EXAMINING STAKEHOLDER PERCEPTIONS TOWARDS SEAGRASS AS BLUE CARBON:AN ANALYSIS OF CHALLENGES & SOLUTIONS TO SEAGRASS RESTORATION IN WASINI AND VANGA, KENYA

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A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of Master of Science in Maritime Affairs

Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me. The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature):.....

(Date): 26/09/2023

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Abstract

Title of Dissertation: Examining Stakeholder Perceptions towards Seagrass as Blue Carbon: An Analysis of Challenges & Solutions to Seagrass Restoration in Wasini & Vanga, Kenya

Degree: Master of Science

Seagrasses has a significant role in the coastal environment due to the numerous ecosystem and socio-economic benefits they provide to humans and the marine environment. In Kenya, the degradation of seagrass continues to occur due to human and natural factors which affects the numerous benefits that seagrass provides as a blue carbon ecosystem. As habitat restoration continues to become a priority in recent times for many countries including Kenya, the research aims to understand stakeholder perception of seagrass as an ecosystem, investigate the challenges and also propose effective solutions to seagrass restoration.

In examining this blue carbon habitat, the important ecosystem services perceived were provision of spawning sites, shelter and foraging grounds for fish and carbon capture. The study also found challenges such as lack of funds and skills to restore, lack of community empowerment as well as destructive fishing practices. Additionally, solutions were explored on prevention of further seagrass loss such as collaboration, nature-based solutions and as well as strengthening enforcement mechanisms to effectively manage this critical ecosystem.

The study used a qualitative approach through semi-structured interviews to collect data. Participants were selected from government agencies, academia, non-governmental organizations and local community. A comparative analysis of two local communities of Wasini and Vanga was conducted to understand in detail the perceptions held, challenges encountered in seagrass restoration and conservation, with an overview from government, non-governmental organizations and academia.

As a result, the study discovered that stakeholder perceptions are important in supporting restoration, with the success of seagrass restoration programs dependent on stakeholder collaboration, clear policies, continuous capacity building and sustainable fishing practices. Ultimately, the study also found that conservation is better than restoration hence more effort should be directed at managing seagrass instead of restoration, which is costly with an undetermined rate of success.

Keywords: Seagrass, Blue carbon, Restoration, Conservation, Kenya, Sustainability

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List of Abbreviations

BE	Blue Carbon
BCE	Blue Carbon Ecosystems
BMU	Beach Management Unit
IUU	Illegal, Unreported, Unregulated fishing
NBS	Nature-based Solutions
NGO	Non-governmental Organization
SDG	Sustainable Development Goals
UN	United Nations

1.0 INTRODUCTION

Marine ecosystems, biodiversity and the ocean environment face an increasing number of disturbances from both natural and human factors (Nabe-Nielsen et al.,2018). These include coastal developments (Ma et al.,2017), land-based pollution (Daoji & Daler.,2004), destructive fishing practises (Halpern et al.,2007), overexploitation of ocean resources (Coleman et al.,2002), as well as climate change, that have adversely affected marine life (Gattuso et al.,2018). The situation is prevalent for near-shore ecosystems because of excess disturbances due to their proximity to the pressures (Dunic et al.,2020). The global population index is increasing, resulting in more disturbances/pressures on the ocean due to the high dependency for food and other resources (Curan et al.,2002). The United Nations estimates that the global human population will reach 9.2 billion people by 2050. Therefore, human population growth especially in the coastal areas, is to a large extent contributing to the pressures negatively influencing essential functions of important marine ecosystems (Todd et al.,2019). Marine ecosystems provide numerous ecosystem services such as water purification (The Ocean Foundation, 2003), functioning as spawning grounds and nurseries of numerous invertebrates and fish species (Kaewsrikshaw et al.,2020), foraging spots and habitats to other marine species like green turtles and dugongs (Unsworth et al., 2019), and also prevent against coastal erosion (Ondiviela et al.,2014). Blue carbon ecosystems (BCE) also act as carbon sinks (Omollo et al., 2022) and can sequester carbon from the atmosphere to the bottom of the ocean helping to reduce the greenhouse gas emissions that have currently been at the focus of global interest, as a mitigating factor in reducing the impacts of climate change such as global warming (Arnell & Reinard, 1996), extreme heat (Clarke et al.,2022) and increased drought (Natural Resources Defence Council, 2022). Recent researches reveal that the impact of these disturbances to the marine ecosystems is accelerating as reported by a global analysis index, over 60% of the ecosystem services they provide continue to dimmish (Mooney et al., 2009). The outcome of these disturbances is that the marine ecosystems continue to be lost at an accelerating rate worldwide (Waycott et al.,2009).

Seagrasses are marine flowering plants found in shallow waters that can form as underwater meadows (Coles et al.,2011). They provide numerous ecosystem services that are beneficial to human beings as well as ecological importance such as food production and regulating the environment (Lima et al.,2023). In as much as seagrass provides these benefits, annually, it is estimated that up to 7% of seagrass is lost (United Nations, 2022). In Kenya, seagrass is estimated to cover 3400 ha (Lugendo, 2016), but with an annual loss of 0.85% per year since 1986 (Harcourt et al,2018). The decline in seagrass has resulted in increased coastal erosion (Gracia et al.,2018), wave action (Gillis et al., 2014), reduced catch for certain fish species (Ofiara & Seneca,2006). Additionally, the loss also affects seagrass linkages with other ecosystems and habitats such as mangroves (Waycott et al.,2019), thereby creating ecological disturbances that may have more long-lasting effect to marine biodiversity. Disrupting this important interconnectedness with the other ecosystems also affects seagrass critical role as a blue carbon ecosystem (BCEs). Macreadie et al (2023) defines blue carbon (BC) as "organic carbon that is captured and stored by the oceans and coastal ecosystems, particularly by vegetated coastal ecosystems such as seagrass meadows, tidal marshes, and mangrove forests". The stored carbon remains buried in the floor of the oceans or trapped in seagrass sediments for many years (Reynolds,2018), and is reported to significantly reduce the carbon emissions emanating from greenhouse gases in the atmosphere by acting as a carbon sink (Salinas et al.,2020). However, due to degradation, the excess carbon is released back in the atmosphere resulting in climate change that has devastating consequences such as extreme weather events and thus, has been ranked as one of the global threats to life (Intergovernmental Panel on Climate Change, 2022).

In order to reduce the many effects caused by these pressures to safeguard human well-being, numerous management actions have been taken around the world to reduce further loss of seagrasses through different methods including restoration (Tan et al, 2020). However, the path to restoration has not been easy due to diverse reasons such as high costs associated with restoration activities (Unsworth et al.,2018), lack of restoration skills (Shilland et al.,2021), direct mechanical damage from fishing

activities that drag and uproot seagrass (La Manna et al., 2015) and also feeding on seagrass by herbivores among others (Uku et al.,2021).

Kenya is endowed with a rich diversity of marine ecosystems including seagrass beds along its coastline (Tuda & Omar.,2012). Twelve species of seagrass have been recorded along the East African coastline (Githaiga et al.,2017). However, due to the exerted pressure from the human and natural factors, seagrass ecosystems have shown signs of degradation especially due to destructive fishing practises (Githaiga et al.,2017) and feeding by herbivores (Uku et al.,2021). As a result, losses of ecosystem services continue to be experienced such as reduced fish catch (Lugendo,2016). In response to reduce further degradation, the Kenyan government and other stakeholders have put efforts to restore seagrass to reduce the ecosystem imbalance with seagrass restoration project undertaken in 2007 and 2015 in Diani and Wasini, respectively (Uku et al.,2021). However, seagrass restoration efforts have been met with different challenges such as the lack of resources to monitor restoration programs (Uku et al.,2021) and also the lack of skills needed to conduct restoration (Githaiga et al.2017). On the other hand, challenges need solutions for restoration programs to succeed. Review of conservation policies on seagrass (McClanahan et al.,2005), increased stakeholder collaboration (Dencer-Brown et al.,2022), creation of cost efficiency programs (Saunders et al.,2020) as well as financial access may assist to effectively reverse seagrass loss (Tan et al, 2020). Notably, many researches on marine restoration mainly focus on the ecological processes of restoration such as species composition, planting techniques among others, neglecting an important component of human element which largely affects restoration (Vaughn et al., 2010; Tan et al, 2020; McAfee et al., 2022)

This research thus seeks to examine stakeholder perceptions on the importance of seagrass as a blue carbon ecosystem, highlight the imminent challenges that Kenya has and continues to face in restoring the degraded or lost seagrass, and at the same time provide potential solutions.

2.0 MATERIALS & METHODS

2.1 Research Method

Qualitative research approach by use of semi-structured interview was used for this research to collect data. I used the semi-structured interview because it provided the flexibility needed to obtain in-depth information from the respondents by allowing them to express their views without restrictions and also highlight areas of particular interest on restoration. Face-to-face interviews were conducted by following the semi-structured guide to obtain information based on stakeholder experiences and perceptions in seagrass restoration and conservation processes as one of important blue carbon ecosystems and also strategies to improve, and find better ways to restoration and conservation to add more knowledge for future restoration programs.

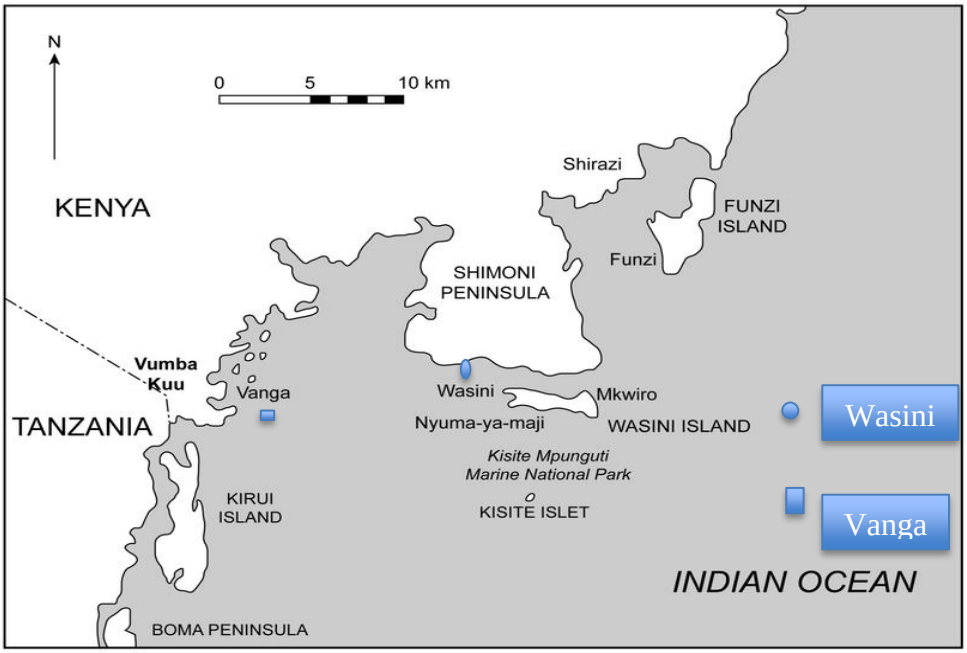
2.2 The Area of Study

The study area lies along the Shimoni-Vanga seascape in Kwale County, South coast of Kenya, covering two villages; Wasini island and Vanga, 4.66°S 39.37°E and 4°39'0" S 39°13'0" E respectively. As with many countries around the world, seagrasses in these areas have continued to face threats especially from human interaction with the marine environment on a daily basis because the villages are mainly fishing communities dependent on the ocean for their daily sustenance. Conservation projects in both communities involved the community, government agencies and NGOs who are the key stakeholders for this research.

Wasini community has carried out conservation and restoration of projects including corals and seagrass. In Vanga, a carbon offset scheme on mangroves has incorporated seagrass conservation as an incentive to be implemented in their conservation programs due to interconnectedness of the two habitats; mangroves and seagrass. These areas will be used to study the challenges that the programs faced towards restoration and conservation at the community level. It will also reveal the level of awareness and perceptions of seagrass as blue carbon incorporated in conservation programs, community involvement and the solutions to the bottlenecks faced in seagrass conservation. This will provide the information on the intended subject for

this study on the stakeholder perceptions, challenges encountered and solutions towards seagrass restoration.

Fig 1: Map of South Coast Kenya showing Wasini and Vanga



2.3 Ethical issues

The World Maritime University (WMU) research and ethics committee provides guidelines for researches that involve human element. I received an approval to conduct the research and collect data through the semi-structured interviews. Consent was also sought from the participants to confirm that their participation was voluntary. The participants were assured confidentiality and anonymity of the information provided for integrity and transparency purposes.

2.4 Data Collection and Analysis

2.4.1 Data Collection

Primary data was collected through semi-structured interviews using the referral technique. I identified respondents who met certain criteria as per the research

objectives, who recruited other participants that share almost the same characteristics, making it easy to connect with respondents which saves time (Heckathorn,2002). In this study, 34 participants were interviewed from different stakeholder groups to establish the real problems associated with restoration, especially with the community as the key drivers behind conservation and also as main users directly in contact with the ecosystem. I assigned a code W1, W2, Wn. to represent the participants from the local community of Wasini and V for Vanga. The research includes twelve participants from both communities, five from government agencies represented by G, three from NGOs represented by N, four from academia represented by A. The full list of the participants is provided in table 1 below.

