Understanding Perceptions of Climate Stressors and Mitigation Measures Employed by Women Seaweed Farmers in South District of Zanzibar, Tanzania

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Abstract

The objective of this study was to understand the perceptions of women seaweed farmers on climate stressors and mitigation measures employed to moderate them. The study was carried out in two villages found along the coast in the south district of Unguja Island (Paje, and Jambiani). The villages were chosen because they have the majority of women who engage in seaweed farming. Surveys were conducted to collect quantitative data whereas Focus group discussion and observation methods were employed to collect qualitative data. A total number of 128 women seaweed farmers were used as the sampling frame in the study. Results revealed that seaweed is widely practiced by the majority (87.5%) of married women with (54.7%) of them who had primary education, and (53.3%) of them aged between 29-38 years old. In the same vein, the majority (58%) were aware of the climate stressors which impede seaweed production. The common climate stressors that were reported were increasing seawater temperature (33%), high wind (27%), and irregular rainfall (20%), disease outbreak (ice-ice) 17%, and salinity (3%). The common mitigation strategies employed were; the adoption of deep water farming (30%), improving farming facilities (22%), engaging in other income-generating activities (16%), increasing the frequency of farming (12%), mobilizing men to engage on seaweed farming (9%), and decreasing farm size (5%). The government and other stakeholders need to invest more in the highlighted mitigation measures for the sake of improving seaweed production. Investing more in research and development of improved innovative interventions such as; adoption of integrated multi-trophic aquaculture (IMTA) system to support the seaweed sector is of utmost importance in the economic development of Zanzibar and other coastal communities in the country and the global.

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1.0 Introduction

Globally the surface temperature has risen unusually by around 1.5 °C, causing changes in the climate system, a phenomenon known as climate change which creates some consequences known as "stressors" such as sea level rise, drought, etc. (FAO, 2021; ECMWF, 2023). Climate stressors have been causing effects in human activities including agriculture which is the mainstay of the economy in developing countries (Largo et al., 2020; Cleyndert et al., 2021; Kalumanga et al., 2023). The Intergovernmental Panel on Climate Change (IPCC) has depicted climate change as a result of stressors including temperature variation which marks changes in climate over time (IPCC, 2018). Climate change stressors are among the most challenging issues confronting mankind today including the production of agricultural products (Kalumanga et al., 2014; Kunzmann et al., 2018; Rusekwa, 2020). Ocean acidification, sea-level rise, and rises in the frequency and severity of extreme events (temperature, droughts, floods, cyclones, heat waves, and wildfires) are examples of climate stressors (Brugere et al., 2019; Hassan et al., 2019). These stressors have caused risk, widespread, and irreversible impacts on both social and economic production activities persuaded by human beings on land and water globally (Adger et al., 2009; IPCC, 2014; FAO, 2020). Climate stressors are currently mentioned to strain the production of seaweeds globally due to climate changes happening in the ocean (Hassan, 2019; Valizadeh, 2020; FAO, 2021).

Seaweed production has been expanding exponentially over the last few decades, and growing international demand for this product, particularly from countries with no traditional consumption or use of seaweeds (Cottier-Cook et al., 2016; Msuya, 2020). Seaweed production has been incorporated into many communities based on coastal resources management projects and fisheries in the world (Mustelin et al., 2020; Ivy et al., 2022). Seaweed is produced throughout the world, as a food resource as well as an export commodity (FAO, 2018; Kalumanga, 2018; Makame et al., 2019). World seaweed production is currently focused in the Far East accounting for 99.8% of global production by quantity and 99.5% by value in 2008 (FAO, 2021). The global seaweed industry is worth more than USD 6 billion per annum of which some 85 percent comprises food products for human consumption. Seaweed-derived extracts of carrageen, agar, and alginates make up almost 40% percent of the world hydrocolloid market in terms of foods the rest come from certain animals, microbes, and land plants (FAO, 2018; Brugere et al., 2020). The production has grown significantly over the last 30 years where a peak in production of 196,570 tons was recorded in 2015, although a 43% reduction in production was observed between 2015 and 2020. Among of the decrease was due to the consequences of climate stressors (Rusekwa et al., 2020).

Africa has significant coastal resources available to increase its seaweed production and capitalize on this growing demand. Climate stressors and low gate prices are just a couple of the challenges faced by the industry (Cottier-Cook et al., 2021). Africa is a continent of great potential for seaweed farming. The continent encompasses a wide array of climatic zones from the cool northern and southern temperate environments to the warm tropical waters near the equator which support the production of seaweeds (Cleyndert, 2021). In terms of global production, the African continent ranks in second place for aquatic plant production producing 112,815 tonnes. Yet this is only a fraction of the 32.2 million tonnes produced by Asia in 2018 (FAO, 2020). Excluding Asia, Africa has significantly outperformed other continents since 2002, particularly with the production of carrageen-producing red algae, such as Kappaphycus spp. and Eucheuma spp. The production of seaweed plants in Africa is currently concentrated in Tanzania (Zanzibar) followed by Madagascar and South Africa in 2018. Other countries, however, including Kenya, Morocco, Mozambique, Namibia, and Senegal, are all still either currently producing or have previously produced seaweeds in the past few years (FAO, 2020).

