in local markets, with 24% noting no such changes (Silas et al., 2022). Chi-square analysis across villages revealed significant variations in responses ($\chi^2$ (3, n = 96) = 31.27, $p < 0.05$). While all communities in Somanga noticed fluctuations in quality and price, other villages differed in their observations, with Songosongo (96%), Songomnara (58%), and Namakongoro (50%) displaying varying levels of perception regarding this influence (Figure 21).

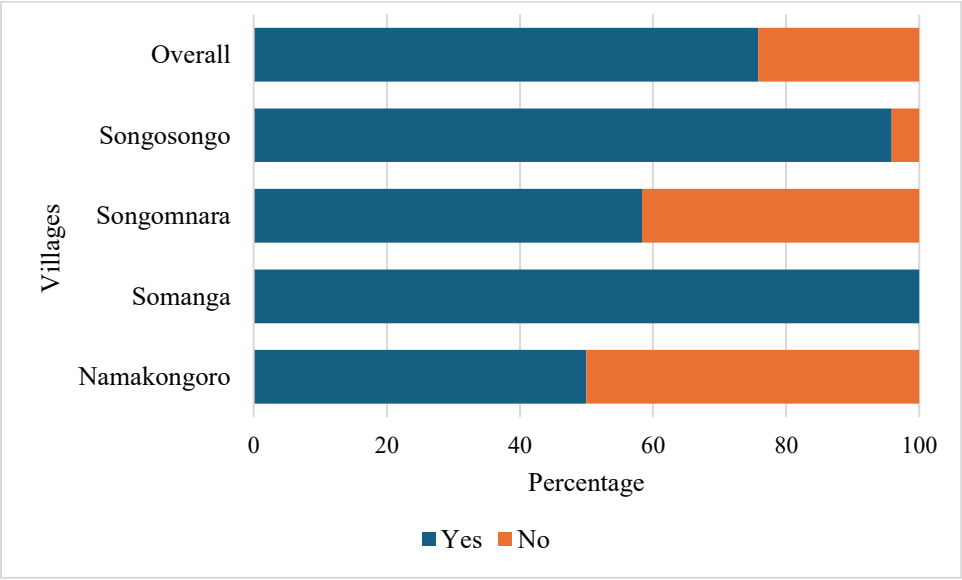


Figure 21: Fluctuations in octopus prices in local markets.

Further enquiry into observed changes revealed that 94% of respondents perceived an improvement in octopus quality, while 3% noted price decreases due to market oversupply and 3% noted price increases due to reduced supply (Figure 22). Across villages, responses differed significantly, with Songosongo (100%), Somanga (86%), Songomnara (86%), and Namakongoro (86%) reporting improvements in quality ($\chi^2$ (6, n = 96) = 73.14, $p < 0.05$).

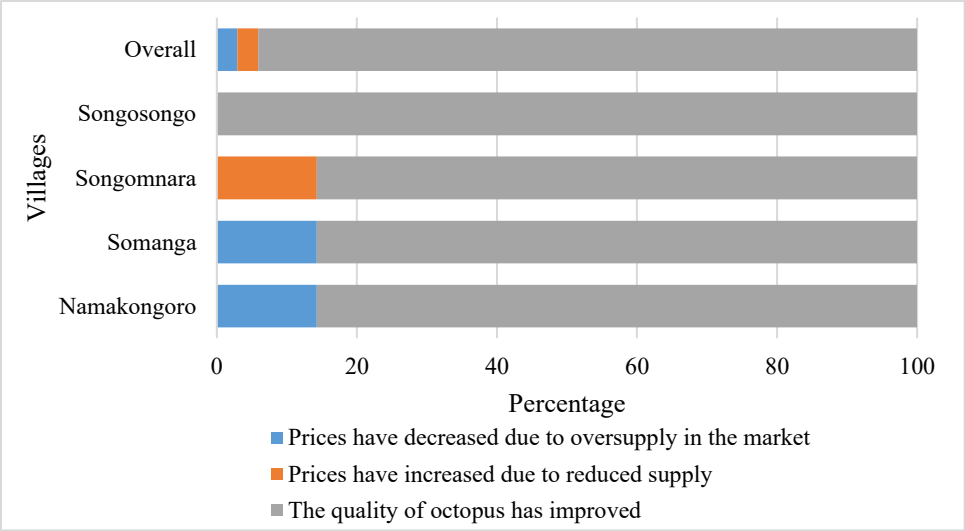


Figure 22: Effects of closure on octopus quality and price

These divergences may stem from various factors. For instance, Songosongo's high response rates regarding improved quality and price may be attributed to their substantial octopus production during openings, prompting support from organisations such as WWF, which provided ice-flake-making machines to enhance quality and storage capabilities. In contrast, other villages may lack such quality measures, leading them to sell octopus immediately upon landing, resulting in price fluctuations due to oversupply.

Key Informants (KIs) reported significant price reductions during openings, with Somanga experiencing a drop from 6,000 TZS to 3,000 TZS per kilogram, while Namakongoro and Songomnara sold for 4,000 TZS. Additionally, reliance on small agents who offer varying prices based on weight further impacts community income and livelihood.

However, despite the fluctuations in price observed during the opening, the community still experienced significant benefits in terms of their income. This could be attributed to the high catch rates reported during the opening period of the fishery. According to the findings, individual fishers can catch approximately 100–150 kg of octopus within three days of opening, with individual octopuses weighing between 3.5–8 kg. This remarkable yield contrasts with the catch rates in other areas and during non-closure periods.