Table 1: List of all interviewees, their code names, expertise, date and duration of interview

S/N	Code name	Date of interview	Stakeholder category	Institution	Duration of interview
1.	W1	07/07/2023	Local community: fisherman	Wasini BMU	22:29
2.	W2	07/07/2023	Local community: fish trader	Nuru women group, Wasini	14:23
3.	W3	07/07/2023	Local community, fisherman	Wasini BMU	15:45
4.	W4	07/07/2023	Local community, fisherman	Wasini BMU	11:18
5.	W5	12/07/2023	Local community, BMU Chairperson	Wasini BMU	35:40
6.	W6	12/07/2023	Local community, fisherman	Wasini BMU	12:00
7.	W7	12/07/2023	Local community, fisherman	Wasini BMU	8:55

8.	W8	12/07/2023	Local community, fisherman	Wasini BMU	8:57
9.	W9	12/07/2023	Local community, fisherman	Wasini BMU	12:03
10.	W10	12/07/2023	Local community: fisherman	Wasini BMU	12:29
11.	W11	12/07/2023	Local community, fisherman	Wasini BMU	12:43
12.	V1	08/07/2023	Local community, fisherman	Vanga BMU	7:51
13.	V2	08/07/2023	Local community, fisherman	Vanga BMU member	12:26
14.	V3	08/07/2023	Local community, women fishmonger	Vanga BMU	10:11
15.	V4	14/07/2023	Local community; fisherman	Vanga BMU	15:47
16.	V5	18/07/2023	Local community: fisherman	Vanga BMU	10:41
17.	V6	18/07/2023	Local community: fisherman	Vanga BMU	10:41
18.	V7	18/07/2023	Local community: BMU Chairperson	Vanga BMU	17:43
19.	V8	18/07/2023	Local community: Seagrass & Mangroves project coordinator	Vanga community-based organization	38:00
20.	V9	18/07/2023	Local community: fish trader and	Vanga women group	12:52

			community conservationist		
21.	V10	18/07/2023	Local community: Fisherman	Vanga BMU	13:23
22.	V11	18/07/2023	BMU Chairpeson	Jimbo BMU, Vanga	12:16
23.	G1	14/07/2023	Government: Senior warden, blue carbon ecosystems conservation and MPA management	Kenya Wildlife Service	14:41
24.	G2	14/07/2023	Government: Fisheries officer involved in management of fisheries and ecosystem protection	Kwale county government	15:37
25.	G3	14/07/2023	Government: security officer involved in marine conservation and ecosystem protection	Kenya Coastguard Service	13:23
26.	G4	18/07/2023	Government: fisheries officer	Vanga-Kwale county	18:51
27.	G5	18/07/2023	Government: Station manager and expert on seagrass matters	Kenya Marine & Fisheries Research Institute	30:12

28.	A1	07/07/2023	Academia – involved in seagrass projects and research	University of Nairobi	27:25
29.	A2	07/07/2023	Academia – involved in seagrass projects and research	University of Nairobi	23:45
30.	A3	08/07/2023	Academia: researcher involved in seagrass projects	University of Edinburgh	28:42
31.	A4	10/07/2023	Academia: researcher, lead expert in seagrass projects	Kenya Marine & Fisheries Research Institute	30:23
32.	N1	14/07/2023	NGO; program coordinator involved in blue carbon ecosystems restoration and conservation	Reefolution NGO	33:31
33.	N2	15/07/2023	NGO – project coordinator on blue carbon offset programs	Project coordinator, Climatek	32:59
34.	N3	09/09/2023	Programs officer on ecosystem management	World wildlife fund	25:20

2.4.2 Data Analysis

To analyze the data, I used *otter.ai* tool (www.otter.ai) to transcribe the information from the interviews conducted, then categorized and sorted the data into three themes using deductive approach thematic analysis by the process of coding (Williams & Moser.,2019). The themes were used to link the interviews with the objective of the research. They were divided as below:

1. Stakeholder perceptions on the importance of seagrass as BCE
2. Challenges to seagrass restoration
3. Solutions to seagrass restoration

Using the above themes, the data was then divided into two sections: first, a comparative analysis of the perceptions of Wasini and Vanga local communities on importance of seagrass, the challenges encountered and appropriate solutions to seagrass restoration. Secondly, opinions from the Government, Academia, and NGOs that provide a critical overview of the restoration challenges and solutions to seagrass in Wasini and Vanga. It shows the highly prioritized responses from the different responses based on the data sets, presented in a graph form by use of Microsoft Office Excel. Through this, a comprehensive understanding of the stakeholder perceptions on the importance of seagrass as BCE in Wasini and Vanga, the challenges and potential risks encountered in restoration as well as proposed solutions in order to effectively restore and protect the seagrass ecosystems, will be realized. Additionally, the data sets presented in graphical form provide a visual representation of the current environmental and socio-economic conditions of the area and help to identify areas of concern that require further investigation.

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3.0 RESULTS

The results from the conducted interviews using the semi-structured interview guide (Appendix A) as shown below, seek to answer the 3 themes for this research to determine (i) Stakeholder perceptions on the importance of seagrass as a BCE, (ii) Challenges to seagrass restoration (iii) Solutions to seagrass restoration. The content received from the interviews was divided in two parts; first part on demographic information (Section A) while the second part dwell on the subject matter of seagrass (Section B). Additionally, it was presented and organized in a manner that corresponds to the 3 themes, and further, discussed in detail as shown below.

3.1 Section A: Demographics for Wasini and Vanga Local Communities

The respondents were randomly chosen based on their years of experience in ocean trading activities, mainly fishing and fishing extended services as well as seagrass restoration and conservation. The experiences have shaped their knowledge and perceptions in BCE at the community level as shown by the number of years each participant has been involved in figure 2 below, with the high number in Wasini between 15 - 20 years, while for Vanga is between 10 - 15 years.

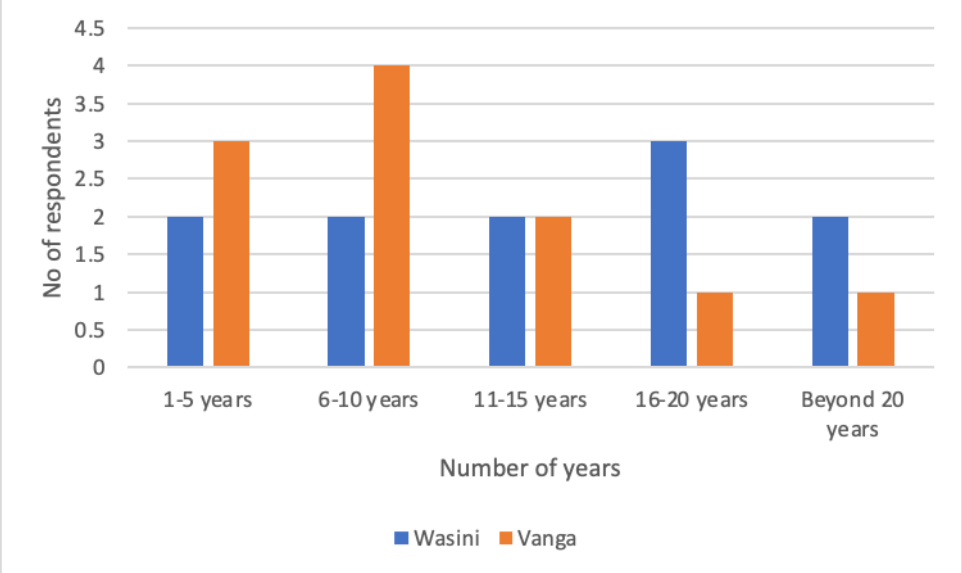

Fig 2 : Graphical representation in number of years the participants have been involved in ocean activities

3.2 Section B: Thematic Analysis

3.2.1 Theme 1: Stakeholder perceptions on the importance of seagrass as a blue carbon ecosystem (Question 1,2,3)

Seagrass, as an ecosystem, provides numerous ecosystem services that benefit the environment and humans. All the participants said that they know seagrass and had heard about blue carbon, commonly termed "*hewa kaa*" in the local language. According to Figure 3, seven out of eleven participants from Vanga were aware of the relationship between seagrass and blue carbon, compared to six out of eleven participants from Wasini.

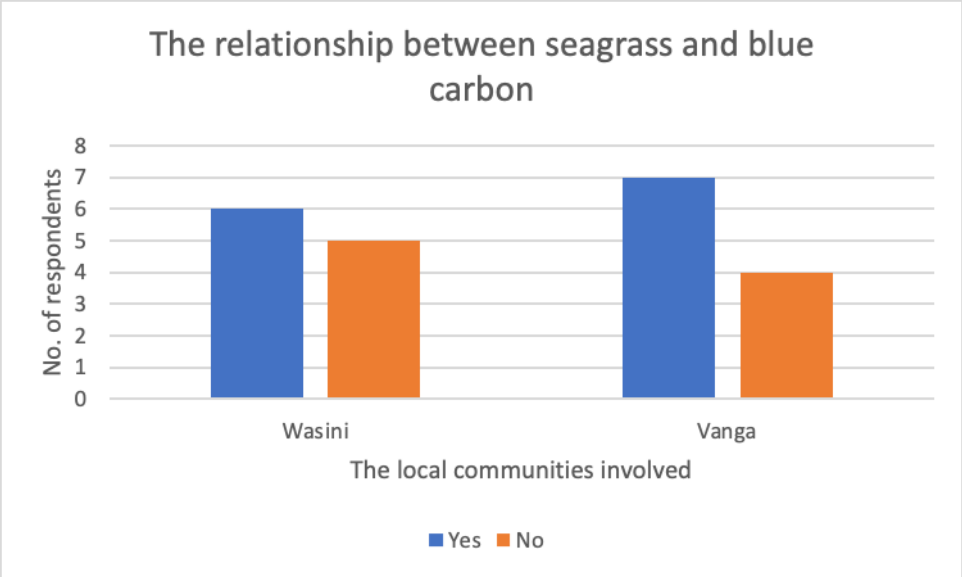

Figure 3: Graphical presentation of knowledge on the relationship between seagrass and blue carbon as per number of respondents

<u>Overview of Category G, A and N</u>

All categories agreed that both Wasini and Vanga communities are not well-informed on blue carbon. In as much as they are aware of seagrass, its importance and the role it plays in carbon capture, only a section of the community is aware, based on figure

3 above. This is especially for Vanga because of the payment of ecosystem project on mangroves which is part of BCEs.

Q4. The Potential Benefits of Seagrass Restoration in Terms of Blue Carbon

Based on the results on figure 4 below, both communities realize that the most significant benefit from seagrass restoration is the increase in foraging grounds for fish (100%) and more habitat and spawning grounds once restoration is done successfully (100%). The third benefit mentioned was the increase in carbon sinks once seagrass cover is restored, at 55%. Additionally, 45% of the Wasini community knows the importance of seagrass in stabilizing the coastline against coastal erosion, compared to 18% in Vanga. Lastly, both communities dismally realize the benefit of seagrass as a climate change mitigation factor as the lowest ranking in as seen in the graph below. Furthermore, the Wasini community is more aware of the potential of seagrass to absorb carbon dioxide from the atmosphere, with 45% understanding its significance compared to only 18% in Vanga.

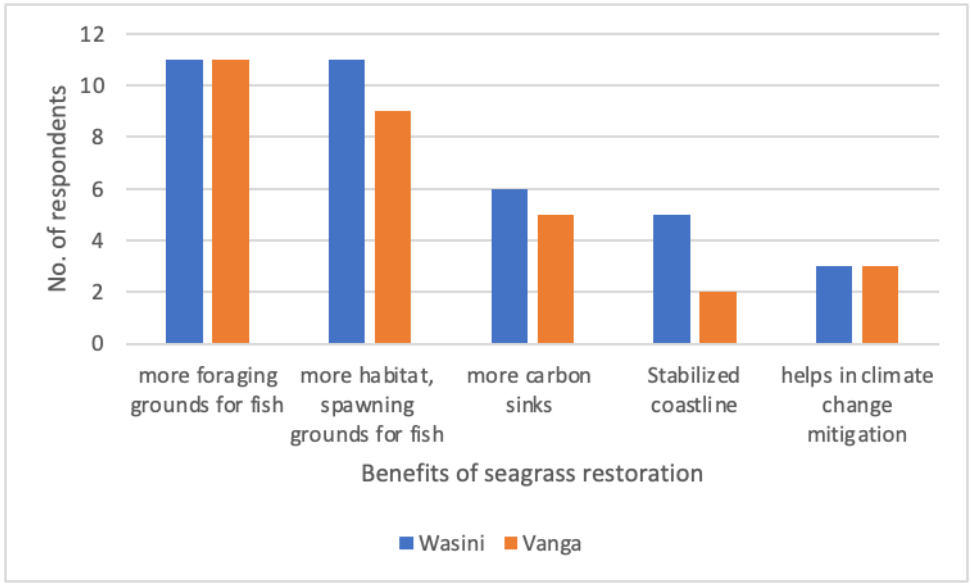

Figure 4: Graphical representation of benefits of seagrass restoration as blue carbon by percentage

Overview of Category G, A and N

From figure 4 above, all the categories are in consensus on the communities' knowledge on benefits of seagrass restoration. They acknowledge that both communities rely heavily on fishing for their livelihoods, therefore, the degree of seagrass cover would have an impact on fish catch. This is the reason for majority of respondents mentioning on foraging and habitat benefits from seagrass restoration as opposed to increased carbon sinks, coastline stability and less on climate change.

Q5. What tools and methods are available to measure and monitor the success of seagrass restoration in Wasini, Kenya?

Based on the interviews, figure 5 below shows that both communities' respondents equally share the same viewpoint. They have continuously relied on indigenous knowledge to monitor seagrass loss as well as growth, to determine the rate of seagrass cover from time to time. however, few respondents have been exposed to new methods through training by NGOs and Academia such as using quadrants and keeping records of seagrass progress.

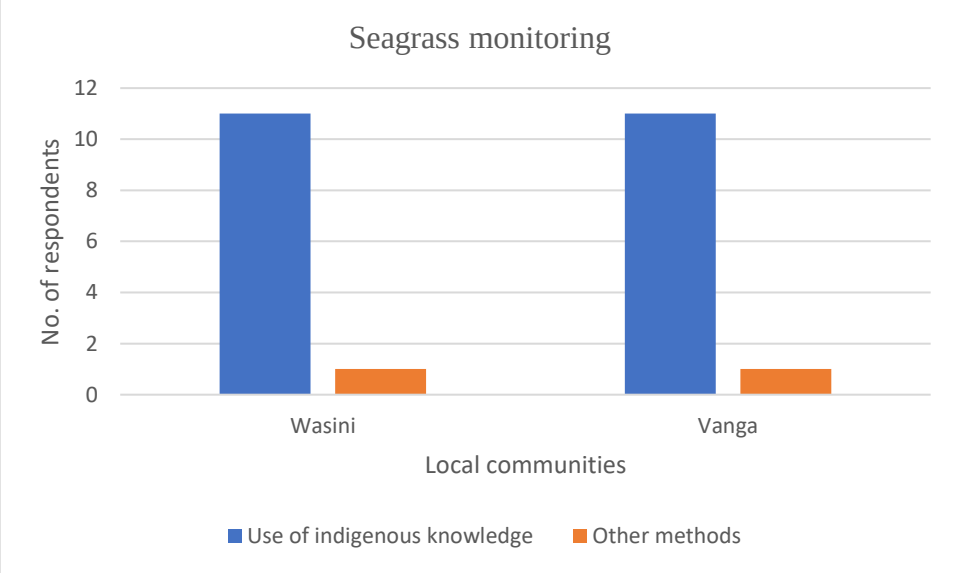

Figure 5: Graphical representation of seagrass monitoring methods to measure seagrass progress by number of respondents

Overview from Category G, A and N

All the respondents said that the local communities continue to rely on indigenous knowledge to monitor the seagrass progress. However, through academia and NGOs, new methods and tools such as seagrass watch protocol, remote sensing, the use of quadrants and seagrass nets are used. The communities have also been provided with snorkeling gear to monitor seagrass even in high tide. They also reported that records are kept for periodic monitoring to know the progress.