Tanzania possesses a richness of seaweed species and a diversity of approximately 428 seaweed species of Rhodophyta, Chlorophyta, and Phaeophyceae have been recorded in the country (Msuya, 2020). Two common types of seaweed produced in the country commonly in Zanzibar are (Eucheuma cottonii and Eucheuma spinosum), these are commonly cultivated by women who account for 88 percent of seaweed farmers (Msuya, 2020). Consequently, the sector is important to the economic status of many rural women and generally has had favorable effects on the life of coastal villagers in Zanzibar (Hassan et al., 2019; Lange & Jiddawi, 2009; RGoZ, 2009; Valderrama et al., 2013).

Seaweed farming in Zanzibar is not just an economic activity; it's a lifeline for many people and a determinant of their livelihoods (Hair et al., 2019). The seaweed industry has faced challenges, from fluctuating market prices to the adverse effects of climate change (Ateweberhan et al., 2015; Kalumanga, 2018). Zanzibar produces about 12,594 tonnes of seaweed annually, with exports of close to 14,000 tonnes of seaweed per year (RGoZ, 2023). The higher-valued species (Euchema cottonii) have been suffering from the effects of climate stressors (higher water temperature and variations in salinity (Raikar et al., 2001). Meanwhile, the production of the lower-value species (Euchema spinosum) which now constitutes the bulk of production and exports is bringing little income to farmers (Msuya, 2020). Regardless of its performance climatic stressors observed in Zanzibar are characterized by increased temperature, increased winds, and irregular rainfall these changes have negatively affected coastal seaweed farming yields and quality (Brugère et al., 2019).This paper intended to study the perceptions of women seaweed farmers on climate stressors and investigate the mitigation measures employed by farmers in mitigating the climate stressors.

2.0 Methodology

2.1 Study area

The study was conducted in Zanzibar because it is the third top producer of seaweeds in the global and most top exports in the archipelago. Moreover, 90 percent of seaweed farmers are women (Kalumanga, 2018). Zanzibar is a semi-independent archipelago within the United Republic of Tanzania and its population relies heavily on a vulnerable marine resource base including seaweeds production (Songwe et al., 2017).

2.3 Research Approach

Both qualitative and quantitative approaches were used. Qualitative data were used because it can help to get detailed information as well as provide room to answer research questions as information provided by the participants. Quantitative data helped phenomena that can be expressed in terms of quantity (Kothari, 2004). The study adopted a cross-sectional design which involved data collection at a single point in time. The cross-sectional was implemented by gathering the data through questionnaires, focus group discussions, and in-depth interviews pertaining to climate stressors and seaweed production (Lelissa, 2018).

2.4 Population of the Study

Women dealing with seaweeds farming were selected because they constitute 90 percent of all seaweed farmers in the study area.

2.5 Sampling Design

Both probability and non-probability sampling techniques were employed in the study.

2.5.1 Non-probability sampling

Purposive sampling involved officers from the Ministry of Blue Economy, Fisheries and Local government particularly Shehia and the District.

2.5.2 Probability sampling

A simple random sampling technique was employed to select women dealing with seaweed farming in the study area.

2.6 Sample Size

According to Singh (2007), a sample size is a small population selected for observation and analysis by observing the characteristics of the sample in which one can make certain inferences about the characteristics of the population from which is drawn.

Yamane's (1967) formula was used to draw the sample size.

$$N = \frac{N}{1 + N(e)^2}$$

N = Population of smallholder farmers (185)

n = sample size estimate

e= level of significance (5%)

$$n = \frac{185}{1 + 185(0.05)^2}$$

$$n = \frac{185}{1.45}$$

$$n = 128$$

A total of 128 respondents were sampled from the population.

2.7 Data Collection Methods

Both Primary and secondary data were collected.

2.7.1 Primary Data

Primary data were collected through interviews, focus group discussion, observation and survey method.

2.7.2 Secondary Data

Secondary data were collected through documentary review of both online and hardcopy materials including, papers, journals, books policies including the Zanzibar blue economy policy of 2020.

2.8 Data Analysis

Statistical Package for Social Sciences (SPSS) software version 22 and excel were used in analyzing quantitative data.