Addressing these quality and pricing challenges is necessary to maintain community motivation and compliance with the closure regulations. Collaborative efforts involving local and central governments, NGOs, and stakeholders should focus on providing essential facilities and resources, such as processing equipment (e.g. freezers and ice-flake making machines), to enable long-term storage and maintain quality. Direct connections with processing plants and training on quality and marketing practices can empower communities and ensure sustainable economic benefits from octopus reef closure. Moreover, Songosongo can serve as a valuable example for other villages currently implementing or considering octopus reef closures, such as Namakongoro, Somanga, and Songomnara. By studying Songosongo's approach, including how they address pricing and marketing challenges and other best practices employed in the village, neighbouring communities can glean valuable insights for their initiatives.

### *4.5.2 Effects of octopus reef closure on supply and demand*

The survey sought to investigate the impact of octopus reef closures on the supply and demand dynamics of octopuses. Respondents were queried about any observed changes in octopus supply and demand since the initiation of the practice to determine the nature of these alterations. The findings revealed that most respondents (94 %) noted changes in octopus supply and demand, while the remaining 6% did not perceive any differences. Analysis across the villages displayed significant variations, with all communities in Somanga and Songosongo reporting changes, whereas Songomnara (92%) and Namakongoro (83%) also acknowledged alterations ($\chi^2$ (3, n = 96) = 32.59, $p < 0.05$) (Figure 23).

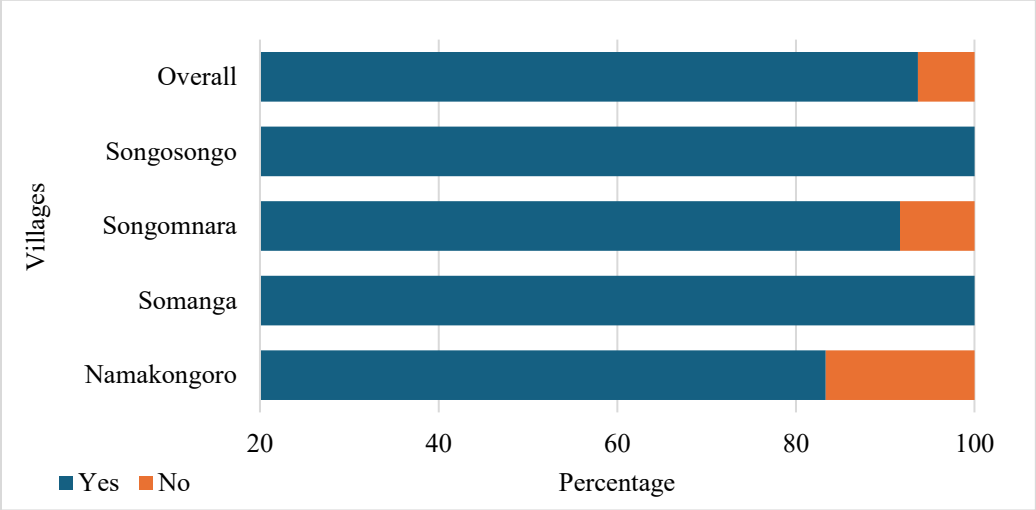


Figure 23: Changes in octopus supply and demand since the closures were introduced.

When probed further regarding the nature of these changes, the respondents indicated diverse patterns. Approximately 48% reported a significant increase in octopus supply and demand, 44% noted a slight increase, 7% observed a slight decrease, and 1% did not notice any changes. Significant differences emerged across villages in these observations. Notably, Songosongo (83%) reported a significant surge in both supply and demand, whereas Songomnara (36%), Somanga (43%), and Namakongoro (25%) cited similar increases, but to a lesser extent ($\chi^2$ (9, n = 96) = 174.26, $p < 0.05$). Moreover, Songomnara (27%) reported a slight decrease in supply and demand, in contrast to Namakongoro (5%), where no changes were discerned (Figure 24).

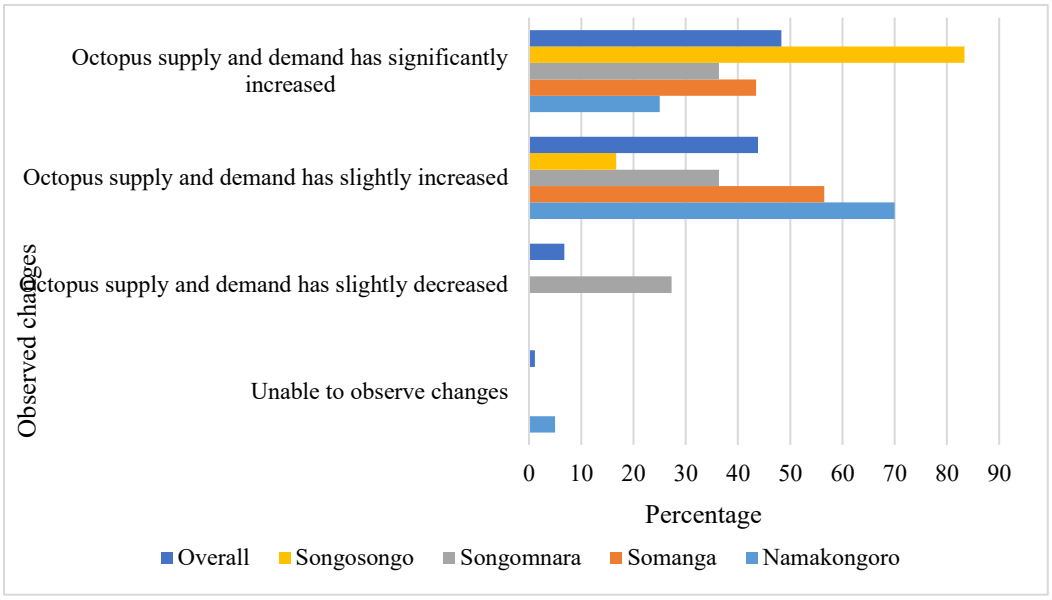


Figure 24: Changes in octopus supply and demand observed by community.