Q6. What are the expected outcomes to seagrass restoration?

As shown by figure 6 below, the majority of the respondents from both Wasini and Vanga communities expect an increase in fish stock and catch as a result of seagrass restoration. Secondly, as a result of increased fish catch, the income levels of households is set to increase due to the increase in fish catch. another aspect from both communities show that restoration programs have an effect on knowledge through the skills acquired from the seagrass restoration program after seagrass has been restored. Lastly, more respondents from Vanga community felt that after restoration, there will be easy access to fishing grounds than before, because the closer seagrass grows near shore, the more the presence of fish species. The Wasini community recorded a lesser number (one) compared to Vanga (four).

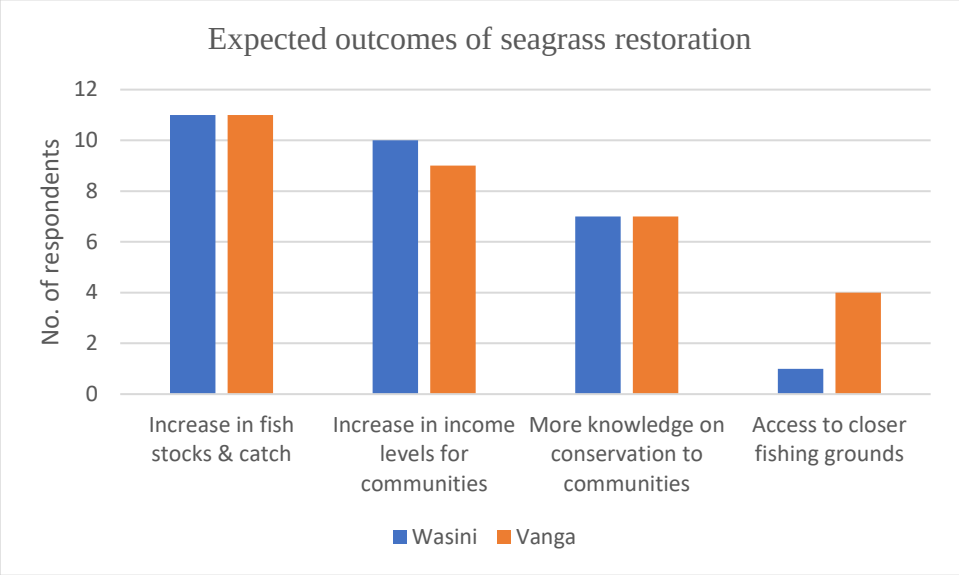

Figure 6: Graphical representation of expected outcomes of seagrass restoration in numbers of respondents

Overview of Categories G, A and N

Based on the results on figure 6 above, all the categories affirmed that fish stocks and catch as well as incomes from fish sales will increase after successful seagrass restoration. The A and N categories added that the communities will gain more knowledge that will help both communities to manage and protect seagrass as a result of the exposure received from the restoration program. Lastly, all the three categories agreed that seagrass restoration will improve fisheries and other marine biodiversity, re-introduce lost or endangered species in the area like dugongs.

3.2.2 Theme 2: The Main Challenges to Seagrass Restoration

Q7. What are the main challenges that affect seagrass restoration in Wasini, Kenya?

The challenges to seagrass restoration are numerous. From the results presented in figure 7 below, ten out of the eleven participants in Wasini community where seagrass

restoration occurred recorded the biggest challenge to be the use of destructive fishing practices. They also mentioned the scarcity of funds needed to run the restoration programs such as training, equipment and others, as another major challenge mentioned by all 11 participants. Lack of skills to restore seagrass and the problem of herbivores such as sea urchins feeding on the seagrass was mentioned by eight and nine out of the eleven respondents, respectively. Other challenges mentioned were the lack of clear policies to manage seagrass restoration and conservation and the delicate nature of seagrass that can be easily washed away by ocean waves and strong currents. Lastly, experts to fully manage restoration programs are few, making it difficult for them to manage a number of programs especially for longer periods, mentioned by four respondents. Similar problems occur in Vanga with destructive fishing practices also as the major challenge pointed out by all eleven respondents. Subsequently, on the lack of funds to restore seagrass, seven out of the eleven people mentioned it as challenge, which is less compared to all eleven participants that agreed on this challenge from Wasini.

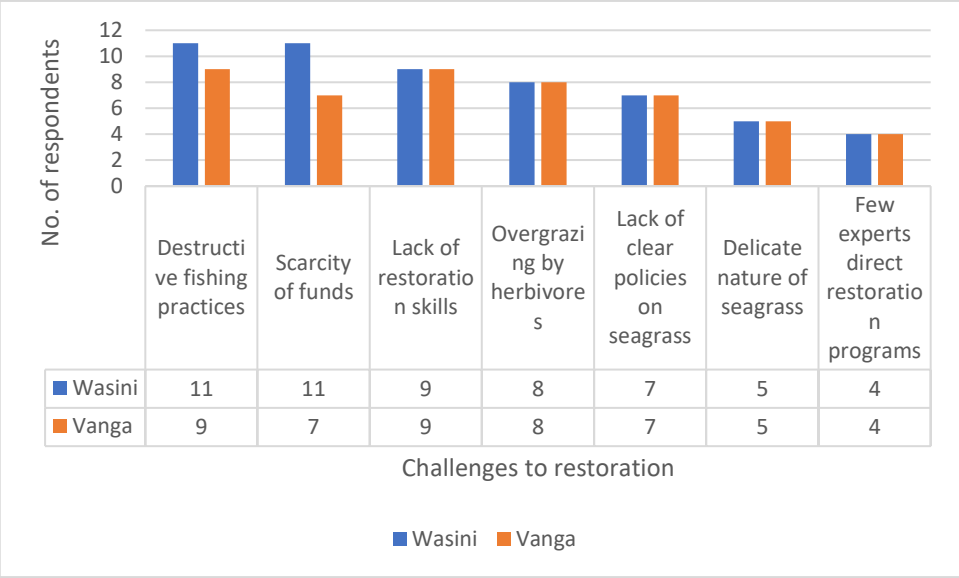

Figure 7: Graphical representation of the main challenges to seagrass restoration in number of respondents

Overview from Stakeholders for Categories G, A and N

Destructive Fishing Practices

The Kenyan government established BMUs at the county (local) level with a role of ensuring that no fishing illegalities occur at their area of jurisdiction and also protection of breeding areas to boost fisheries. From their point of view, the category N said that both Wasini and Vanga are under BMU management but are not fully capacitated to enforce the ban on use of the destructive practices due to lack of resources and management problems, thus, seagrass degradation continues to occur.

The NGOs and academia both mentioned that most of the fisherfolk are poor and are not in a position to abandon their gear for better fishing methods because they lack funds to purchase new gear. This continues to affect seagrass restoration by the fisherfolk.

Scarcity of Funds

The government agencies agreed that there are no funds available for both communities to restore seagrass. The past restoration in Wasini as well as the carbon offset project in Vanga were both funded by NGOs. On their part, they said that there is no budget to undertake restoration because they do not receive any allocation for seagrass restoration and/or conservation from the national government. This continues to hamper restoration efforts. Both the communities and government hence rely on donors in funding the restoration projects which takes time and is often not sustainable.

The NGOs felt that both communities come from poor backgrounds, majorly relying on small scale fishing trade. The Academia held the view that the professionals involved in restoration programs only offer professional advice and assist in research but do not have the funds to help the communities in running them. Therefore, seagrass degradation still continues.

Lack of Skills to Restore Seagrass

Category G agree that both communities as well as themselves, do not possess the required skills to undertake restoration. Due to the reliance on donor funding, they can only wait until the funds are accessible, contributing to delays in seagrass restoration.

Category N said that indeed both communities and government need skills such as scientific monitoring, data collection, suitable methods for restoration and others. For category A, they also agree that both communities lack the skills, however, they can only assist in skills development subject to availability of funds, which is another challenge in seagrass restoration.

Feeding on Seagrass by Herbivores

Category A and N pointed out the need to further investigate the presence of herbivores that are overgrazing on seagrass, contributing to faster seagrass loss. However, category G was not aware hence made no mention of such an occurrence.

Lack of Clear Policies on Seagrass Management & Restoration

All the categories of G, N, A participants agreed that there are no direct policies governing seagrass management, protection and restoration. There is no lead agency to spearhead restoration programs. With no proper legal framework, the responsibility is left with communities to initiate, oversee and monitor seagrass restoration programs. Since it is not their mandate, seagrass restoration is only conducted on voluntary basis which is not effectively managed due to lack of expertise in restoration and capacity to enforce practises that hamper restoration.

Problem of Few Seagrass Experts in Kenya

All categories agreed that the lack of experts to direct seagrass project is a major factor in dealing with seagrass losses. They mentioned that at present, Kenya has few experts to inform major decisions on restoration because they are needed in many coastal projects in other areas along the coastline. Getting more experts, they said, can help in dealing with the two other challenges mentioned by the communities such as imparting knowledge on restoration skills and finding solutions to reduce overgrazing by the herbivores, thereby reducing the overall challenges mentioned above.

Q8. What are the potential risks associated with restoring and preserving seagrass habitats in Wasini, Kenya?

As per the results shown by figure 8 below, all the respondents of Wasini and Vanga communities reported that community resistance was a major risk to seagrass restoration. The second risk was loss of livelihoods due to designation of restoration areas that limits fishing grounds, mentioned by eleven respondents from Wasini and ten respondents from Vanga. Another risk reported was the increase in transboundary conflicts due to the limitations of fishing space by mentioned by few, two and one from Wasini and Vanga respectively. Lastly, the least risk mentioned by a few respondents from both communities did not foresee any risk to restoration claiming that seagrass occurs naturally, hence no risk to fishing because it will self-generate with time.

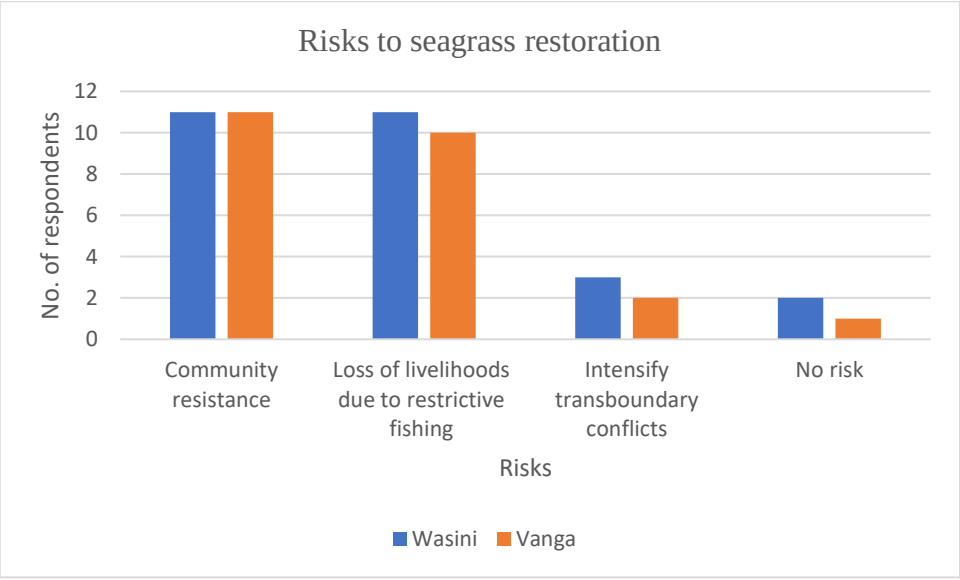

Figure 8: Graphical representation on potential risks to seagrass restoration in Wasini by number of respondents

Overview of Category G, A and N on Risks to Restoration

All the categories reported that community resistance was the major risk because of restricting their fishing grounds when designating areas for seagrass restoration. The restriction affects fish catch which lowers income levels for households. They said that resistance can affect seagrass restoration progress where there is no stakeholder buy-in, as witnessed in a past seagrass restoration program in Diani, within the same county of Kwale. On the loss of livelihoods, all categories agreed that there is a risk in not finding an acceptable alternative source of income or livelihood for the communities after limiting fishing grounds which reduces their fish catch resulting in low sales. They affirmed on the need to either establish an alternative fund from the already constrained resources or new economic activities to compensate the community for conducting seagrass restoration. As realized from the results of this study, restoration and conversation of seagrass in both communities is on voluntary basis and may not be appealing to many. As a repercussion, there is a need to compensate the communities to take care of their daily needs once they stop their regular fishing activities to attend to restoration programs. Failure to this they said, the restoration project risks underperformance or abandonment in worst case. Additionally, due to proximity of Wasini and Vanga geographically to the Tanzanian border, category G mentioned the risk of intensity of transboundary conflicts as a result of the communities extending their fishing space beyond acceptable border points due to the fishing restrictions to pace way for seagrass restoration. They reiterated that the capacity to enforce was already lacking and thus, it will be difficult to manage any illegalities from fishermen crossing over to the neighbouring country.

Q9. What resources are available to support seagrass restoration efforts in Wasini, Kenya?

The availability of resources is important in actualizing seagrass restoration exercises. Majority of participants (eight out of eleven) from Wasini said that there are no resources to undertake seagrass restoration, mainly relying on donors and other well-

wishers. Only three out of eleven said that the community is ready to participate and provide the assistance needed even with little funds and volunteers as a starting point. For Vanga, five out of eleven said that resources are available but not adequate to effectively manage seagrass restoration. These findings are presented by figure 9 below.