3.0 Findings and Discussion

3.1 Demographic Characteristics of Respondents

3.1.1 Age

Age is a fundamental measure of population growth and an important variable in this study since it determines the understanding of the person, and the division of labor. Age helps to predict workforce groups of women dealing with seaweed farming in the study area and shows how most they are active in seaweed farming activities. Based on this fact, the ages of the respondents were categorized into 3 groups ranging between 29-38 years; 39-48 years, and above 60 years. Results as presented in Table 3.1 show that the majority of women 53.1 percent were found at the age of 29-38 years followed by 32.8% percent who ranged from the age of 39-48 years and 14.1 percent who were above 60 years. Findings are also in line with the Tanzania Human Development Report (2017) which reported that the working force age in Tanzania ranges from 18- 50 years.

3.1.2 Education

Respondents were also asked to state their level of education as it defines one's ability to solve problems and handle things including business, farming, and other economic activities. Results as depicted in Table 3.1 show that 54.7 percent of the respondents had primary education followed by 29.7 percent of them who had secondary education while 15.6 percent had informal education. This means that the majority of women engaging on seaweed farming have primary education. Finding implies that respondents have basic education which can enable them to write and read. However, studies by Kalumanga et al., (2023) pointed out that primary education among farmers is not enough to transform the agriculture sector in Tanzania because the sector requires highly advanced technology which can easily be led by educated personnel.

3.1.3 Marital Status

Marital status was used in this study to understand which categories of people were involved in seaweed farming activities. Respondents were asked to identify themselves as whether they were married, widows, or divorced. Results as presented in Table 3.1 show that 87.5 percent of women were married, 4.7 percent were widows, and 7.8 percent were divorced. These findings imply that the majority of women who engage in seaweed farming are married. Similar findings by Msuya (2017) depict that the majority of women who are dealing with seaweed farming are married, thus they bear family responsibilities which require them to engage in seaweed farming for income generation and well-being of their household members.

Table: 3.1 Demographic Characteristics of the Respondents

Variables	Category	Frequency	Percent
Age group	29-38	68	53.1
	39-48	42	32.8
	above 60	18	14.1
Education level	Informal	20	15.6
	Primary	70	54.7
	Secondary	38	29.7
Marital status	Married	112	87.5
	Widow	6	4.7
	Divorced	10	7.8

Source: Field data (2022)

3.2 Farmers Perceptions on the Effects of Climate Stressors on Seaweeds Production

Results, as indicated in Figure 3.1 show that the majority 33 and 27 percent of the respondents agree and strongly agree respectively that climate stressors affect seaweed production in the study area. The findings imply that 60 percent of the respondents understand climate stressors and their effects on seaweed production. Likewise, findings by Masud et al., (2017) and Msuya (2020) show that seaweed farmers are aware of the climate change stressors including high-temperature which cause epiphyte and diseases like ice-ice, which results in die-off seaweeds, poor growth, and decreased production. Findings also justify that respondents are aware of the effects of climate change after attending trainings on the impacts of climate change, and concerns on seaweed production.

Related findings by Cleyndert et al., (2021) reported that women seaweed farmers normally attend different workshops provided by the government and stakeholders on the effects of climate change on human being livelihoods.

During an interview with one respondent a farmer at Jambiani was contrary to the findings after reporting thus:

> *"The determination of seaweed production depends on GOD, everything happens by the will of God although we experience changes every time which stress our crops, particularly seaweed farmers we don't have clear reasons as to why these changes happen regardless of the hitches we get"*.

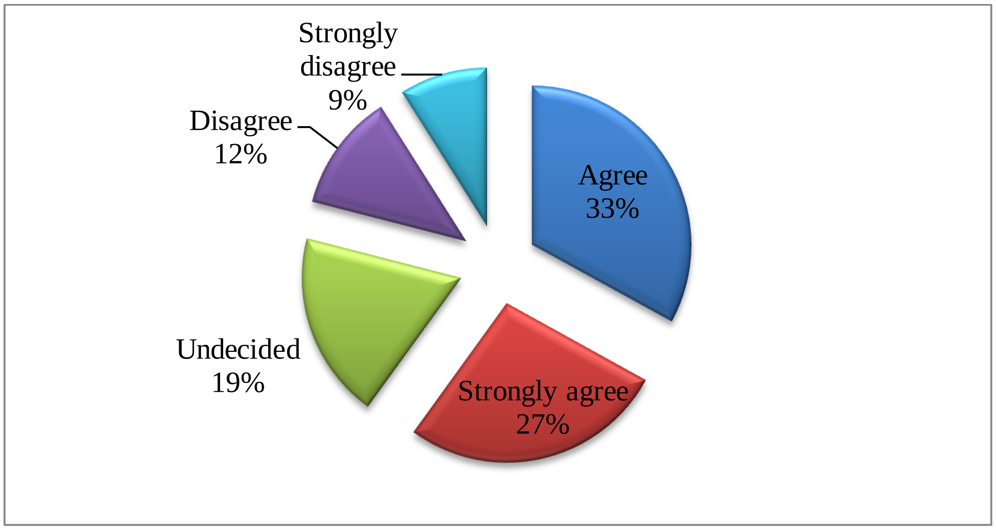
However, results as depicted in Figure 3.1 also show that only 12 and 9 percent of the respondents disagree and strongly disagree respectively that climate stressors affect seaweed production. These findings imply that only 21 percent of the respondents are not aware of the effects of climate stressors which generally affect seaweed production. Findings by Makame (2021) show that seaweed farmers believe that changing variations in climate and oceanic parameters positively impacted the growth, yield, and quality of the seaweeds produced due to the rise of temperature witnessed from December to February. Similarly, Makame (2019) argued that most farmers understand the effects of climate stressors, however, understanding the climate stressors can help them change their farming method and safeguard against probable risks and challenges in the future.