The differing outcomes across the villages can be attributed to various factors. For instance, in Songosongo, the substantial increase in supply and demand may be linked to the high quantity of octopuses caught during the three-day opening period. Despite facing challenges in other areas, such as market prices, Songosongo maintains a robust demand due to its leading position in catches and the high quality of its products. Conversely, other villages experienced more modest increases in supply and demand because their catch volumes were not as substantial as those in Songosongo. Additionally, the presence of local processors and vendors in bustling villages like Somanga may influence octopus distribution, benefiting smaller-scale enterprises while potentially impacting larger suppliers differently.

### *4.5.3 Economic benefits experienced by communities due to octopus reef closures.*

The survey aimed to delve into the economic advantages brought about by octopus reef closures in local communities, seeking to unravel the specific economic benefits they derive. Overall, the findings revealed a variety of economic gains reported by the respondents. Approximately 45% of respondents highlighted the increase in the octopus population, 19% noted the enhanced sustainability of the fishery, 17% observed an improvement in the quality of the octopus catch, 12% mentioned the strengthening of community cohesion, 5% cited higher market prices for octopus, and 1% reported reduced competition among fishers and other benefits (Figure 25). Some respondents also mentioned contributing to village development because of the revenue generated from octopus fishing.

Upon analysing the responses across different villages, significant variations in the economic benefits and factors influencing community compliance were observed ($\chi^2$ (18, n = 96) = 62.98, $p < 0.05$). The increase in the octopus population emerged as a common factor across all villages, with significant proportions in Namakongoro (56%), Songomnara (58%), Songosongo (40%), and Somanga (33%). Similarly, enhanced sustainability of the fishery was prevalent across villages, with rates of 27%, 21%, 12%, and 10% in Somanga, Songosongo, Namakongoro, and Songomnara, respectively. Additionally, the improvement in the quality of octopus catch was significant, with rates of 20%, 16%, 20%, and 10% across the villages

(Figure 25). In Songosongo, the importance of strengthened community cohesion was highlighted, consistent with previous findings.

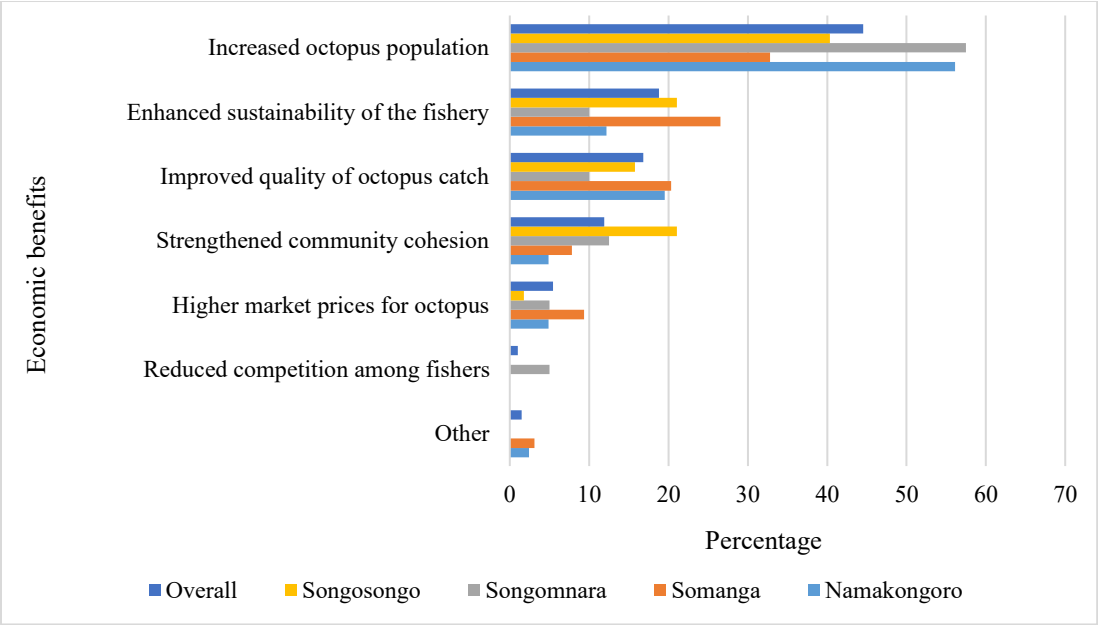


Figure 25: Economic benefits experienced by the communities due to octopus reef closures.

These findings provide clear evidence that octopus reef closure management measures yield economic benefits for communities, with significant variations across villages. Furthermore, these practices enhance the economic well-being of fishermen and benefit the entire community along the value chain, contributing to the sustainability of the octopus fishery. Key Informants (KIs) supported these findings, emphasising the closures' positive economic impact on various stakeholders, including vendors, processors, and small business owners. Since the implementation of closures, livelihoods in these communities have transformed, with some families being able to afford proper accommodations, support their children's education, invest in alternative livelihoods, and contribute to overall village development. Nevertheless, it can be supported by the economic importance of the octopus fishery, as it generates significant cash for the communities.