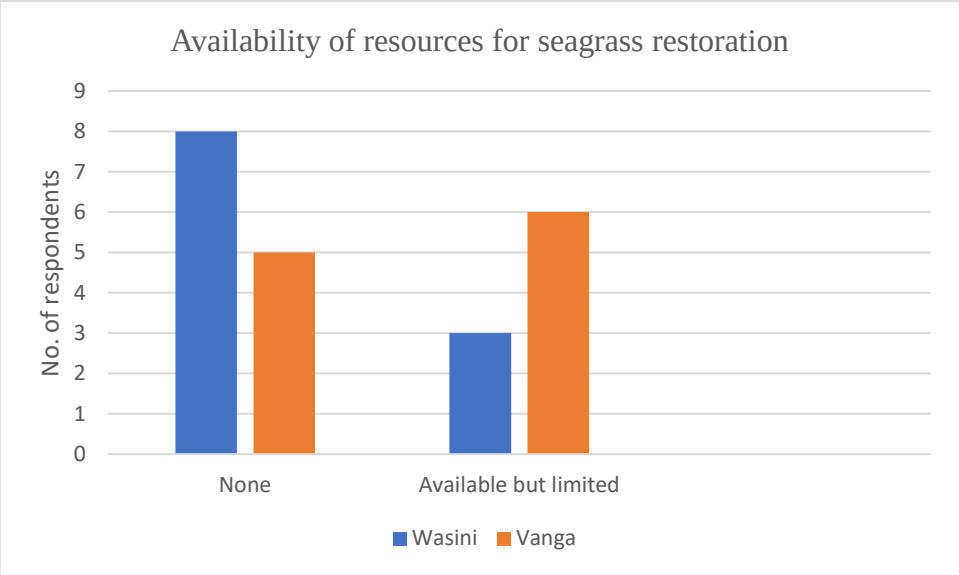

Figure 9: Graphical representation on the availability of resources for seagrass restoration by number of respondents

Overview from Categories G, A & N

As per category G, they felt that the are no available resources to undertake seagrass restoration programs. They reported that both the central and county government have no budgetary allocation exclusively for seagrass restoration and conservation. The A category shared the same view. They rely on government or private sector to conduct research, mapping and other activities failure to which, no action for restoration will be taken. The N category said that the resources are available but limited because they have to rely on well-wishers and volunteers from interested conservation groups/persons which takes time and can only cover for a certain period hence not sustainable.

Q10. Is the community empowered to conserve and restore seagrass for the future?

The lack of awareness on seagrass matters can inhibit restoration progress. Both Wasini and Vanga communities reported that the communities are not empowered to restore seagrass, with eight from Wasini and seven from Vanga. Only three from Wasini and four from Vanga, said that the community is empowered on seagrass conservation through awareness workshops and trainings. The result is shown by figure 10 below.

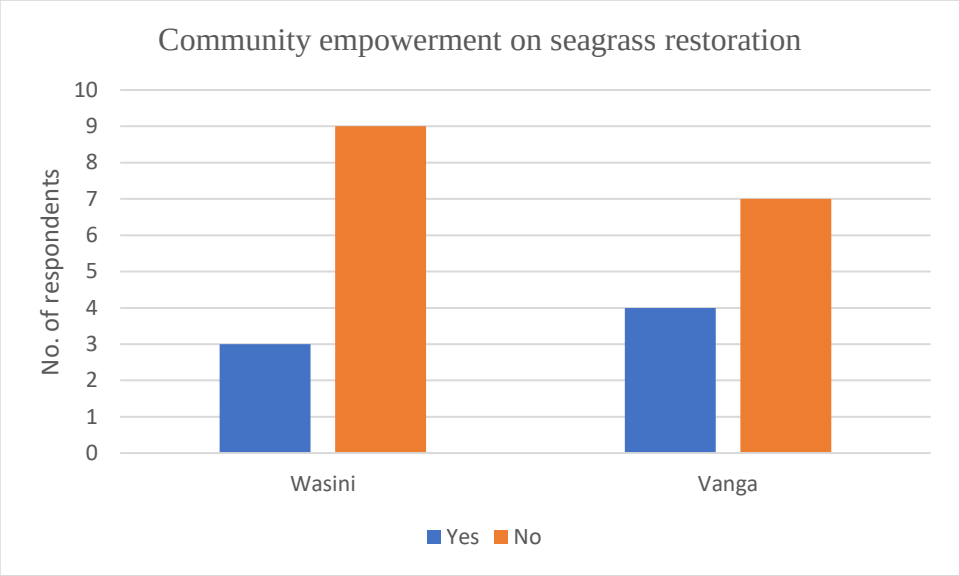

Figure 10 : Graphical representation by number of respondents on community empowernment in carrying out seagrass restoration

Overview of Categories G, A and N

From the results in figure 10 above, all the three categories agreed that the awareness conducted over the years is still not adequate hence, not sustainable. There is need to continously sensitize the commuitnies on the importance of blue carbon ecosystems, train on monitoring and data collection, among other needs to conserve and restore the ecosystems.

Q11. Is there any regulation/policy that facilitates processes to enhance seagrass restoration at national or county level?

Laws are important to guide, enforce and hold accountable the actions towards seagrass restoration and conservation. In Wasini, six of the eleven respondents said that they are not aware of any national regulation on seagrass restoration. The other five reported that seagrass conservation is only provided as general provisions under other legislation such as Fisheries Management & Development Act of 2016, BMU by-laws at county level. The feel is the same for Vanga community where seven of the eleven respondents are not aware of any policy as shown by figure 11 below.

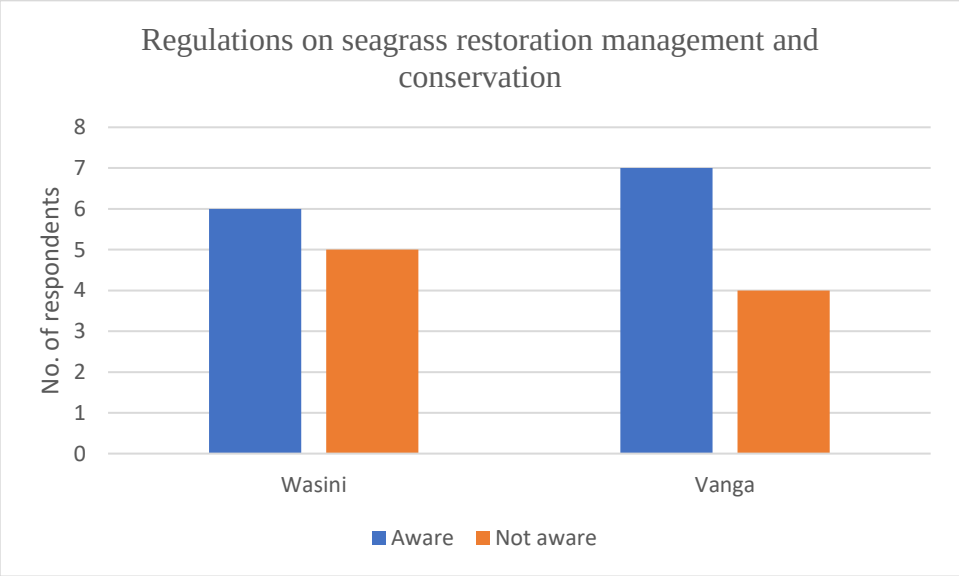

Figure 11: Graphical representation on regulation/policies to facilitate seagrass restoration by number of respondents

Overview by Categories G, A and N

All the categories pointed out that there is need to formulate specific regulations on seagrass matters as an ecosystem. Review of national laws to incorporate seagrass management is important for delivery of specific mandate and to also strengthen institutional capacity through creation of a regulatory framework that directly supports seagrass conservation. However, the existing general provisions on conservation and

protection of mangroves and coral reefs guidelines by Forest Act and Wildlife Act are assumed to include seagrass as a BCE and thus, is covered by the mandated agencies.

3.2.3 Theme 3: Strategies to be Implemented for Successful Seagrass Restoration Programs

Q12. Communities lack funds to engage in seagrass restoration. What avenues are available for them to carry out restoration without affecting livelihoods?

All participants from both Wasini and Vanga communities pointed out on the need to conserve the current seagrass cover as opposed to restoration to allow them to continue with the fishing activities while protecting the seagrass, as shown by figure 12 below. They also suggested community sensitization meetings to create more awareness to reach more people at grassroot level. This was mentioned by nine respondents from Wasini compared to seven from Vanga community. Another avenue proposed was to address the main challenges threatening restoration. Lastly, five respondents from Wasini community proposed the establishment of temporary closures compared to one from Vanga community.

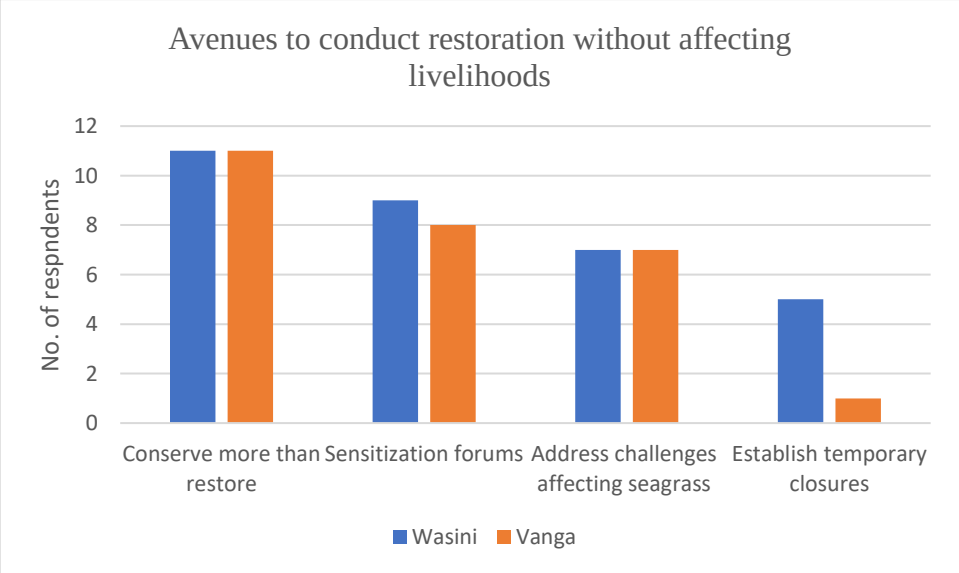

Figure 12:Graphical representation of avenues for communities to conduct restoration by number of respondents

Overview for Categories G, A and N

All the categories agreed with the community proposals. Sensitization forums will ensure more people understand the need to conserve seagrass and thus will protect it as they engage in their daily activities to support their livelihoods. The challenges that affect seagrass also need to be addressed to prevent further loss. However, the Academia higlighted more on the need to conserve than restore compared to the rest of the suggestions proposed because restoration programs are capital and labour intensive than conservation with an undetermined rate of success. Lastly, temporary closures will ensure that after some period of time, the area can be re-opened for the communities to continue fishing as opposed to Marine Protected Areas (MPA) that are prohibitive and restrictive (no-take zones).

Q13. What strategies can be implemented to ensure a successful restoration and preservation of seagrass habitats in Kenya?

In addressing the challenges mentioned by the two communities, a number of appropriate solutions were proposed as presented by figure 13 below. For Wasini community, all the eleven participants felt that sourcing for funds from donors to undertake the restoration projects was the most important. This is because the previous restoration project stalled majorly due to lack of finances needed for equipment, training, etc. Secondly, the need for capacity building in Wasini was also proposed by all the respondents. Thirdly, Wasini community mentioned the need to strengthen the enforcement capacity to reduce the impact of degradation by destructive fishing methods, mentioned by ten out of the eleven respondents. Another solution proposed by eight of the eleven respondents, was the need for collaboration and partnerships of relevant stakeholders to provide the necessary resources such as funds from NGOs, training from experts/academia. Other solutions proposed was to increase the seagrass cover by active restoration and also designation of temporary closures by the government to allow the seagrass to grow with less disturbances.

The Vanga community was in agreement with Wasini on the need for funds, enforcement on destructive fishing practices and also collaboration. However, on

capacity building, only four respondents agreed against the eleven from Wasini. The increase of seagrass cover was less proposed. Some participants said that seagrass grows naturally on its own hence, care is only needed to minimize the threats that reduce seagrass as opposed to planting afresh. Additionally, four participants proposed the establishment of temporary closures as opposed to only two from Wasini.

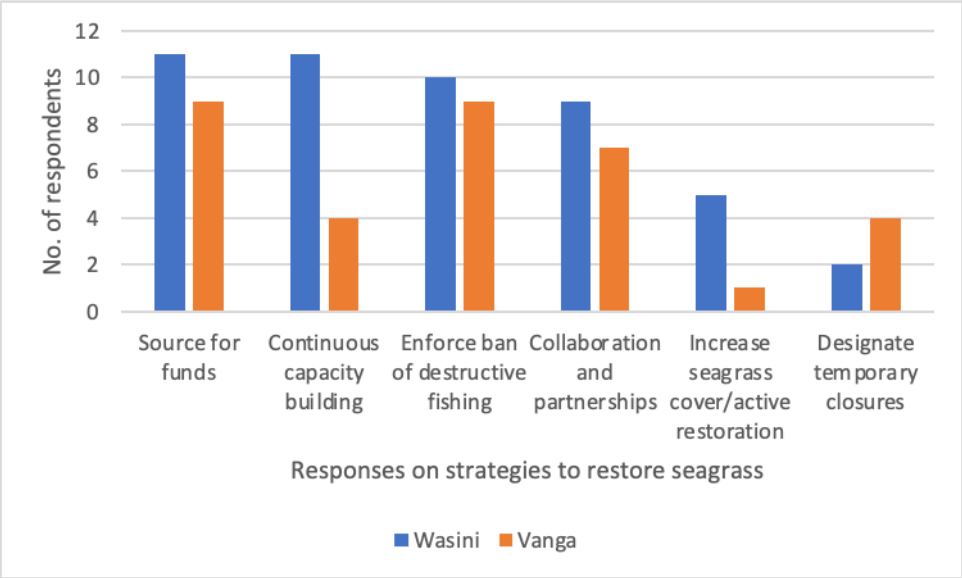

Figure 13: Graphical presentation on strategies and solutions proposed to seagrass restoration challenges

Overview of Categories G, A, N on Solutions to Restoration Challenges

Source for Funding

The participants from category G agreed with the communities that funds are an important component in seagrass restoration. They proposed that in future, the national budget should include specific provisions to manage seagrass protection and conservation as opposed to generalized budget. However, at present, the G and A categories of respondents mentioned that both communities can only continue to rely on NGOs and well-wishers for assistance. As for the N category, the approach was to establish scalable and cost-effective methods to seagrass restoration by use of Nature-based Solutions (NBS) as a strategy to manage costs instead of communities relying on donors. NBS will enable restoration by use of natural and socio-economic

components available within and without the habitat to restore, thereby lowering the overall cost of the program.