According to the report of the Zanzibar Seaweeds production statistics (2020) indicate that the production of Spinosum Spp in the year 2020 decreased from tonnes 8,668.2/ha compared to 16,665/ha in 2015 while for Cottonii Spp it was 116.4/ha in 2020 and tons 58.2/ha in the year of 2015. This report shows the negative results of climate change as it decreases the amount of spinosum production. According to Ateweberhan et al., (2015) devised that, seaweed growth is affected by salinity, water temperature, Ph, radiation, water oxygen content, sedimentation rate, nutrition, seed size, genetic materials, epiphytes, fish and diseases infection. Thus, there is a need for farmers to understand climate stressors and bay strategies to counteract them. During an interview with one of the key informants at the Ministry of Blue Economy said that.

"Although some seaweed farmers do not observe the effects of climatic stressors directly or they are unaware of why seaweed is not growing well. Many were aware of changes and some of them reported that stressors were having big effects on seaweed farming, including reduction of the yields. The more valuable species e.g. cottonii cannot be farmed anymore especially in shallow, so farmers have to produce the lower valued

one which is spinosum, thus that situation causes farmers to become aware of the bouncing back mechanisms towards mitigating the effects of climate stressors".

Figure 3.1: Perceptions of Seaweed Farmers on Climate Variability



Source: Field data, (2022)

3.3 Stressors of Climate Variability on Seaweeds Farming

3.3.1 Increasing Sea water temperature

Results as shown in Figure 3.2 indicate that 33 percent of the respondents acknowledged that there is an increase in seawater water temperature which affects seaweed production. Results imply that temperature increase is the the main stressor for seaweed farmers. Comparable findings as given by Makame et al., (2019) asserted that seaweeds especially "spinosum spp" are planted in shallow water which gets hotter during dry season and makes seaweed not to survival suitably. Changes of climate have caused weather fluctuations including increase of temperature which harm seaweeds as when it becomes hotter to above 29°C die-off happen. Results are supplemented by the interview with Sheha at Jambiani ward who coined thus:

> *"I have a long history with my shehia farmers, particularly in the issue of seaweed farming, the number of seaweed farmers is decreasing day by day due to challenges of die-off which is caused by high temperature"*

Findings correspond to those reported by Hassan (2019) who noted that changes that occur in ocean including increase of temperature are due to the circulation of air and ocean, volcanic eruption, and other factors that affect any economic activities conducted in water. Furthermore, Msuya et al., (2017), and Largo et al., (2020) contended that increasing seawater surface temperatures (SST), are linked to disease and pest outbreaks. They further added that SST has increased in shallow waters where seaweeds are cultivated from a maximum of 31°C in the 1990s to 38oC between 2014 and 2020. During the hot season (December-February), water temperatures typically range from 33-38ºC in the shallow waters, severely affecting seaweed farms and resulting in a decline in production, even for the more heat-tolerant species, like *spinosum.* Nevertheless, studies by Masud et al., (2017), and Raikar et al., (2001), argued that seaweed production declines as temperature increases. Seaweed farming is susceptible to environmental shocks and stresses. Studies by FAO, (2020) estimated that future temperature projections will increase to 1.5–2 °C by 2050s. Seaweed die-offs will be exacerbated and its sustainability is therefore questionable if adaptation is not achieved. Refer Table 3.2 showing temperature and salinity fluctuations a numerical modeling study which were carried out using the Regional Ocean Modeling System (ROMS) for the Tanzanian coast area. However, the model results indicated the presence of a current on the surface that develops during the Northeast (NE) monsoon.