These results provide clear evidence that octopus reef closures have significant economic implications for communities. Addressing identified challenges, such as community engagement, product quality and pricing, marketing strategies, and the integrity of Beach Management Units (BMUs) leadership associated with the closures, could further enhance these benefits. This enhancement would not only positively impact the local community but could also have broader implications at the national level, potentially increasing government revenue streams through royalties.

### *4.5.4 Significance of octopus fishing to the overall livelihood of the community*

Despite the known positive economic impact of octopus reef closures on both local communities and the nation, this survey aimed to understand the significance of octopus fishing to the overall livelihoods of community members, particularly fishers, processors, and vendors. Overall, 55% of respondents viewed octopus fishing as essential, constituting their entire

income, while 30% considered it important, contributing significantly to their earnings. Additionally, 10% reported it as moderate, acknowledging its contribution to their income but noting other sources as well, and 5% considered it negligible, having little impact on their earnings (Figure 26).

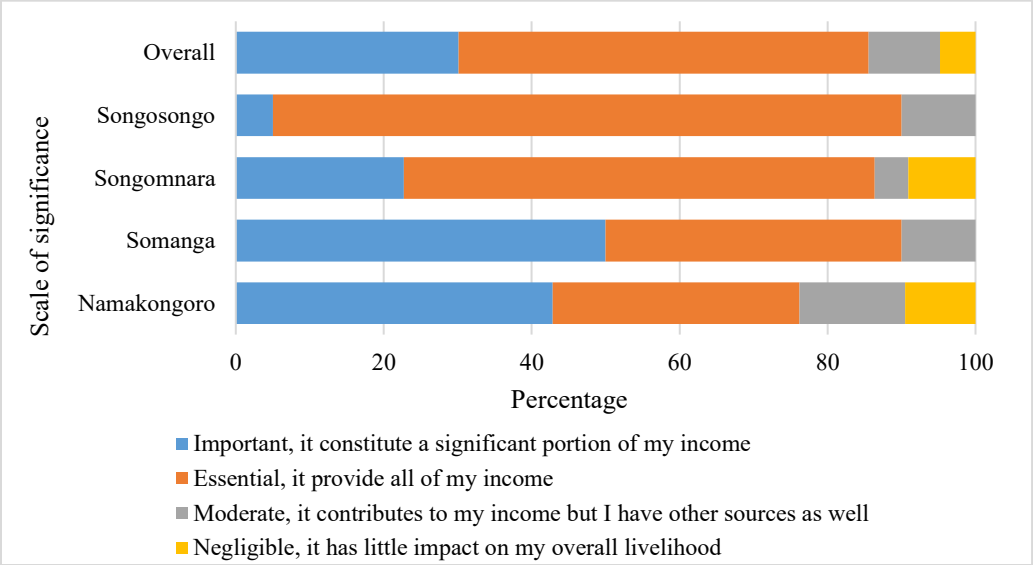


Figure 26: Significance of octopus fishing to the overall livelihood of the community.

Analysis across villages revealed significant variations in the importance of octopus fishing to the community ($\chi^2$ (9, n = 96) = 94.85, $p < 0.05$). The perception that octopus fishing provides all of one's income emerged as common across all villages, with significant proportions in Songosongo (85%), Songomnara (64%), Somanga (40%), and Namakongoro (33%). Similarly, the perception that fishing contributes to income but is supplemented by other sources was prevalent, with rates of 14%, 10%, 10%, and 5% in Namakongoro, Somanga, Songomnara, and Songosongo, respectively. In Somanga, Namakongoro, and Songomnara, it was deemed important, constituting a significant portion of the respondents' income, with rates of 50%, 43%, and 23%, respectively (Figure 26).

These findings reflect the diverse economic situations in these villages, particularly in Somanga and Namakongoro, which have a range of economic activities. In Songosongo, where octopus fishing dominates livelihoods, with 85% of respondents viewing it as essential, this reliance on octopus fishing may influence compliance levels within the community. KIs have reported high compliance in Songosongo, with compliance levels varying from moderate to high in Somanga, Namakongoro, and Songomnara, likely influenced by the catches and income generated from octopus fishing.

This emphasises the importance of context-specific approaches to fisheries management and community development initiatives. By recognising the unique circumstances and priorities of each community, policymakers and stakeholders can tailor interventions to address specific needs and maximise the benefits derived from octopus fishing while promoting its sustainability and resilience. Furthermore, good practices in community engagement and surveillance observed in Songosongo should be replicated in other villages with support from government-sponsored programs.

## 4.6 Community Perception on Sustainability, Compliance Challenges, and Improvement Suggestions for Octopus Reef Closure Practices

### *4.6.1 Perception of community on sustainability of octopus fishery*

The survey aimed to assess community perceptions regarding the sustainability of octopus fisheries through the implementation of octopus reef closures. By delving into community attitudes towards well-being and livelihoods, valuable insights were gained. Overall, an overwhelming majority (93 %) of respondents perceived the closures as significantly enhancing the sustainability of octopus fisheries. In contrast, 5% believed that closures somewhat enhanced sustainability, while 2% expressed concerns that closures might somewhat reduce sustainability (Figure 27).

Upon analysing responses across villages, significant differences in perspectives emerged ($\chi^2$ (6, n = 96) = 63.57, $p < 0.05$). In Songosongo, an impressive 100% of respondents viewed octopus reef closures as enhancing sustainability, followed closely by Songomnara (96%), Somanga (91%), and Namakongoro (83%). However, a small percentage in Namakongoro (17%) and Songomnara (4%) felt that closures only somewhat enhanced sustainability, while 9% in Somanga perceived closures as somewhat reducing sustainability (Figure 27).