Continuous Capacity Building

The need for continuous capacity building was mentioned by all categories, stressing that in as much numerous workshops on restoration and conservation have been held in both Wasini and Vanga communities, the approach is not sustainable because most times, the communities may not be able to remember much due to passage of time, the scientific methods to collect and monitor the success rate of seagrass that need careful study to prevent reporting of wrong data. Additionally, changes occur in the marine environment such as storms, climate change, coastal developments and others which need new approaches and skills.

Enforce Ban on Destructive Fishing Practices

The G category mentioned the need to strengthen the enforcement capacity by actively working with the communities through the BMUs to effectively reduce seagrass degradation. From the N and A categories, they felt the need to not only strengthen capacity on the ban, but also offer alternative gear that does not destroy seagrass to lessen the impact.

Stakeholder Collaboration and Partnerships

All the G, A and N categories pointed out the need for increased collaborative efforts and partnership of all the stakeholders in ensuring all the seagrass restoration needs are met. Each stakeholder will have a role to play to ensure the restoration requirements are available. They said that collaboration pools resources and skills with reliance on each other when gaps and challenges arise.

Increase Seagrass Cover and Designate Temporary Closures

These suggestions were least mentioned by both communities because of the limitation it places on fishing grounds. However, category G, A and N highlighted on the

importance of designating temporary seagrass restoration closures to allow seagrass to allow seagrass to mature before opening up areas for fishing. This is to prevent permanent restrictions on the limited fishing grounds available to the communities. Additionally, they pointed out that permanent no-take zone may face resistance which can negatively affect seagrass restoration efforts. The mechanism is to increase seagrass cover and at the same time, allow small-scale fishing to continue.

Q14. How can blue carbon programs contribute to the success of seagrass restoration in Wasini, Kenya?

In Kenya, the blue carbon offset projects continue to increase as a climate mitigation measure and conservation. As per figure 14 below, the Wasini community knows less of the importance of these projects towards supporting livelihoods as mentioned by only three out of the eleven respondents. Similarly, on increasing awareness on the importance of BCE was mentioned by only one respondent. The rest of Wasini respondents are not aware of any importance to BCEs. In contrast, for Vanga, the majority of participants are aware of such projects and felt that they do contribute to success of seagrass restoration and conservation with nine mentioning on source of livelihoods, six supporting carbon projects as they increase awareness of BCEs and only one was not aware of any contribution.

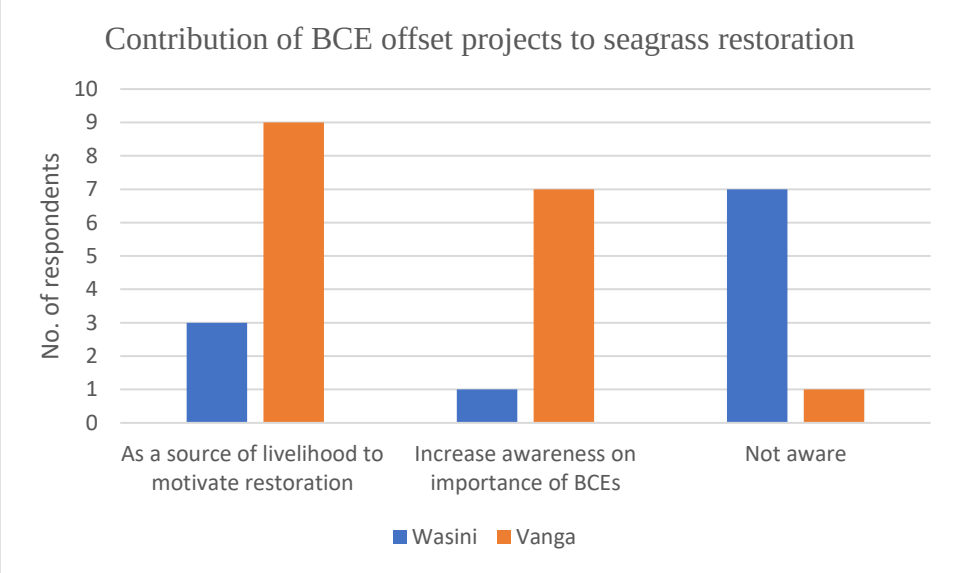

Figure 14:Graphical represenatation on contribution of BCEs projects towards seagrass restoration by number of respondents

Overview of Category G A and N

All categories agreed on the contribution of BCE projects towards seagrass restoration and conservation, more for Vanga than Wasini because of the benefits gained from the sales of carbon credits. The communtites are willing and able to participate in conservation in Vanga due to the presence of the project as opposed to Wasini community where no such project exists. The benefits motivate the Vanga community to conserve, creates more understanding on the significance of seagrass conservation and protection because of the tangible benefits. They become aware that sustainability of the projects depends on seagrass cover, hence ,the more the degradation of BCEs the more the loss of the benefits from the carbon sales.

15. How can local communities, private sector and government work together to support seagrass restoration in Wasini, Kenya?

All the respondents, eleven from each community proposed the need for collaboration to support the communities in seagrass restoration programs as shown by figure 15 below.

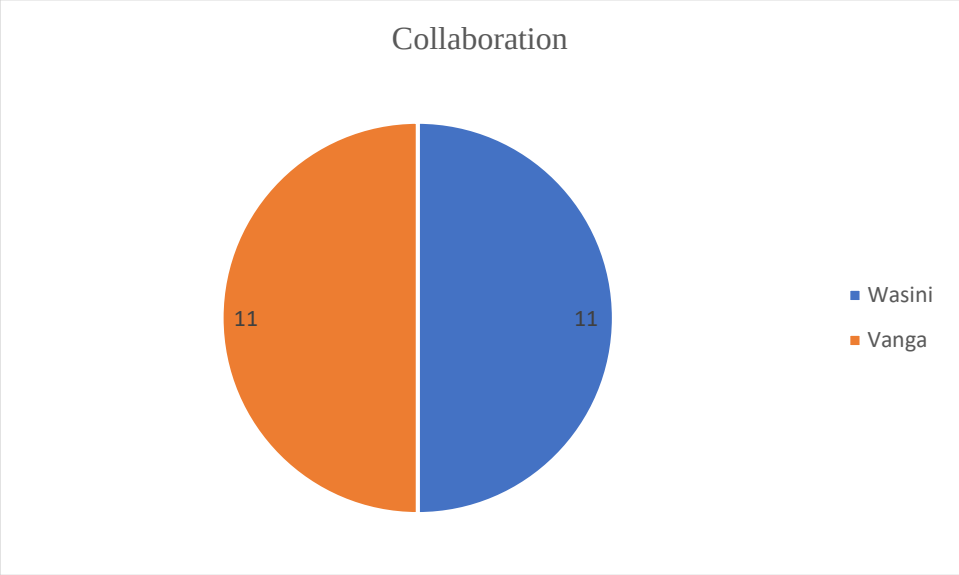

Figure 15: Pie chart representation of communities and stakeholder support in seagrass restoration

Overview of Categories G, A and N

All the categories advocated for increased stakeholder collaboration and partnership of the coastal communities with government, private sector and any other stakeholder willing and able to assist in seagrass restoration. The support, they felt was a workable strategy that promotes pooling of resources and ideas for seagrass restoration to be conducted. The N category added the need for co-management, adaptive management of BCEs conservation as collaborative strategies towards seagrass restoration and conservation as opposed to top-down approach which they reported, has not solved degradation of seagrass around many the coastal areas in Kenya.

Q16. How can blue carbon projects increase compliance on conservation in the coastal areas when carrying out restoration work?

Due to the lack of a carbon offset project in Wasini, the response on the awareness and influence of such projects towards compliance was low as compared to Vanga, as depicted by figure 16 below. For Vanga community, ten respondents mentioned that

the carbon projects propel more action towards conservation to increase more carbon capture as opposed to one respondent from Wasini. secondly, nine respondents felt that the projects promote the community to conserve more for sustainability of the projects with its benefits with only two respondents from Wasini. Finally, nine respondents said the more the carbon offset projects, the more compliance compared to only one respondent from Wasini.

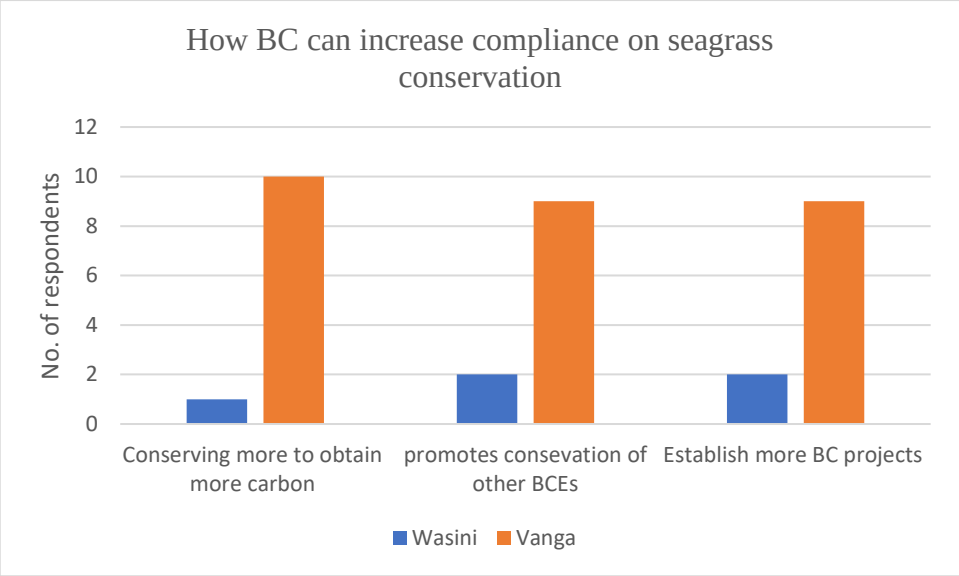

Figure 16: Graphical representation of how blue carbon projects can increase compliance on seagrass conservation by number of respondents

Overview of Category G, A and N

All the categories agreed that the carbon offset projects have an influence on conservation especially in Vanga because such a project exists compared to Wasini. They pointed out the need to establish more projects for the benefit of the communities as well as the BCEs through conservation and compliance.

Q17. What role do you believe blue carbon projects can play for seagrass restoration in Wasini, Kenya?

Based on figure 17 below, Vanga community, eight respondents out of eleven compared to two from Wasini, felt that the carbon offset projects will open up job opportunities. Also, seven of the eleven respondents from Vanga compared to three from Wasini mentioned that because communities will be conserving and protecting the BCEs to sustain the carbon offset projects, there will an increase in carbon sinks. In addition, the role of BC projects to improve fisheries was mentioned by four respondents from Vanga and three respondents from Wasini. Lastly eight respondents from Wasini reported that they are not aware of the role of BC compared to only two respondents from Vanga.

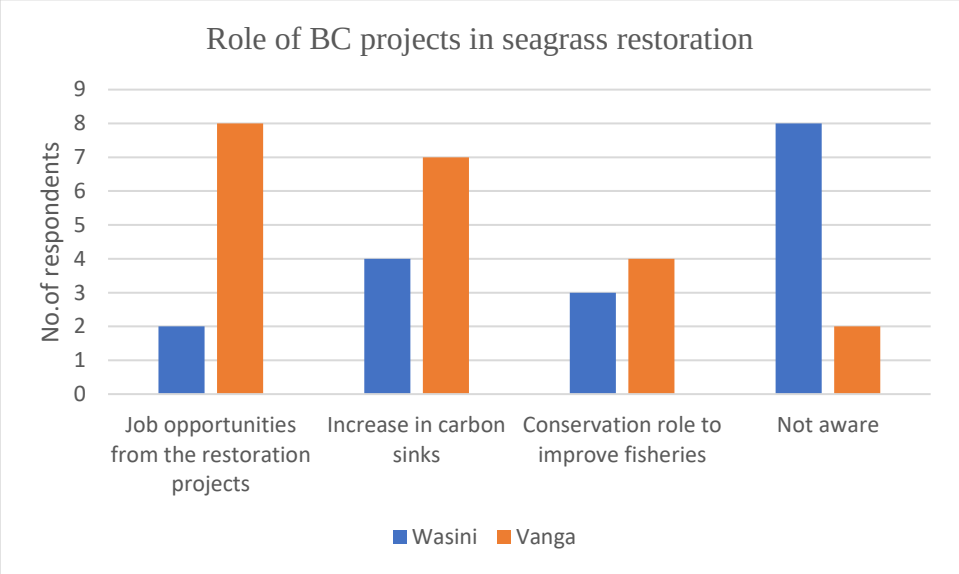

Figure 17: Graphical representation on the role of blue carbon projects in seagrass restoration by number of respondents

Overview of Categories G, A and N

Based on figure 17 above, all categories felt that the blue carbon projects play an important role for the marine environment and also for the people. The presence of

these projects has improved Vanga community livelihoods through job creation of monitoring, conservation, protection of seagrass, where the proceeds are ploughed back to the community for social amenities. They also mentioned that the projects play a significant role on conservation especially in improving fisheries as shelter and spawning sites for fish, which has the potential to increase fish stock. However, they agreed that the awareness level on the importance of the projects is less for Wasini compared to Vanga.

Q18. Is seagrass restoration a driving factor in ensuring more carbon sequestration for Kenyan marine ecosystem in Wasini?

Even with the advent of the blue carbon projects in Kwale such as Vanga Blue Forest in Vanga and *Mikoko Pamoja* in Gazi, carbon sequestration process remains largely unknown by both communities. This is evident as seven out of eleven respondents for Wasini and six out of eleven respondents for Vanga were not aware of the relationship of seagrass with carbon sequestration, as shown by figure 18 below. Only three for Wasini and four for Vanga, sparingly mentioned on the influence seagrass has on carbon capture. Consequently, one respondent for each community felt that seagrass restoration is not as a diving factor for carbon sequestration.