Table 3.2: Numerical Modeling Results Showing fluctuations in temperature and Salinity

Month	Temperature	Salinity
January	23.4- 30.4°C	35.6-35.9
February	28.2- 30.3°C	35.3-35.6
March	28.9 -32.9°C	35.1-35.3
April	31.7 - 34.2°C	34.9-35.1
May	31.5 -34.0 °C	34.7-35.0
June	30.8 - 33.0°C	34.6- 35.0
July	27.0 - 29.2°C	34.8 -35.1
August	26.9- 28.3 °C	35.0-35.3
September	25.9 - 28.4°C	35.2–35.4
October	26.9 - 28.9°C	35.4 –35.5
November	27.9 - 29.8°C	35.4- 35.5
December	28.5 - 30.0°C	35.6-35.7

Source: Data collected at ZMA (2016).

3.3.2 Increasing Salinity in the Ocean

Results as presented in Figure 3.1 show that 3 percent of the respondents argued that increasing salinity in the ocean affects seaweed production. Increasing salinity in the ocean is the stressor resulting from climate variability which impedes seaweed production. Findings by Msuya (2022) coined that fluctuation in the ocean salinity decreased the growth and the quality of seaweeds. Raikar et al., (2001) reported that salinity in intertidal farming may affect the growth and general production of seaweeds. One of the respondents at Paje village when interviewed said thus:

> *"Six years ago I used to harvest between 300 to 400 kilograms of seaweed every month on my one-acre farm but now after the salinity of the ocean increased, I am only harvesting less than 60 kilograms of seaweed on the same farm".*

Findings by Mustelin et al., (2020) seconded that because seaweed farming is practiced in the ocean there is no doubt that change occurring in the ocean including increasing salinity can have some effects on the production of seaweeds. However, Brugere et al., (2019) reported that oceanic salinity fluctuations may lead to poor yield and production of seaweeds.

3.3.3 Disease outbreak

The finding in Figure 3.2 shows that 17 percent of the respondents mentioned disease outbreaks as one of the stressors resulting from climate variability. The commonly reported seaweed diseases are ice-ice diseases which lead to the death of seaweeds and alter their color.

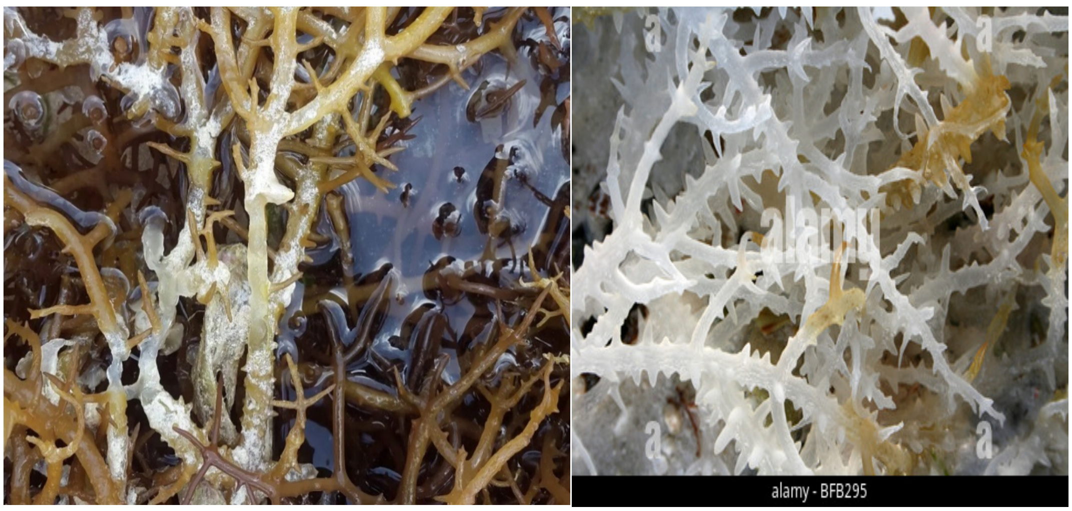
Similar findings by Rusekwa (2020), and Ivy et al., (2022) coined that disease outbreaks such as ice-ice have significant effects on the livelihoods of seaweed farmers; they further added that each year sea weeds farmers from low and middle-income countries around the world are faced by ice-ice diseases which effect production. The findings are also supported by Largo et al., (2020) who propounded that fluctuations in seaweed production are brought by the prevalence of ice disease as well as epiphyte infestation.

One of the respondents during the interview said thus:

> "*The seaweeds which are cultivated change the color and decay due to the presence of ice-ice disease and when this happens we throw them thus our production decreases"*

Findings by Largo et al., (2020) connote that the seaweed aquaculture industry in Zanzibar has been facing as well as the impact of the seaweed die-off due to ice-ice diseases which declined income and revenues for thousands of farmers and traders and, recognizing the compounded problems that about 20,000 seaweed farmers' livelihood are based on a single aquaculture system affecting mostly women and youth. Similarly, studies by Cleyndert et al., (2021) pointed out that the most valuable species of *cottonii* cannot be farmed in many areas in Zanzibar due to poor growth and *die-off* driven by disease such as “ice-ice”, this phenomenon has caused a reduction of several seaweed farmers in Zanzibar.