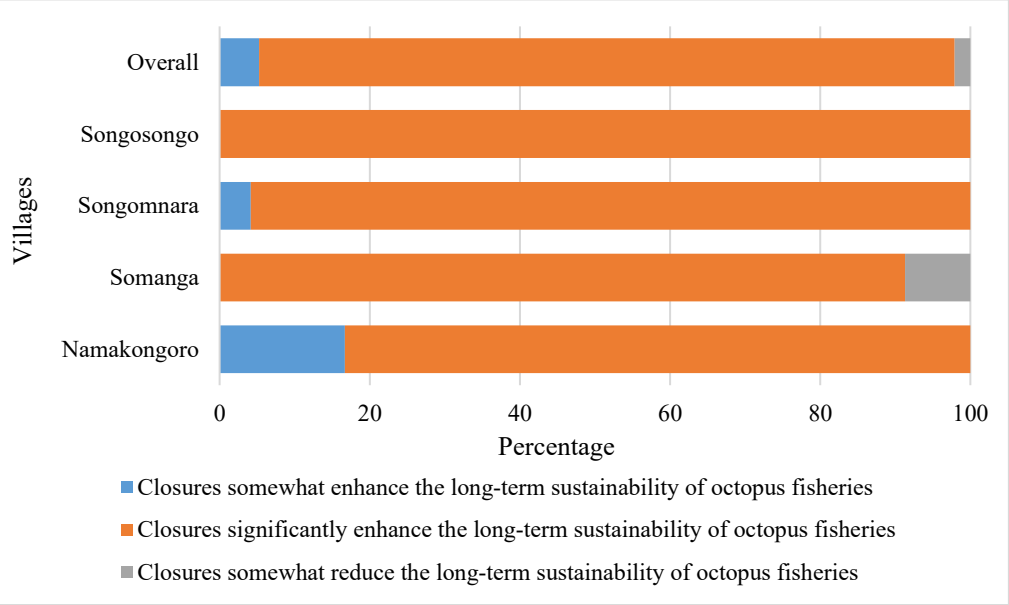


Figure 27: Community perception of octopus fishery sustainability

These findings highlight a prevailing sentiment among most communities, indicating strong support for octopus reef closures to enhance long-term sustainability. It is noteworthy that the positive outcomes observed from the practice likely influenced these perceptions. KIs echoed the importance of continuing reef closures, emphasising their role in increasing octopus populations and enhancing overall ecosystem health. Additionally, KIs noted additional benefits, such as increased revenue and individual income resulting from the practice.

Moreover, community members expressed a willingness to apply similar practices to other fast-growing and short-lived species, recognising the potential for broader ecological and economic benefits. This indicates that because *O. Cyanea* grows quickly and has a short lifespan,

communities readily supported the measure as it requires optimal closure times, making management easier. This underscores the value of community-led conservation efforts and the potential for scalable solutions to address sustainability challenges beyond the octopus fisheries.

Overall, the positive perception of octopus reef closures highlights the importance of community engagement and collaboration in conservation efforts. By fostering a sense of ownership and responsibility among community members, sustainable practices can be implemented and maintained more effectively for the benefit of present and future generations.

*4.6.2 Challenges faced by the community in complying with octopus reef closures.*

Despite high levels of compliance with octopus reef closure management measures, communities face various challenges associated with these practices. The survey aimed to identify the challenges encountered by the community regarding octopus reef closures. When asked about their challenges, 27% of respondents mentioned the loss of income during closure periods, another 27% cited limited awareness or understanding of closure regulations, 18% reported other challenges such as inadequate support from the local government, and the remaining respondents did not identify any specific challenges. Additionally, 10% of respondents highlighted their dependence on octopus fishing for basic needs, 7% mentioned economic hardship due to the temporary cessation of fishing, and 5% noted limited alternative sources of income opportunities during closure and difficulty in monitoring and enforcing compliance (Figure 28) and (In Songosongo, loss of income during closure periods and dependence on octopus fishing for basic needs were prominent challenges, likely due to the village's high reliance on fishing, particularly octopus fishing for livelihoods.

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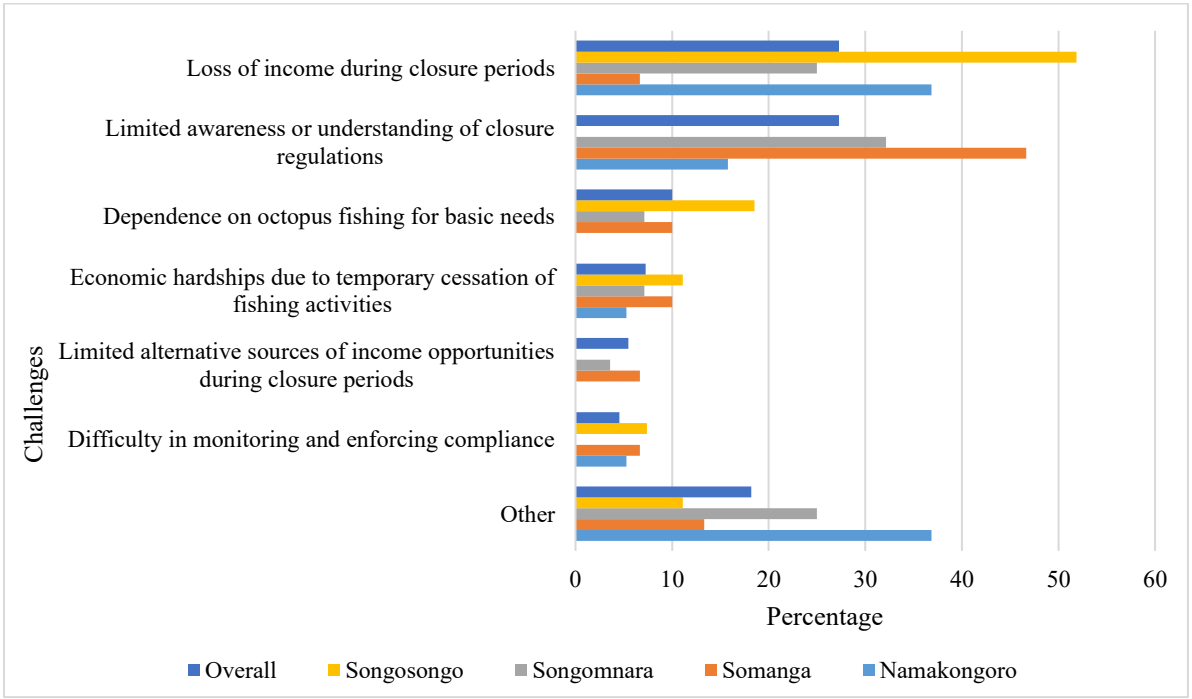