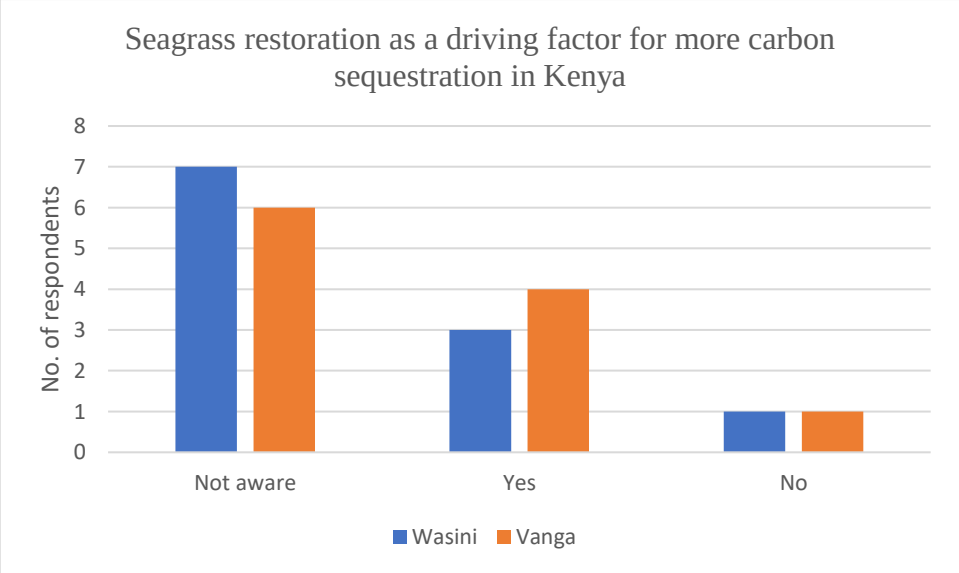

Figure 18: Graphical representation on seagrass as a driving factor for more carbon sequestration

Overview of Category G, A and N

From category G, only one out of the five respondents, understood on carbon sequestration. The process is still largely unknown except for the A and N categories. The two categories agree that seagrass restoration plays a crucial role in capturing and storing carbon through sequestration.

4.0 DISCUSSION

4.1 Findings

This study reveals the stakeholder perceptions on seagrass and its importance as a BC. It also highlights the challenges encountered and proposed solutions towards seagrass restoration projects from the interviews conducted. The results from this study can assist decision-makers make informed decisions on conservation policies by addressing gaps presented by challenges and the solutions given for future seagrass restoration programs in Kenya. The research findings are discussed as per the 3 themes; stakeholder knowledge on the importance of seagrass as a blue carbon, challenges and solutions to seagrass restoration as per below:

4.1.1 Theme 1: Stakeholder perceptions on the importance of seagrass as a BCE

The results from the interviews confirm that the respondents from both communities are aware of seagrass and its importance (figure 3) through the provision of the ecological services as benefits (figure 4) and expected outcome from seagrass restoration projects (figure 6). Majority of the respondents from both communities mentioned benefits in providing shelter, foraging, spawning and feeding grounds to fish as well as other marine species, less compared to climate change mitigation. Since both are fishing communities, the major elements of expected outcomes mentioned were increased fish stock which would result in increased fish catch and ultimately increased income for livelihoods from sale of the huge catch. The other respondents (G, A and N) confirmed the same position on the importance, benefits and expected outcomes of seagrass as mentioned. Generally, stakeholder understanding of seagrass and its significance is critical because it can add value to seagrass restoration and conservation. Previous studies have shown that stakeholders can provide useful information about seagrass habitat that may be helpful when carrying out restoration, by identifying threats and imbalances in conservation approaches and/or offer support where necessary (Amone-Mabuto et al., 2023; Ruiz-Frau et al., 2019; Valdez et al., 2020). Conversely, other researches on perceptions of people on the importance of

seagrass show that it may be difficult for stakeholders to know about it due to its existence under water, thus, it becomes challenging for communities to understand the need to conserve it (Ollgren,2019). Consequently, from these findings, the overall perception from both communities and the other stakeholder categories confirms adequate level of awareness on seagrass, its importance as a BC and the ecological services it provides. However, the results (figure 2) show that more participants from Vanga community are aware about seagrass as BCE compared to Wasini. The difference can be attributed to the presence of carbon offset community project in Vanga, where carbon trading occurs but no such project is in Wasini. This difference was also shared by the stakeholder categories (G, A and N) that the carbon offset project has exposed Vanga community to understand more on seagrass as a useful resource that benefits them.

The study findings also show that both communities are the main resource users because of their interaction with the ocean on a daily basis carrying out fishing, therefore, their perceptions and level of awareness are important as it will play a vital role in supporting future programs (Amone-Mabuto et al., 2023). This is by providing information through indigenous knowledge that can be helpful in seagrass restoration and conservation programs. A realization from these findings is that stakeholder understanding of seagrass habitat increases compliance of restoration and conservation measures. Previous studies in Sweden have shown that when people understand the importance of marine environment protection, their behaviour changes positively towards reducing negative impacts (Elggren, 2019). The same has been experienced in the Philippines by Sumeldan et al (2021), stating that a well-informed community is likely to be more compliant to marine conservation measures than a less-informed one.

4.1.2 Theme 2: The Main Challenges to Seagrass Restoration

In as much as restoration is a tool to conserve seagrass, the success rate is highly dependent on identifying and managing the anthropogenic disturbances to ensure their survival (Mokumo et al., 2020).The results from the study show that the main challenges to seagrass restoration are destructive fishing practices, scarcity of funds to conduct restoration, lack of regulations/policies and enforcement on seagrass conservation, lack of skills to restore, feeding on seagrass by marine herbivores and lack of experts to direct and oversee restoration projects. Based on the findings in figure 7, the major challenge to restoration mentioned by all stakeholders in both Wasini and Vanga is destructive fishing practices such as trawling, beach seines, spear guns and anchoring of boats that uproot seagrass shoots. Similarly, these fishing practices have been cited as the major contributor to global seagrass decline, for example, South Africa where up to 80% seagrass loss was attributed to destructive fishing practices like seining nets (Phair et al., 2020). Similarly, all the interviewed respondents confirmed that lack of funds is a setback to restoration. It was stated that the government does not allocate funds for seagrass restoration. Both communities operate small-scale fishing to sustain households, which is not adequate to finance restoration programs hence the reliance on donors. However, they mentioned that even from donors, the funds are usually constrained and are only operational within the project's limited time frame. This means that as the project time lapses, so do the funds and all related conservation activities. The same challenge has been found in other studies, stating that restoration projects dependent on donor funds are often limited due to the constrained finances and time and thus, are usually not sustainable (Quevedo et al., 2020). As reported by Wasini participants from the interview, previous restoration projects in the area could not proceed due to the same reason with one donor-funded project costing USD 630,000 per hectare (Uku et al.,2021) which the community and government could not raise. Comparatively, as found in Vanga, the community does not entirely rely on donors for seagrass conservation. This is because some of the proceeds from the carbon offset project have enabled them to manage BC conservation. Nonetheless, the participants from Vanga community said that the funds

are still not adequate because part of it is utilized in running community projects such as provision of water services, construction of classrooms and other social amenities

Another challenge from the findings is the lack of skills to restore. It was mentioned by all respondents that stakeholders do not possess the necessary skills to undertake restoration programs. As shown by figure 10, the community is not well-empowered in seagrass management and restoration with no resources (figure 9). To establish such a project, skills are required to find suitable sites for planting, sustainable management approaches and skills for long term monitoring to assess the project progress. In addition to challenges, lack of clear policies for seagrass restoration was also mentioned. Most respondents agreed that seagrass lacks a regulatory framework that distinctly puts the responsibility on a specific agency to spearhead seagrass management. Presently, there are numerous agencies mandated to protection and preservation of marine ecosystems in Kenya such as wildlife service, coastguard service, forest service, environmental management authority, among other. However, respondents pointed out that only general provisions on protection and conservation of marine ecosystems are mentioned, deemed to include seagrass. As realized from this study, the lack of clear policy framework and numerous government agencies involved in BCE management creates a conflict of mandate with no accountability of any agency to undertake seagrass restoration. The same challenge has been experienced in the Philippines where weak law enforcement and conflicting mandates on the roles played by government agencies has aggravated habitat degradation of BCEs with less or no intervention (Quevedo et al., 2021). Also, the study realized that the BMUs have insufficient capacity for MCS (monitoring, control and surveillance), adding to the weak enforcement thereby affecting seagrass conservation (Tschentscher et al., 2023). Consequently, with no lead agency to provide guidance on restoration, a realization from the findings is that the initiative to carry out seagrass restoration is not top-down. It is upon the communities to approach other stakeholders (NGOs, researchers, government, private sector) to establish seagrass restoration programs on voluntary basis. Notably, for Vanga community, the carbon offset project motivates the communities to be more proactive in protecting seagrass due to the monetary

benefit accruing from the sale of carbon credits compared to Wasini where the programs are purely on a voluntary basis. Results from the remaining challenges were the same case as Wasini, as shown in the figure 7; few experts to direct restoration programs. Restoration needs well-informed actions, guidance to strategically manage the projects (Van Katwijk et al., 2016). These actions require a multifaceted and scientific approach led by experts on seagrass matters. Selection of suitable sites, suitable species to plant, species adaptability, choice of planting methods and techniques need seagrass experts who are few in Kenya. As shown by figure 5, both communities monitor seagrass using indigenous knowledge which may not scientifically give factual propositions hence the need for experts. These sentiments were echoed by the categories of government and academia. Contrastingly, in New Zealand, the incorporation of science and local knowledge has been productive through collaboration where the local community provided valuable insights and observations that improved seagrass restoration project (Tan et al., 2020).

The challenge of feeding by herbivores was highlighted by both communities and academia where overgrazing by marine herbivores like sea urchins continue to reduce seagrass cover. The same was experienced in Bermuda, where overgrazing by green turtles led to loss of seagrass meadows (Fourqurean et al., 2010). This continues to reduce seagrass, adding to challenges to restoration. Community resistance was adversely mentioned by majority of respondents. Lastly, the increase in transboundary issues and community resistance were also mentioned by all respondents as a risk emanating from restoration. This occurs due to limiting of fishing grounds to pave way for seagrass restoration, resulting in migratory and IUU fishing. As realized, Wasini and Vanga are located at the periphery, and thus, transboundary conflicts may occur. Such issues have led to severe conflicts in Bay of Bengal and created spill-over effect of IUU fishing and over-exploitation of fisheries within the neighboring countries of Bangladesh Thailand (Kafdak et al.,2012).

4.1.3 Theme 3; Strategies to be Implemented for Successful Seagrass Restoration Programs

In addressing the challenges, the interviewed participants proposed the need to strengthen institutional capacity, source for funds to undertake restoration programs as well as collaboration and partnerships of stakeholders (figure 13). From the interviews, the overall perception held by all respondents was the need to strengthen both government and BMUs in enforcing the ban on destructive fishing practices and related activities to reduce the impact in destroying seagrass. Since fishing is a core activity, they felt that more enforcement would ensure that the fishermen adhere to marine environment protection and conservation regulations to avoid more seagrass loss from boat anchorage, use of fish traps and beach seines. Additionally, there is need for introduction of sustainable fishing practices (Wallner-Hahn (2017), to manage seagrass loss as proposed by Category N from such as gear restrictions.

On funding, majority of the interviewed participants proposed sourcing for funds from donors and establishment of budgetary allocations from national and county levels specifically for seagrass projects. On the same note, other previous researches propose on establishing more payment of ecosystem services such as the Vanga Blue Forest project as a strategy to obtain funds for investing in BCEs (Wylie et al.2016). Both communities also mentioned that since the restoration exercise is voluntary, it will be more effective if the volunteers can be compensated for the time spent in restoration instead of fishing. As realized from the study, securing their daily sustenance was more important than seagrass restoration unless some financial incentive was offered. The same scenario was mentioned by Lucrezi & Cilliers (2023), stating that volunteering is constrained by time and resources, with volunteers requesting for an incentive as a motivating factor for marine restoration activities.

Another proposal was stakeholder collaboration was mentioned by majority of participants (figure 15), in terms of pooling of resources to fund the seagrass restoration initiatives. Similarly, this finding was also reported in Australia where collaboration of researchers, community and other stakeholders was seen as a measure that is likely to increase the success rate of seagrass restoration because each group

contributes a skill, idea, resource or experience required for progression of the project (Tan et al., 2020). Other proposed solutions from the research findings are the adoption of adaptive management measures to respond to threats especially from natural factors such as wave action, feeding of seagrass by herbivores and sea level rise that destroy seagrass. This management concept allows the use of outcomes from previous management actions to improve and refine future management activities (Gamble et al.,2021).

As realized from this study, conservation is better than restoration (figure 16). Successful seagrass restoration is costly and can take years to actualize (Fraschetti et al., 2021) and thus, providing a conducive environment for seagrass to exist naturally can be more sustainable and less costly compared to restoration (Gamble et al.,2021). Other concepts mentioned from the findings are integrating NBS into seagrass conservation and management practises as mentioned by category N. In essence, NBS are advanced and innovative strategies to promote both adaptation and resilience through the use of nature and societal needs (Nelson et al.,2020) by using naturally existing mechanisms to uphold conservation strategies that are both eco-friendly, enforceable, cost-effective and sustainable (UNEP,2020). This concept has been experienced in Indonesia, where NBS methodologies were applied to seagrass restoration successfully (Rifai et al.,2023).

As per the study findings, continuous capacity building was also proposed by all stakeholders to ensure that communities remain well-equipped with skills from to undertake restoration programs. From previous restoration project in Wasini, Uku et al.,2021 proposed the need for repetitive training ensures that the communities know the correct monitoring practises of seagrass progress. Conversely, as per figure 13, the Vanga community respondents felt that many trainings and workshops on BCE conservation and management have been conducted hence, less needed.

In addition, the study findings proposed the introduction of alternative source of livelihoods to reduce the disturbances in the ocean. Since both Wasini and Vanga mainly practice fishing, other economic activities may be introduced to reduce the sea-going fisherfolk from trampling and disturbing seagrass progress. However, majority

of the community respondents were sceptical on this, as opposed to the overview given by categories G, A and N, where aquaculture was proposed. This is because, both communities have relied on fishing as the main activity for many generations, hence may resist change. Another solution proposed form the findings is the concept of resilience, which has also been mentioned in previous researches as a strategy in strengthening coastal communities (O'leary et al., 2022), like Wasini and Vanga in building resilience to prevent further seagrass loss and also as an important action towards climate change mitigation. The concept is used globally as a tool for BCEs and involves analysing how the stressors and pressures resist and recover from loss and degradation (Unsworth et al.,2015). It is reported that building resilience helps in designing and implementation of various interventions to manage the pressures in the marine environment as they occur (Dooks,2022) that can be incorporated in both Wasini and Vanga conservation measures. Notably, it is a realization from this study and previous restoration programs in Kenya and across the world that many of such programs are carried out on small scale which does not match the scale of human disturbances (Fraschetti et al.,2021) resulting in low success rate. Ultimately, there is need to look beyond restoration by incorporating different best practises to seagrass restoration, stakeholder inclusivity, establishing proactive conservation ethics as well as strategies that minimize the cost for effective seagrass restoration in future (Amone-Mabuto et al., 2023; Ruiz-Frau et al., 2019).