Plate 1: Ice-ice diseases infecting seaweeds at Paje village in Zanzibar



Source: Field data (2022)

3.3.4 High Wind

Findings as presented in Figure 3.1 show that 27 percent of the respondents reported wind as among the stressors resulting from climate variability. Winds are reported to deplete seaweeds and wash them away due to the changing of the weather, normally the seaweeds get ripped off by the wind thus becoming a big challenge to farmers when they visit their farm they don’t find the plated seaweeds.

As revealed during an interview session at Jambiani village one respondent said thus:

> *“When the wind is high it leads to the increase of the sea waves which plug out our ropes and pegs which support seaweeds in water. This process always endangers our farming as we always get loss of our seaweeds and farms in general thus we find ourselves in poor production of seaweeds as intended”.*

The findings are in line with those of Hamad, (2013), and Msuya (2022) who reported that the problem of high wind causes seaweed to be washed away from the lines, and the result is the loss of seaweed farms. Refers to Plate 2 which shows how wind washed away pegs and ropes that support seaweeds at Jambiani Village. Plate A show seaweeds farm before the damage of wind while plate B shows the features after the occurrence of high wind.

Plate 1: Effects of high winds on seaweed farms at Jambiani village

A B

Source: Field data (2022)

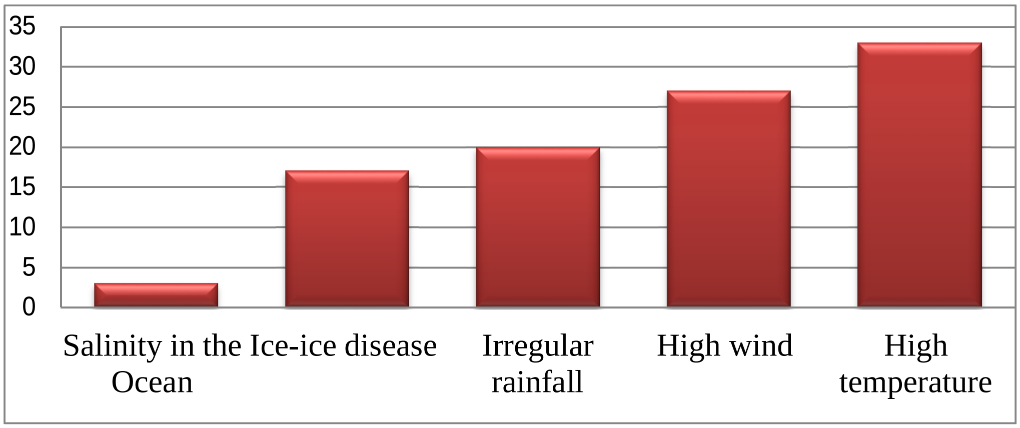
3.3.5 Irregular Rainfall

Results as shown in Figure 3.1 indicate that 20 percent of the respondents argued that the existence of irregular rainfall is a stressor resulting from climate variability which hampers seaweed production. This situation implies that irregular rainfall affects seaweed productivity, especially in its ability to survive, and reduces seaweed quality. Irregular rainfalls have high effects on seaweed production and unexpectedly high rainfall warns/washes away seaweed, it also makes the drying process difficult when drying seaweeds. Similarly, Makame (2021) reported that heavy rainfall affects seaweed both at the farm and during the duration of drying. A related finding by Mohammed (2014) connotes that high rainfalls create difficulties for farmers to dry their seaweed; this causes a decline in the price and quality of seaweed which ultimately results in low prices in the market.

One of the respondents during the interview at Paje village said thus:

"During the season of high rainfall (Masika) we don't get right places for drying seaweeds due to lack of storage facilities, which makes us to delay the harvesting of seaweeds. This condition has instigated a big loss of seaweeds, as most of our produce dies while on the farm during the rainy season, due to a lack of storage facilities.