Figure 28: Challenges faced by the community in complying with octopus reef closure.

Analysis across villages revealed significant variations in the challenges faced by communities in compliance ($\chi^2$ (18, n = 96) = 148.97, $p < 0.05$). Loss of income during closure periods emerged as a common challenge across all villages, with significant proportions in Songosongo (52%), Namakongoro (37%), Songomnara (25%), and Somanga (7%). Conversely, limited awareness or understanding of closure regulations was a major challenge in Namakongoro, Somanga, and Songomnara. In Songosongo, loss of income during closure periods and dependence on octopus fishing for basic needs were prominent challenges, likely due to the village's high reliance on fishing, particularly octopus fishing for livelihoods.

Table 4: The mean value and mode (most frequent) of responses regarding the challenges faced in compliance.

| **Challenges of communities faced during closure** | **Mean** | **Mode** |
|---|---|---|
| Loss of income during closure periods | 30.09 | 30 |
| Limited awareness or understanding of closure regulations | 23.65 | 30 |
| Dependence on octopus fishing for basic needs | 8.92 | 11 |
| Economic hardships due to temporary cessation of fishing activities | 8.38 | 8 |
| Limited alternative sources of income opportunities during closure periods | 2.56 | 6 |
| Difficulty in monitoring and enforcing compliance | 4.83 | 4 |
| Other | 21.57 | 20 |

Moreover, in Namakongoro and Somanga, limited awareness was a significant challenge, possibly attributed to the size of the villages and the diversity of economic activities among residents. These villages may benefit from increased awareness meetings and training sessions to enhance community understanding of the closure regulations.

Key informants also highlighted their challenges as the management bodies and regulators of the closure process. These challenges include limited resources for Somanga, leading to reduced patrols and increased theft, as well as reduced prices during the opening due to oversupply, as reported by (Silas et al., 2022). Namakongoro and Songosongo faced challenges such as limited patrol equipment and the village government's lack of participation in patrols, indicating areas for improvement in enforcement and support mechanisms.

These findings emphasise the need to address the challenges faced by communities, including income loss during closure periods, limited awareness of closure regulations, and insufficient resources for patrols and enforcement. Collaboration among the MLF, LGAs, and other stakeholders is essential to support communities in ensuring the effective implementation of octopus reef closure practices and promoting sustainable fisheries management. This support should include resources for surveillance and enforcement, training, data collection, processing facilities, and infrastructure development, as well as facilitate the ability of the communities to withstand price and market fluctuations.

#### *4.6.3 Communities suggestions on the improvement of octopus reef closure management measure*

The survey findings underscore the fundamental challenges and complexities associated with octopus reef closure management measures, urging communities to suggest improvements. A

significant proportion of respondents (47%) advocated for enhancing community awareness through education and outreach programs ($\chi^2$ (18, n = 96) = 130.63, $p < 0.05$). This significant difference in sentiment was echoed across all villages, with notable emphasis on Songosongo (52%), Songomnara (55%), Somanga (53%), and Namakongoro (24%). This is essential for ensuring that community members understand the importance of compliance and actively participate in conservation efforts. Strengthening enforcement mechanisms to ensure compliance emerged as another common suggestion, with 24%, 21%, 21%, and 64% of respondents from the respective villages expressing support for this approach which can help deter violations and promote greater adherence to closure regulations (Figure 29).