Figure 19: Images of seagrass before and after restoration courtesy of Wasini BMU

4.2 Integration of Blue Carbon Projects into Seagrass Conservation

Many countries, especially developing states like Kenya, have an investment gap in marine conservation, restoration and protection (Brears, 2022). As shown by the results finding in this study, both governments and coastal communities lack the capacity to pool resources for BCE restoration. In addition, there are no incentives to invest and promote seagrass restoration. To assist in mobilizing such investments, the establishment of carbon offset programs are currently used as incentives to promote conservation through sale of carbon credits (Oreska et al., 2020) and at the same time, motivate communities towards BCE conservation, as shown by figure 14, in order to benefit communities through sale of carbon credits. At the global level, there is an increased interest in payment of ecosystem services to support seagrass initiatives (Cullen-Unsworth & Unsworth., 2016). As stated by Herr et al (2019), it is an integrated approach that supports conservation and at the same time, sustains coastal livelihoods without seeking for alternatives. As realized in this study, the community carbon offset project in Vanga (Vanga Blue Forest Project) aims to protect and conserve mangrove ecosystem. However, due to the synergistic effect with other BC, success of one ecosystem is directly linked to the success of the other (Moberg & Ronnback,2003). The project has incorporated both mangrove and seagrass to promote a healthy and well-functioning marine environment essential for growth of marine biodiversity (Carlson et al, 2021). Through the project, buyers pay an additional cost as a way to mobilize for more funds to manage seagrass conservation (Vanga Blue Forest Project, 2020). From the study findings, it was mentioned that it was better to conserve than restore seagrass (figure 16), the project integrates seagrass as a means to promote conservation and preventing seagrass losses as a means to ecosystem protection. The project offers monetary benefits from the carbon effort scheme to Vanga community thereby creating a solid incentive for conservation and thus, opens up opportunities to promote sustainable financing to seagrass restoration and rehabilitation (Blue Nature Capital Financing Facility Project report, 2021). The introduction of this carbon program has enhanced compliance to marine environment protection and has helped to safeguard the ecological services while at the same time

maintaining livelihoods (Oreska et al.,2020). As realized through this study, the alignment of the carbon project presents a viable way to restore and conserve BCE without relying heavily on donors, hence solving the challenge of scarcity of funds. In addition, it's a realization from this study that the project acts as a supplementary source of livelihood to Vanga community as opposed to establishing new alternative livelihoods which may be costly and less preferred to fishing. This strategy can be a sustainable solution for communities to conserve and receive benefits as in the case of Japan (Kuwae at al.,2022), as opposed to volunteer program like the case in Wasini. Through this research, it is evident that the uptake of blue projects can be a viable way to promote conservation in the coastal communities to prevent seagrass loss, reduce poverty and create enlightened communities on BCE management. In addition, the projects also provide an enabling environment for the promotion of UN SDGs on reducing hunger (SDG 1), zero poverty (SDG 2) through sustainable fisheries and benefits from carbon sales which increase household income for the community, as well as tackling climate change through blue carbon ecosystems, SDG 13 on climate action. It also promotes SDG 14, life below water by protecting the marine environment through conservation thereby promoting healthy ecosystems.

5.0 CONCLUSION

To fully address and conduct seagrass restoration as a measure, it is important for stakeholders to understand their significance in the marine ecosystem (Elggren, 2019). This study highlighted the perceptions held by stakeholders on the importance of seagrass and its significance as a blue carbon ecosystem. Additionally, it outlined the challenges of seagrass ecosystem and solutions to restoration. From the study findings, stakeholders are aware of seagrass as an important habitat of the marine environment providing ecosystem services such as carbon sinks, creates an enabling environment for fish and other marine species to multiply by providing foraging, shelter and spawning ground, improving biodiversity as well preventing coastal erosion. Also, the study found out that seagrass was perceived to be of significance because it helps in mitigating the effects of climate change. The challenges that hamper seagrass restoration were perceived to be scarcity of funds to conduct restoration, use of destructive fishing mechanisms that destroy seagrass, lack of skills to restore seagrass. Other challenges mentioned from the study were lack of experts to direct restoration programs, feeding on seagrass by herbivores as well as lack of regulation/policies to support seagrass restoration. The study also provided solutions to address the highlighted challenges for future restoration programs; strengthening enforcement of destructive fishing methods to prevent further seagrass loss, source for funds to support seagrass restoration, improvement of skills and awareness of stakeholders through continuous capacity building. Other solutions such as stakeholder collaboration and partnership, formulation of policies to directly manage seagrass restoration and conservation as a BCE and establishing supplementary or alternative livelihoods to reduce disturbances in the seagrass restored areas, were also proposed.

Although multidisciplinary approaches towards seagrass restoration continue to gain momentum both internationally and nationally, more still needs to be done at the local level (Wilson & Forsyth., 2018). It is evident from this study that the ecosystem services need to be safeguarded to sustainably protect the marine environment, the planet and humans. The knowledge on the importance and significance of seagrass

helps in empowering coastal communities to understand the significance of these critical ecosystem to enhance compliance to seagrass conservation measures in order to prevent further seagrass loss. As realized from the research, seagrass restoration is an important measure to ensure sustainability of the numerous ecosystem services, the benefits they provide and also in maintaining a healthy ecosystem. In addition to the findings, there is a need to conduct restoration as a process instead of a project or program, as mentioned by Shumway et al (2021), by incorporating it in all levels of institutions such as private, public, civil societies and training institutions. The role of BCE benefits not only the people directly working in the ocean, but the whole population at large, and thus, conservation and protection of marine resources should be everyone's concern. Ultimately, the process should uphold inclusivity to include many stakeholders instead of focusing on particular groups such as the youths, students who can volunteer and learn from an early age, on the importance of marine ecosystems and conservation.

However, with all the solutions from the findings in this study, the challenges to seagrass restoration remain elusive. Emerging coastal developments and the impact of climate change continue to add to the already existing challenges. Above all, from the study it was realized that seagrass restoration is a suitable management tool to reduce degradation but is among the costly habitats to restore and the success of such programs are difficult to predict (Rezek et al., 2019). Therefore, there is still need for further research on long term performance and success of seagrass restoration projects where all the perceived disturbances and challenges have been addressed, especially in the wake of climate change as a major threat to humans and the planet (Shivanna, 2022).

5.1 RECOMMENDATIONS

Restoration and conservation of seagrass across the world should be prioritized to lessen the increasing impacts of climate change and to sustain their critical role in providing livelihoods to coastal communities like Wasini and Vanga (Herrera et al.,

2022, Chitara-Nhandimo et al.,2022). Therefore, numerous strategies need to employed to safeguard livelihoods, promote conservation and protection of seagrass. From the research findings, the study recommended on increased stakeholder collaboration (community, academia, government, NGOs, private sector, interested parties) in pooling resources, funds, ideas and tools required to carry out seagrass restoration and conservation programs. Funds are crucial in carrying out restoration activities, thus, the government ought to allocate funds from the national budget and at the county level to assist communities with seagrass restoration programs, reducing the heavy reliance on donor, which is not sustainable.

The study also recommends stakeholder involvement and participation of restoration programs from the onset to overcome stakeholder resistance especially from the coastal communities because they are the main resource users and highly dependent on the ocean for their livelihoods. Resistance may negatively impact on the continuation of the restoration projects.

Capacity building ought to be continuous to empower stakeholders with skills improvement, sharpen technical oversight and enhance monitoring of seagrass restoration which is critical to ensure proper management and long-term success of seagrass restoration programs (Uku et al.,2021).

Another recommendation from the study is the establishment of a robust legal framework that directly includes seagrass management as opposed to the general provisions from numerous Acts of parliament, from different government agencies for clarity and ownership of the mandate on seagrass conservation. In addition, the government needs to appoint a lead agency to spearhead restoration and all matters of seagrass management. Similarly, strengthening the enforcement capacity of existing structures (BMUs, Coastguard service, Fisheries management) towards seagrass management including ban on destructive fishing practises that destroy seagrass, will assist in managing the seagrass ecosystem. Promotion of sustainable fishing practises and provision of alternative fishing gear was also encouraged to enable the poor coastal communities to continue with their fishing activities without affecting livelihoods. Also recommended was the provision of supplementary (carbon offset scheme) or

alternative source of livelihoods such as aquaculture as well as designating temporary closures will ensure that seagrass is conserved and at the same time, the communities maintain their daily sustenance.

Lastly, the study recommended the evaluation of past and current seagrass restoration programs in Kenya and around the world as a baseline to build on when selecting the most favourable approach to seagrass restoration. Globally, seagrass restoration is still a maturing field in BCEs conservation, therefore, improved techniques and strategies continue to be developed to enhance the success of future programs (Tan et al.,2020). The use of cost-effective restoration programs such as NBS, ecosystem resilience, adaptive management approaches are encouraged in this study to reduce costs due to scarcity of funds and high costs of restoration programs. This will ensure project longevity, sustainability and effectiveness. These techniques and approaches will assist decision makers make informed decisions on the most suitable seagrass restoration programs for Kenya.

REFERENCES

Abani, M. M. (2017). Assessment of community driven-ecotourism on marine resource conservation: The case of Kuruwitu and Wasini (Doctoral dissertation, Pwani Unviersity).

Abelson, A., Reed, D. C., Edgar, G. J., Smith, C. S., Kendrick, G. A., Orth, R. J., & Nelson, P. (2020). Challenges for restoration of coastal marine ecosystems in the Anthropocene. *Frontiers in Marine Science*, *7*, 544105.

Aboud, S. A., & Kannah, J. F. (2017). Abundance, distribution and diversity of seagrass species in lagoonal reefs on the Kenyan coast. *American Academic Scientific Research Journal for Engineering, Technology, and Sciences*, *37*(1), 52-67.

Amone-Mabuto, M., Mubai, M., Bandeira, S., Shalli, M. S., Adams, J. B., Lugendo, B. R., & Hollander, J. (2023). Coastal community's perceptions on the role of seagrass ecosystems for coastal protection and implications for management. *Ocean & Coastal Management*, *244*, 106811.

Arnell, N. W., & Reynard, N. S. (1996). The effects of climate change due to global warming on river flows in Great Britain. *Journal of hydrology*, *183*(3-4), 397-424.

Boyd, C. E., McNevin, A. A., & Davis, R. P. (2022). The contribution of fisheries and aquaculture to the global protein supply. *Food security*, *14*(3), 805-827.

Brears, R. C. (2022). Voluntary Carbon Offsets Financing Nature-Based Solutions. In *Financing Nature-Based Solutions: Exploring Public, Private, and Blended Finance Models and Case Studies* (pp. 213-239). Cham: Springer International Publishing.

Broekhoff, D., Gillenwater, M., Colbert-Sangree, T., & Cage, P. (2019). Securing climate benefit: a guide to using carbon offsets. *Stockholm Environment Institute & Greenhouse Gas Management Institute*, *60*.

Buelow, C. A., Connolly, R. M., Turschwell, M. P., Adame, M. F., Ahmadia, G. N., Andradi-Brown, D. A., & Brown, C. J. (2022). Ambitious global targets for mangrove and seagrass recovery. *Current Biology*, *32*(7), 1641-1649.

Chitará-Nhandimo, S., Chissico, A., Mubai, M. E., Cabral, A. D. S., Guissamulo, A., & Bandeira, S. (2022). Seagrass Invertebrate Fisheries, Their Value Chains and the Role of LMMAs in Sustainability of the Coastal Communities—Case of Southern Mozambique. *Diversity*, *14*(3), 170.

Clarke, B., Otto, F., Stuart-Smith, R., & Harrington, L. (2022). Extreme weather impacts of climate change: an attribution perspective. *Environmental Research: Climate*, *1*(1), 012001.

Coleman, F. C., & Williams, S. L. (2002). Overexploiting marine ecosystem engineers: potential consequences for biodiversity. *Trends in Ecology & Evolution*, *17*(1), 40-44.

Cullen-Unsworth, L. C., & Unsworth, R. K. (2016). Strategies to enhance the resilience of the world's seagrass meadows. *Journal of Applied Ecology*, *53*(4), 967-972.

Curran, S., Kumar, A., Lutz, W., & Williams, M. (2002). Interactions between coastal and marine ecosystems and human population systems: perspectives on how consumption mediates this interaction. *Ambio*, *31*(4), 264-268.

Daoji, L., & Daler, D. (2004). Ocean pollution from land-based sources: East China Sea, China. *Ambio*, 107-113.

de la Torre-Castro, M., & Rönnbäck, P. (2004). Links between humans and seagrasses—an example from tropical East Africa. *Ocean & Coastal Management*, *47*(7-8), 361-387.

Dencer-Brown, A. M., Shilland, R., Friess, D., Herr, D., Benson, L., Berry, N. J., & Huxham, M. (2022). Integrating blue: How do we make nationally determined contributions work for both blue carbon and local coastal communities? *Ambio*, *51*(9), 1978-1993.

do Amaral Camara Lima, Mariana, Thaisa F. Bergamo, Raymond D. Ward, and Chris B. Joyce. "A review of seagrass ecosystem services: providing nature-based solutions for a changing world." *Hydrobiologia* (2023): 1-16.

Dooks, T. C. (2022). Briefing: Blue Carbon-March 2022 Climate Change Committee.

Dunic, J. C., Brown, C. J., Connolly, R. M., Turschwell, M. P., & Côté, I. M. (2021). Long-term declines and recovery of meadow area across the world's seagrass bioregions. *Global Change Biology*, *27*(17), 4096-4109.

Elggren, S. (2019). People's perception of seagrass ecosystems-a Step Zero analysis in establishing marine protection of seagrass around Gotland, Sweden.

Fraschetti, S., McOwen, C., Papa, L., Papadopoulou, N., Bilan, M., Boström, C., & Guarnieri, G. (2021). Where is more important than how in coastal and marine ecosystems restoration. *Frontiers in Marine Science*, *8*, 626843.

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., & Serrano, O. (2012). Seagrass ecosystems as a globally significant carbon stock. *Nature geoscience*, *5*(7), 505-509.

Gattuso, J. P., Magnan, A. K., Bopp, L., Cheung, W. W., Duarte, C. M., Hinkel, J., & Rau, G. H. (2018). Ocean solutions to address climate change and its effects on marine ecosystems. *Frontiers in Marine Science*, 337.