3.2 Stressors of Climate Variability on Seaweeds Farming



Source: Field Data (2022)

3.4 Mitigation Measures Employed by Women Seaweeds Farmers

3.4.1 Adoption of Deep Water Farming

Results as depicted in Figure 3.2 indicate that 30 percent of farmers practice deep water farming as a mitigation strategy against stressors of climate variability. Results imply that the majority of farmers currently performing deep water seaweed farming as an alternative to cope with the increasing temperature and ice-ice disease at the intertidal zone which affect seaweeds particularly when farming along shallow water. Farmers assumed that seaweed grows better in deeper water, particularly the most valuable species *cottonii* and it was considered the most efficient method to address stressors of climate variability. This type of seaweed *Eucheuma cottonii* has high economic value because it contains compounds used as raw materials for industries. Further studies by Cleyndert et al. (2021), and Amri et al,. (2017) both acknowledged deep water seaweed farming as a strategy to increase production and combat die-offs in seaweeds, thereby increasing profit through engaging farming in floating lines. Nevertheless, Duarte et al., (2017) reported that deep seaweed farming is difficult as it requires an individual to have swimming skills, diving facilities, safety skills, and access to the boat to transport equipment during the planting and harvesting period. Therefore, farmers need training in technology adoption for them to be competent in deep water farming systems. Participants during FGD revealed thus:

"Always, Deep-water farming involves the use of new technology to farm in the deeper and cooler water which supports the growth of seaweeds. It also requires the involvement of men to help us drive a boat and swim to place nets in deep water. Although we are taught some swimming lessons and skills, few of us can manage farming in deeper water. Generally, as farmers, we believe that seaweed grows better in deeper water, particularly the more valuable cottonii species. In comparison with both the off-bottom method, and the deep-water method, deep water is better as it avoids disease and sea-grass infestation"

Plate 3: Women supported by men in using boat for planting and harvesting seaweeds in deep water at Jambiani village

Source: Field data (2022)

3.4.2. Increasing Frequency of Farming

Results as presented in Figure 3.2 show that 12 percent of the respondents farmed more frequently as a strategy to mitigate stressors of climate change. Studies by Makame et al., (2019) asserted that regular farming is reported as a solution for the climate-related stressors face by seaweed farmers, who always fail to produce good yields because of stressors of climate variability. During a focus group discussion at Jambiani village, participants said thus:

> *"We have found ourselves spending more time in the sea because we have to farm every season since we are not sure of which season we will get good results for our production. As we farm frequently we try to be in the probability position to harvest many times"*

3.4.3 Engaging on other Income Generating Activities

Results, as shown in Figure 3.2 illustrate that 16 percent of respondents noted that farmers are now shifting from farming of the seaweeds to other income-generating activities such as petty business, as mitigation measures to stressors of climate variability. This reason for the said shift is due to changes of weather in the ocean particularly the climatic stressors, which make them not to produce the expected amount of seaweed. This strategy is applied by seaweed farmers as an alternative to mitigate the effects of climate variability.

During an interview, the officer at the Ministry responsible for trade affairs said thus:

…."the number of farmers in the south district in 2022 decreased from 2000 to 400 as many seaweed farmers are stopping farming due to loss of their crops resulting from stressors of climatic change which hinders seaweed production"...

Studies by Valizadeh (2020) found that there is a relationship between climatic stressors, the decrease in the production of seaweeds, and the number of seaweed farmers in Zanzibar. Seaweed farmers in Zanzibar are now starting to change to other income generating activities. In the same vein, Ivy et al (2022) observed that the number of seaweed farmers in Unguja Island is declining as some of them are deciding not to continue with farming, meanwhile they started to engage in other income-generating activities including petty trading like selling vegetables and fruits.

3.4.4 Attending Training on the Effects of Climatic Stressors

Results as shown in Figure 3.2 indicates that 6 percent of the respondents reported that attending training on climate change is among the mitigation measures against stressors of climate variability. Findings given by Kalumanga et al., (2014), and Shimba et al., (2021) also confirmed that farmers who attended training on the impacts of climate change have a high chance of mitigating the stressors of climate variability which affect production.

3.4.5 Improving Farming Facilities (Equipment's)

Findings as presented in Figure 3.2 shows that 22 percent of the respondents acknowledged that the use of new technology and modern equipment in seaweed farming is among the potential strategies to mitigate stressors of climate variability. Results imply that improved technologies helped seaweed farmers to improve their farming and increase production. Further findings by Viktoria et al., (2018), and Kalumanga, (2018) observed that the old or traditional seaweed farming technology that is commonly used in Zanzibar includes the usage of peg and rope, which are placed in shallow water. This local facility is always wiped out by winds and farmers loose their produce. Findings by Brugere (2021) urged that improved technology can lead to increased production of higher-valued seaweed like *cottonii spp,* which is produced in deep and cooler water. Technology, such as, modified sea boats are important for farmers to manage planting seaweed in deep water.

During Focus Group Discussion participants reported thus:

..”With the availability of good facilities like boats, we can go with men into deep water and plant seaweeds like cottonii species which are most valuable. This species can grow better in deep and cooler water, thus technology advancement can enable us to mitigate the effects of climate variability stressors including temperature, which is dangerous to seaweeds in shallow water.