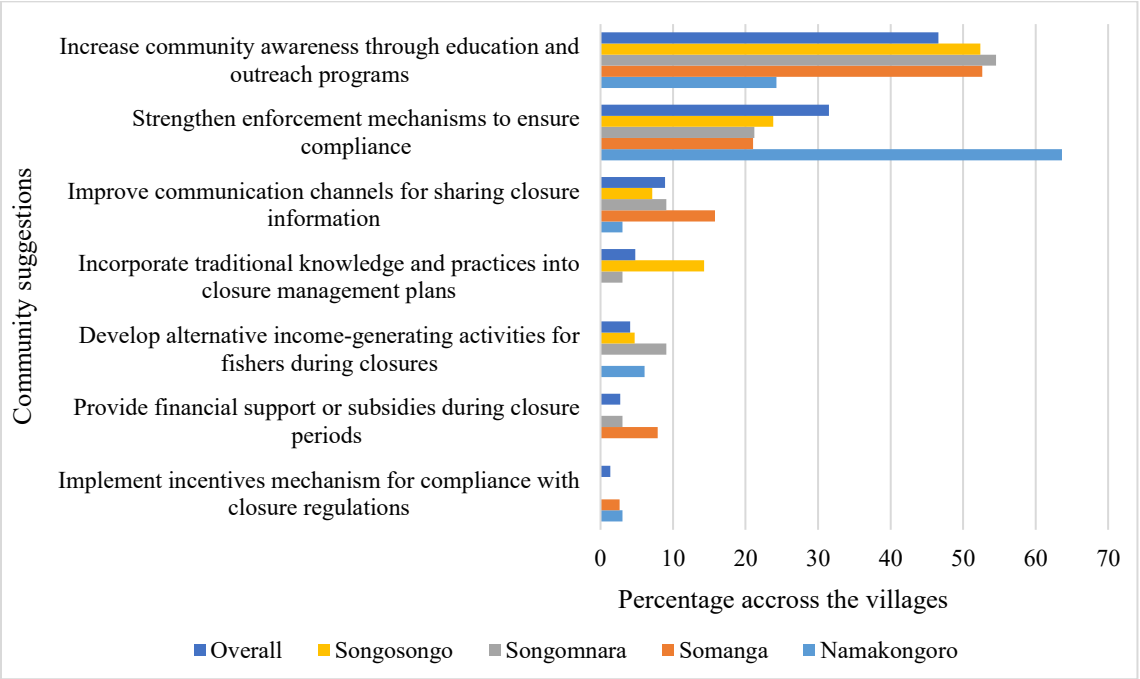


Figure 29: Community suggestions for improving octopus reef closure practices.

These suggestions aim to address the challenges faced by communities in adhering to closure practices. In Somanga, respondents additionally proposed increasing fines and penalties for violations, ensuring the inclusion of all community members, especially fishers, in patrol activities, and providing patrol boats. In Songomnara, the community suggested that the District Authorities collaborate closely with BMUs to manage and oversee the practice, emphasising the importance of respecting community opinions and ideas. This resonates not only with Songomnara but also with other villages.

Overall, these suggestions reflect the community's proactive engagement in seeking solutions to improve octopus reef closure management measures, highlighting the importance of collaborative efforts between stakeholders for effective implementation and sustainability.

# 5 CONCLUSIONS AND POLICY RECCOMENDATIONS

This study aimed to explore community participation and compliance levels, as well as the socioeconomic impact of voluntary octopus reef closures and their interconnectedness. The hypotheses predicted a positive impact on the socio-economic well-being and behaviours of the community, as well as the interconnectedness of socio-economic factors with the compliance level. The findings revealed several key insights as follows: -

i. Community perception and compliance: Compliance levels were high, with most surveyed communities expressing support for voluntary octopus reef closures. They cited benefits such as improved income, enhanced well-being, and strengthened community cohesion as factors influencing their high compliance. Despite variations across villages, there was a consensus on the positive effects of the closure practices.

   Community compliance with reef closure is attributed to several factors, with key elements including the strength and integrity of BMU leadership, robust cooperation between village government and BMUs, effective community engagement, especially in patrol, and the proper utilisation of revenue collection to address community socio-economic issues, especially in Songosongo.

ii. Socio-economic impact: Voluntary octopus reef closures were discovered to have a significant socio-economic impact, resulting in increased catches, higher market prices, and improved livelihoods, as reported by many respondents. An interconnection between socioeconomic factors and compliance levels was observed. However, challenges such as fluctuations in market prices and limited resources for monitoring and enforcement were also identified, which calls for stakeholders actions to address these hurdles.

iii. Octopus fishery sustainability: Community members across villages overwhelmingly perceived octopus reef closures as contributing to the sustainability of octopus fisheries. This positive perception reflects the recognition of the importance of conservation measures in preserving marine resources for future generations.

Based on these findings, further studies are recommended to delve deeper into the socio-economic impacts and compliance effectiveness, as well as their interconnectedness, as they involve many variables and attributes. Furthermore, the following policy recommendations are proposed to enhance the effectiveness of voluntary octopus reef closures and support sustainable fisheries management: -

a) Capacity building: The Ministry of Livestock and Fisheries (MLF) should provide training to the community on voluntary octopus closure guidelines to equip them with the necessary knowledge for successful practice. The guidelines should be translated into simple language which is easily understandable by communities. Furthermore, the MLF should conduct regular monitoring to ensure the implementation of octopus reef-closure guidelines in these villages. Additionally, local governments and other stakeholders should continue to provide training to the fishing community on the conservation and management of fishery resources.

b) Resource support: MLF and Local Government Authorities (LGAs), along with other stakeholders, should continue to provide support for the resources needed for enforcement, monitoring, control, and surveillance activities. This includes investment in processing facilities, patrols, and data collection equipment, as well as training for enforcement personnel and community engagement initiatives. Additionally, the MLF, through the Tanzania Fisheries Research Institute (TAFIRI), should conduct regular monitoring and evaluation of octopus stock, as well as biological and ecological assessments in closed areas. This includes assessing the performance of the temporal reef closure concept.

c) Market support: Efforts should be made by MLF and LGAs to facilitate direct access to processing facilities, promote value-added products and establish fair trade practices to ensure equitable returns for fishers. This will help address market and price fluctuations during the opening and increase the motivation of the community. Furthermore, MLF should develop an octopus marketing strategy to attract both internal and external investors and enhance product quality. The marketing strategy, among others, will provide a mechanism to determine the price at the local level during the openings, thereby strengthening the relationship between the community and buyers and increasing the economic benefits of the closure.