Gillis, L. G., Bouma, T. J., Jones, C. G., Van Katwijk, M. M., Nagelkerken, I., Jeuken, C. J. L., & Ziegler, A. D. (2014). Potential for landscape-scale positive interactions among tropical marine ecosystems. *Marine Ecology Progress Series*, *503*, 289-303.

Gracia, A., Rangel-Buitrago, N., Oakley, J. A., & Williams, A. T. (2018). Use of ecosystems in coastal erosion management. *Ocean & coastal management*, *156*, 277-289.

Government of the Republic of Kenya 2020: Kenya Sixth national report to the Convention on Biological Diversity. Ministry of Environment and Forestry.

Halpern, B. S., Selkoe, K. A., Micheli, F., & Kappel, C. V. (2007). Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. *Conservation biology*, *21*(5), 1301-1315.

Herrera, M., Tubío, A., Pita, P., Vázquez, E., Olabarria, C., Duarte, C. M., & Villasante, S. (2022). Trade-Offs and Synergies Between Seagrass Ecosystems and Fishing Activities: A Global Literature Review. *Frontiers in Marine Science*, *9*, 781713.

Hejnowicz, A. P., Kennedy, H., Rudd, M. A., & Huxham, M. R. (2015). Harnessing the climate mitigation, conservation and poverty alleviation potential of seagrasses: prospects for developing blue carbon initiatives and payment for ecosystem service programmes. *Frontiers in Marine Science*, *2*, 32.

Hilgert, L., Kroh, M., & Richter, D. (2016). The effect of face-to-face interviewing on personality measurement. *Journal of Research in Personality*, *63*, 133-136.

Huxham, M., Kairu, A., Lang'at, J. K., Kivugo, R., Mwafrica, M., Huff, A., & Shilland, R. (2023). Rawls in the mangrove: Perceptions of justice in nature-based solutions projects. *People and Nature*.

Kadfak, A., Bennett, N., & Prugsmatz, R. (2012). *Scoping study on migrant fishers and transboundary fishing in the Bay of Bengal*. BOBLME.

Kandasamy, K., & Alikunhi, N. M. (2011). Tropical coastal ecosystems: rarely explored for their Interaction! *Ecologia*, *1*(1), 1-22.

Kuwae, T., Watanabe, A., Yoshihara, S., Suehiro, F., & Sugimura, Y. (2022). Implementation of blue carbon offset crediting for seagrass meadows, macroalgal beds, and macroalgae farming in Japan. *Marine Policy*, *138*, 104996.

La Manna, G., Donno, Y., Sarà, G., & Ceccherelli, G. (2015). The detrimental consequences for seagrass of ineffective marine park management related to boat anchoring. *Marine Pollution Bulletin*, *90*(1-2), 160-166.

Leighton, K., Kardong-Edgren, S., Schneidereith, T., & Foisy-Doll, C. (2021). Using social media and snowball sampling as an alternative recruitment strategy for research. *Clinical simulation in nursing*, *55*, 37-42.

Lucrezi, S., & Cilliers, C. D. (2023). Willingness to participate in marine volunteering: an international survey. *Journal of Coastal Conservation*, *27*(3), 22.

Ma, P., Ye, G., Peng, X., Liu, J., Qi, J., & Jia, S. (2017). Development of an index system for evaluation of ecological carrying capacity of marine ecosystems. *Ocean & Coastal Management*, *144*, 23-30.

Marion, S. R., & Orth, R. J. (2010). Innovative Techniques for large-scale seagrass restoration using Zostera marina (eelgrass) seeds. *Restoration Ecology*, *18*(4), 514-526.

McAfee, D., Drew, G., & Connell, S. D. (2022). Recentering the role of marine restoration science to bolster community stewardship. *Earth System Governance*, *13*, 100149.

Moberg, F., & Rönnbäck, P. (2003). Ecosystem services of the tropical seascape: interactions, substitutions and restoration. *Ocean & Coastal Management*, *46*(1-2), 27-46.

Mokumo, M. F., Adams, J. B., & von der Heyden, S. (2023). Investigating transplantation as a mechanism for seagrass restoration in South Africa. *Restoration Ecology*, e13941.

Muthiga, N. (2009). Evaluating the effectiveness of management of the Kisite-Mpunguti marine protected area.

Nabe-Nielsen, J., van Beest, F. M., Grimm, V., Sibly, R. M., Teilmann, J., & Thompson, P. M. (2018). Predicting the impacts of anthropogenic disturbances on marine populations. *Conservation Letters*, *11*(5), e12563.

Nelson, D. R., Bledsoe, B. P., Ferreira, S., & Nibbelink, N. P. (2020). Challenges to realizing the potential of nature-based solutions. *Current Opinion in Environmental Sustainability*, *45*, 49-55.

Obegi, B. (2018). Impacts of Blue Carbon Trading in Gazi Bay Mombasa Kenya. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, *43*(1), 13-21.

Ofiara, D. D., & Seneca, J. J. (2006). Biological effects and subsequent economic effects and losses from marine pollution and degradations in marine environments: Implications from the literature. *Marine pollution bulletin*, *52*(8), 844-864.

O'Leary, B. C., Fonseca, C., Cornet, C. C., de Vries, M. B., Degia, A. K., Failler, P., & Roberts, C. M. (2022). Embracing nature-based solutions to promote resilient marine and coastal ecosystems. *Nature-Based Solutions*, 100044.

Omollo, D. J., Wang'ondu, V. W., Githaiga, M. N., Gorman, D., & Kairo, J. G. (2022). The Contribution of Subtidal Seagrass Meadows to the Total Carbon Stocks of Gazi Bay, Kenya. *Diversity*, *14*(8), 646.

Ondiviela, B., Losada, I. J., Lara, J. L., Maza, M., Galván, C., Bouma, T. J., & van Belzen, J. (2014). The role of seagrasses in coastal protection in a changing climate. *Coastal Engineering*, *87*, 158-168.

Opdenakker, R. J. G. (2006). Advantages and disadvantages of four interview techniques in qualitative research. In *Forum Qualitative Sozialforschung= Forum: Qualitative Social Research* (Vol. 7, No. 4, pp. art-11). Institut fur Klinische Sychologie and Gemeindesychologie.

Orth, R. J., Carruthers, T. J., Dennison, W. C., Duarte, C. M., Fourqurean, J. W., Heck, K. L., & Williams, S. L. (2006). A global crisis for seagrass ecosystems. *Bioscience*, *56*(12), 987-996.

Pearse, N. (2019, June). An illustration of deductive analysis in qualitative research. In *18th European conference on research methodology for business and management studies* (p. 264).

Penrod, J., Preston, D. B., Cain, R. E., & Starks, M. T. (2003). A discussion of chain referral as a method of sampling hard-to-reach population. *Journal of Transcultural nursing*, *14*(2), 100-107.

Phair, N. L., Toonen, R. J., Knapp, I. S. S., & von der Heyden, S. (2020). Anthropogenic pressures negatively impact genomic diversity of the vulnerable seagrass Zostera capensis. *Journal of environmental management*, *255*, 109831.

Rifai, H., Quevedo, J. M. D., Lukman, K. M., Sondak, C. F., Risandi, J., Hernawan, U. E., ... & Kohsaka, R. (2023). Potential of seagrass habitat restorations as nature-based solutions: Practical and scientific implications in Indonesia. *Ambio*, *52*(3), 546-555.

Roth, F., & Gustafsson, C. (2021). Policy brief: Healthy coastal ecosystems are crucial to mitigate climate change. *Policy Brief*.

Salinas, C., Duarte, C. M., Lavery, P. S., Masque, P., Arias-Ortiz, A., Leon, J. X., & Serrano, O. (2020). Seagrass losses since mid-20th century fuelled CO_2 emissions from soil carbon stocks. *Global change biology*, *26*(9), 4772-4784.

Shivanna, K. R. (2022). Climate change and its impact on biodiversity and human welfare. *Proceedings of the Indian National Science Academy*, *88*(2), 160-171.

Shumway, N., Bell-James, J., Fitzsimons, J. A., Foster, R., Gillies, C., & Lovelock, C. E. (2021). Policy solutions to facilitate restoration in coastal marine environments. *Marine Policy*, *134*, 104789.

Stankovic, M., Ambo-Rappe, R., Carly, F., Dangan-Galon, F., Fortes, M. D., Hossain, M. S., & Prathep, A. (2021). Quantification of blue carbon in seagrass ecosystems of Southeast Asia and their potential for climate change mitigation. *Science of the Total Environment*, *783*, 146858.

Sunny, A. R. (2017). A review on effect of global climate change on seaweed and seagrass. *communities (Table 1)*, *28*(29), 8.

Todd, P. A., Heery, E. C., Loke, L. H., Thurstan, R. H., Kotze, D. J., & Swan, C. (2019). Towards an urban marine ecology: characterizing the drivers, patterns and processes of marine ecosystems in coastal cities. *Oikos*, *128*(9), 1215-1242.

Tschentscher, T., Chege, N., & Remaury, H. (2023). An Integrated Seascape Approach to Revitalise Ecosystems and Livelihoods in Shimoni-Vanga, Kenya. *Maiko Nishi*, 179.

UNEP (United Nations Environment Programme). (2020). Opportunities and challenges for community-based seagrass conservation.

United Nations (2021) PROJECT SEAGRASS: MAKING WAVES TO SAVE OUR SEAS *United Nations Decade on Ecosystem Restoration 2021-2030* [online] https://implementers.decadeonrestoration.org/implementers/17/project- seagrass-making-waves-to-save-our-seas-wales-uk

Unsworth, R. K., McKenzie, L. J., Collier, C. J., Cullen-Unsworth, L. C., Duarte, C. M., Eklöf, J. S., & Nordlund, L. M. (2019). Global challenges for seagrass conservation. *Ambio, 48*, 801-815.

Wallner-Hahn, S. (2017). *Fishing for sustainability: Towards transformation of seagrass-associated small-scale fisheries* (Doctoral dissertation, Department of Ecology, Environment and Plant Sciences, Stockholm University).

Wegoro, J., Pamba, S., George, R., Shaghude, Y., Hollander, J., & Lugendo, B. (2022). Seagrass restoration in a high-energy environment in the Western Indian Ocean. *Estuarine, Coastal and Shelf Science*, *278*, 108119.

Williams, M., & Moser, T. (2019). The art of coding and thematic exploration in qualitative research. *International Management Review*, *15*(1), 45-55.

Wilson, A. M. W., & Forsyth, C. (2018). Restoring near-shore marine ecosystems to enhance climate security for island ocean states: aligning international processes and local practices. *Marine Policy*, *93*, 284-294.

Wylie, L., Sutton-Grier, A. E., & Moore, A. (2016). Keys to successful blue carbon projects: lessons learned from global case studies. *Marine Policy*, *65*, 76-84.

van Katwijk, M. M., Thorhaug, A., Marbà, N., Orth, R. J., Duarte, C. M., Kendrick, G. A., & Verduin, J. J. (2016). Global analysis of seagrass restoration: the importance of large- scale planting. *Journal of Applied Ecology*, *53*(2), 567-578.

Zeng, Y., Friess, D. A., Sarira, T. V., Siman, K., & Koh, L. P. (2021). Global potential and limits of mangrove blue carbon for climate change mitigation. *Current Biology*, *31*(8), 1737-1743.

Appendices

Appendix A: Semi-Structured Interview Guide

EXAMINING STAKEHOLDER PERCEPTIONS ON SEAGRASS AS A BLUE CARBON: AN ANALYSIS ON THE CHALLENGES & SOLUTIONS TO SEAGRASS RESTORATION IN WASINI & VANGA, KENYA

This is an interview guide for the research that will be conducted as semi-structured interview to participants.

Objectives to explore:

1. Stakeholder perceptions on the importance of seagrass as a blue carbon
2. Challenges to seagrass restoration
3. The possible solutions that Kenya can explore to effectively restore and conserve seagrass.

The interview is purely for academic purposes being part of the requirement for the award of a Master of Science degree in Maritime Affairs at the World Maritime University.

In conducting the research, the guidelines below will apply:

1. Participation in this study is voluntary
2. Interviews will be recorded unless the participant opposes.
3. A participant will have to agree for use of data by signing a consent form.
4. A participant has the freedom to exit the study at any time or withdraw the consent.

5. All information from the participants will be held with strict confidentiality hence no divulging to third parties and all data will be destroyed at the end of the study.

Section A: Demographic Information

1. Which institution do you represent?
2. What group do you represent?
   - Public sector
   - Private sector
   - Local community
   - Maritime expert
   - Academia
   - Non-governmental organization
3. How many years have you been with your organization/association?
4. What is your organization/association key responsibility?

Section B: Interview Questions

Basic Knowledge on Seagrass

Q1. Have you heard about seagrasses?

Q2. Have you heard about blue carbon?

Q3. Do you know the relationship between blue carbon and seagrass?

Q4. What are the potential benefits of seagrass restoration in terms of blue carbon/carbon sequestration?

Q5. What tools and methods are available to measure and monitor the success of seagrass restoration in Wasini and Vanga, Kenya?

Q6. What are the expected outcomes of seagrass restoration in Wasini and Vanga, Kenya?

Challenges to Seagrass Restoration

Q7. What are the potential risks associated with restoring and preserving seagrass habitats in Wasini and Vanga, Kenya?

Q8. What resources are available to support seagrass restoration efforts in Wasini and Vanga, Kenya?

Q9. What are the main challenges to seagrass restoration in Wasini and Vanga, Kenya?

Q10. How is the Wasini & Vanga community empowered to conserve and restore seagrass for the future? Is this approach sustainable?

Q11. Is there any regulation/policy that facilitates processes to enhance seagrass restoration at national or county level?

Solutions to Seagrass Restoration in Wasini

Q12. What strategies can be implemented to ensure a successful restoration and preservation of seagrass habitats in Wasini and Vanga, Kenya?

Q13. How can local communities, private sector and government work together to support seagrass restoration in Wasini and Vanga, Kenya?

Q14. How can blue carbon programs contribute to the success of seagrass restoration in Wasini and Vanga, Kenya?

Q15. Communities lack funds to engage in seagrass restoration. What avenues are available for them to carry out restoration without affecting livelihoods

Q16. How can blue carbon projects increase compliance on conservation in the coastal areas when carrying out restoration work.?

Q17. What role do you believe blue carbon can play for seagrass restoration in Wasini and Vanga, Kenya?

Q18. Is seagrass restoration a driving factor in ensuring more carbon sequestration for Kenyan marine ecosystem in Wasini and Vanga?