Plate 4: Seaweeds facilities used by farmers as a means to mitigate climate variability stressors at Paje

Source: Field data (2022)

3.4.6 Mobilizing Men to Engage on Seaweed Farming

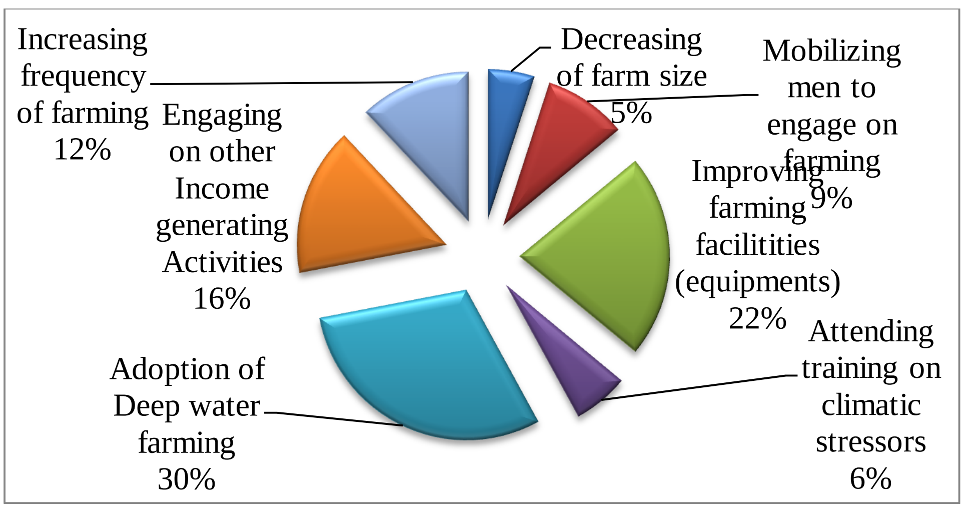
Results, as indicated in Figure 3.2 show that 9 percent of the respondents admitted that engaging men in the farming process can be a strategy to mitigate climate variability stressors. This implies that men have a strong energy, especially in deep water farming which requires swimming experience when planting. Findings were supported by the Local leader at Paje who said thus:

> *"Most of the seaweed farmers are women, who are incapable of farming the higher value species of seaweeds as it requires them to dive into deep water to plant them. Most of the men perceived seaweed farming as women's work because they like to engage in activities that can lead them to get money immediately after finishing the activity.*

3.4.7 Decreasing Farm Size

Findings as presented in Figure 3.2 show that 5 percent of the respondents agreed that decreasing the size of the farm is among the strategies to mitigate stressors of climate variability. This implied that farmers decrease the size of plots to cope with and control the stressors of climate variability. The finding is also supported by Kunzmann et al., (2018) who found that seaweed farming in the south district of Zanzibar is commonly practiced on a small scale as a mechanism to cope with climatic stressors including temperature, high winds, and diseases. However, the low-sale price, and seaweed die-offs, linked to climate change stressors and overgrowth of polluting organisms such as epiphytes (Eklöf et al., 2005; Msuya et al., 2007; Msuya, 2011) these have caused many farmers to decrease their farm size or abandon the activity altogether (Eklöf et al., 2012).

Fig. 3.2: Mitigation Measures Employed by Women Seaweeds Farmers



Source: Field data (2022)

Conclusions and Recommendation

Climate change stressors are happening and fettering the production of seaweeds. Seaweed farmers in the Zanzibar archipelago are in endangerment because they are always struggling to mitigate the impacts of climate change stressors with little success. In contrast, others do not recognize the sources of their predicament. The mitigations of the climate change stressors need to be improved as the climate change stressors will keep increasing and more impacts will manifest. Climate change stressors are always jeopardizing the future economic activities of women in the archipelago by decreasing seaweed production. However, it is recommended that: i). The government has to invest in education for the upcoming farmers because the majority of farmers currently have a primary education level, which does not enable them to understand climate change stressors and its impacts on seaweed production. ii) Men have to be mobilized to join seaweed farming to increase production, because men can manage to control technology facilities that are used in deep water farming systems. iii) The government and other stakeholders have to continue investing in advanced technology that can provide positive results for farmers to mitigate climate change stressors including introduction of climate smart innovations such as, improved integrated multi-trophic aquaculture (IMTA) technology. Also community based aquaculture systems can improve the adaption and mitigation measures of climate change on seaweeds production. iv) Institution support is required, particularly those institutions focusing on research and development to help farmers understand both environmental and socio-economic related challenges. v) Participatory approaches based on absorptive, adaptive, and transformative resilience mechanisms to climate change have to be well studied to improve the whole systems of seaweed production.

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