d) Community engagement: Collaboration between stakeholders, including local communities, government agencies, NGOs, and research institutions should be increased. Communities should be involved in decision-making processes related to fisheries management and conservation initiatives to promote ownership and sustainability. The MLF and LGAs should support and promote the best compliance practices observed in Songosongo. This includes encouraging the community to promote these practices in other villages and emphasising the importance of community engagement to village and BMU leaders.

e) Education and awareness: MLF, LGAs, BMUs, and other stakeholders should continue to enhance awareness and understanding of the ecological and socioeconomic importance of octopus reef closures. This can be achieved through targeted education and outreach programs to enhance compliance effectiveness. Awareness should not be limited to communities implementing voluntary octopus reef closures but should also involve other communities engaged in octopus fishing. Moreover, BMU executive committees should effectively involve other members and the local community in patrols to increase compliance with the closure regulations.

f) Adaptive management: Communities should be trained in the implementation of an adaptive management approach which involves making decisions and adjustments in response to new information and changes in practice to address emerging challenges and opportunities associated with octopus reef closures. Stakeholders should continuously monitor and evaluate the effectiveness of closure measures, incorporate feedback from local communities, and adapt strategies as needed to achieve conservation and livelihood objectives.

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APPENDICES

*Annex 1:Structured questionnaire for fishers, fish vendors, fish processors, small business owners and local community.*

**i. Community Awareness and Participation in Octopus Reef Closure**

1. Are you aware of the presence of octopus reef closure?
2. Are you aware of the reasons for implementing octopus reef closures?
3. How do you get information about the season of closing or opening the octopus reef?
4. How often do you participate in community meetings regarding octopus reef closures?
5. What role do you play in octopus reef closures?

**ii. Adherence to Rules and Decision-Making Involvement**

1. Are you aware of the octopus reef closure rules and regulations?
2. Do you participate in the decision-making process regarding octopus reef closures?
3. Do you strictly adhere to the closure rules and the specified closure periods?
4. What measures do you take to ensure compliance with octopus reef closures?

**iii. Perception of Importance of Compliance with Octopus Reef Closure**

1. How do you perceive the importance of compliance with octopus closure rules?
2. What factors influence your decision to comply with octopus reef closures?
3. Do external factors like weather or market demand impact your ability to comply?

**iv. Socio-Economic Impacts of Octopus Reef Closure on Local Communities**

1. Have you noticed changes in your income from octopus fishing since the implementation of reef closures?
2. Have you experienced any changes in your well-being since the closure implementation? If yes, what are the changes?
3. How have reef closures impacted community cohesion and cooperation?
4. Have there been any conflicts within the community regarding reef closures? If yes, at what scale?
5. Do you believe reef closures benefit the overall well-being of the community?
6. Are there any cultural or traditional beliefs/practices affecting perceptions of octopus reef closures?

**v. Economic Effects of Octopus Reef Closure on Local Economies**

1. Do you believe that the closures have influenced the quality and price of octopus in the market?
2. Have you noticed fluctuations in the quality and prices of octopus in local markets?
3. How do these changes in octopus supply and market prices affect the livelihoods of community members engaged in octopus-related activities?

4. Have you observed any changes in octopus supply and demand since the closures were introduced?
5. What economic benefits have the communities experienced due to octopus closures?
6. How significant is octopus fishing to your overall livelihood?

**vi. Community Perception on Sustainability, Compliance Challenges, and Improvement Suggestions for Octopus Reef Closure Practices**

1. How do you perceive the long-term sustainability of octopus fisheries with closures?
2. What challenges do you face in complying with octopus reef closures?
3. What improvements do you suggest?

*Annex 2:Key informant interview questions.*

**i. Reef Management and Closure Process**

1. How many reefs are present in your village?
2. How many reefs do you typically close at once and for how long?
3. What is the size of the reefs you usually close?
4. How do you normally close the reef, consistently close the same reefs, or alternate and for how long?

**ii. Community Engagement and Decision-Making**

1. How do you communicate reef closure information to the community?
2. Who is involved in the process of closing and opening the reefs?
3. What type of meetings and how many do you typically conduct before closing and opening the reefs?
4. What are the participation rates like during these meetings?
5. Who is responsible for managing the entire process of reef for closure?
6. What are the roles of the community and BMU during the closing and opening phases?

**iii. Enforcement and Compliance**

1. Who sets the rules and regulations for octopus reef closure?
2. Can you mention the rules and regulations you have for octopus closure?
3. What role do you play in implementing and enforcing reef closure?
4. What challenges have you faced in ensuring compliance with closure?
5. How do you assess the level of compliance with closures in your community?
6. From your experience, what factors do you believe have influenced the compliance level as you've assessed it?
7. Are there specific enforcement measures or penalties in place to ensure compliance with reef closure regulations?
8. How do you perceive the long-term sustainability of octopus fisheries with closures?

**iv. Effectiveness and Awareness**

1. How do you assess the overall effectiveness of reef closures in your community?
2. What strategies have been successful in promoting community participation in reef closures?

3. What do you think motivates or incentivizes community members to participate in closure initiatives?
4. From your experience, how would you rate the community's awareness of the ecological importance of reef closures?

**v. Support and Collaboration**

1. How do you collaborate with other stakeholders to manage octopus fisheries sustainably?
2. Have you received adequate support or resources for compliance with closures?
3. How do you perceive the role of local authorities or enforcement agencies in ensuring compliance with closure?
4. Do you know about the existence of a voluntary octopus reef closure guideline? If yes, do you have it and use it during closures?

**vi. Community-Led Initiatives and Compliance Factors**

1. Have you noticed any instances of non-compliance or resistance within the community?
2. Are there any community-led initiatives that enhance compliance?
3. From your experience, what factors contribute to successful compliance with closures?