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Awareness and Perceived Indicators of Climate Change among Seaweed Farmers in Jambiani Village, Unguja Island

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Abstract – Climate change remains to be the biggest challenge threatening to undo sustainability of socio-economic activities. The study investigated seaweed farmers' awareness and their perceived indicators of climate change in Jambiani village, Unguja Island. A cross sectional study was adopted to interview 100 seaweed farmers between September and November, 2016. A mixed approach was used, of which primary data collection tools includes Questionnaires with close and open-ended questions and Focus Group Discussion, and secondary climate data was integrated. The results indicated that, majority (93%) seaweed farmers were aware of the changes in climate, and 97.75% perceived elevation of seawater temperature, 71.76% perceived an increase in intensity of ocean waves and 93.37% south- easterly (Kusi) monsoon wind, 84.58% longer periods of north-easterly (Kaskazi) monsoon winds and 78 % perceived changes in distribution and disappearance of near shoreline fringing reefs as climate change indicators. Analysis of empirical secondary data from TMA showed elevation of terrestrial and seawater temperature by 1.22°C (y=0.03x+30.281) and 0.62°C (y=0.0219x+27.256) respectively as well as big ocean wave heights navigating between months of June and September of the year. Seaweed farmers are aware of the changes in weather and climate and capable to correctly identify and associates different environment-related uncertainties to climate changes, but lack expertise in proper use and integration of various climate instability situations into suitable and appropriate farming practices for improved production. Thus, the study recommends introduction of insurance schemes to the industry as resilience mechanisms to climate related changes in seaweed industry and extension services through extension officers meant to offer technical education and services to seaweed farmers on the best adjustment ways to on-going environmental and weather changes that meant to safeguard seaweed industry.

Keywords – Climate Change, Jambiani Village, Seaweed Farming, Unguja Island.

I. Introduction

Climate change remains to be the biggest challenge threatening to undo sustainability of socio-economic activities. Climate change manifests as the most dominant environmental threat to different marine-based livelihood sources most importantly seaweed farming (Msuya, 2006, 2011). It accounts for variation in the mean state of climate parameters (namely temperature, rainfall, relative humidity and wind speed) persevering for more than 30 years (IPCC TAR, 2001). Increased concentration of greenhouse gases in the lower atmosphere since the industrial revolution is the major root-cause to climate change (IPCC, 2007c). Climate change has resulted to persistent increase in global temperature, sea level rise, increased ocean salinity, melting of ice, increased storm surges and altered precipitation patterns (IPCC, 2007a). Climate change is a major global concern, and is attributed with the collapse of 3 meters wall that meant to protect Pangani Township (URT, 2008), submergence of Maziwe Island in Pangani Township (Lyimo *et al.*, 2013) and reported high cases of coastal erosion (ICMZ, 2009).

Africa is reported as one of the most highly vulnerable continent to extreme weather events and changing weather patterns, partly due to its higher reliance on climate sensitive natural resources (Boko *et al*., 2007; Brown *et al*., 2007 and IPCC, 2007b). It is estimated that, approximately 30 million people live in the coastal region of the western part of the Indian Ocean, with eight million in Tanzania coastal regions (Obura *et al*. 2000) including major islands of Zanzibar and Mafia. Zanzibar's economic base depends on coastal and marine ecosystems distributed along and within the Indian Ocean, that offer enormous number of livelihood opportunities, as well as social and economic benefits through ecosystem services (Mustelin *et al*., 2009). Coastal resources based socio-economic activities of fishing, crop farming, seaweed farming and tourism provide over 30% of Zanzibar's Growth Domestic Product (GDP) (Mustelin *et al*., 2009, 2010). Three percent of Zanzibar's population participate in seaweed cultivation whose product contributes 20% to Zanzibar's export earnings due to annual exportation of more than 30,000 tonnes of dried seaweed (Msuya, 2012).

Commercial seaweed farming in Tanzania commenced officially in Jambiani village, Unguja Island in 1989 through cultivation of imported species of seaweed *Kappaphycus alvarezii* from Philippines (Msuya, 2006; Erika, 2011). Currently three species of seaweed are farmed in Zanzibar and mainland Tanzania namely *Eucheuma denticulatum*, *Kappaphycus alvarezii* and *K. striatum* (Msuya, 2013). Of these species, *Kappaphycus alvarezii* is most fragile to environmental and weather changes in island of Unguja (Msuya, 2012; Makame 2013; Msuya *et al*., 2014). Due to that, Jambiani village has experienced tremendous downfall of seaweed production especially *Kappaphycus alvarezii* species, which fetch higher price in the world market Erica, (2011), explained by production decrease of same species in Tanzania from 1050 tonnes in 2001 to 15 tonnes in 2010 (Msuya *et al*., 2014). Such downfall in seaweed production has been associated with elevated seawater temperature that induce seaweed disease as well as strong ocean waves that cut and wash away seaweeds resulting to loose of approximately 1000 kg of seaweed (dry weight) per single harvest per farmer (ICMZ, 2009; Makame, 2013).

Despite various coping and adaptation strategies adopted by seaweed farmers against environmental and climate related changes, the situation remains the same (Makame, 2013). Due to that, seaweed farmers in Jambiani village have diversified their livelihood options outside seaweed industry to small business, irrigation based vegetable gardens and livestock keeping like keeping poultry, dairy cattle and goats (Makame, 2013). However, proper use of adaptation strategies against impacts of climate change depends on people's knowledge and awareness on the subject matter as well as ability to correctly identify perceived changes in weather and climate (Eriksen et al., 2011; Makame, 2013). But, study on seaweed farmers' awareness and their perceived indicators of climate change attributable to observed production decline in Jambiani village Erika, (2011) is very limited. The present study therefore aimed to assess seaweed farmers' awareness and their perceived indictors of climate change in Jambiani village in order to inform on-going and best new alternative coping and adaptation measures for improved production.

II. Materials And Methods

A. *Geographical location and weather of the Study Area.*

The present study was conducted in Jambiani village Unguja island Zanzibar. Jambiani is the small village located in South region, East coast of Unguja Island, Zanzaibar-Tanzania (Figure 1). The village has an extended shore of approximately 7-10 km along the shoreline Erika, (2011) covering S06°19.263' E039°32.936'. Tropical climate characterized by bimodal rainfall; dominates the area, receiving 1300 and 1700 mm of rainfall per year. The long rains fall between March and May estimated to range between 900 mm and 1200 mm, and short rains fall between October and December, estimated to 400 mm and 500 mm while the dry season dominates between June to September. The mean annual maximum and minimum temperature is 29^0C and 21^0C respectively, characterized by fairly constant average temperatures across the year (MANRLF, 2016).

Figure 1: A map of Unguja Island showing location of study area.
Source: Cartographic Unit, University of Dar es Salaam, 2016.

B. Research design and Approach

A cross sectional research design was used in this study in which data from seaweed farmers were collected only once in study area for three months September to November, 2016 (Kothari, 2004).

C. Sampling procedures

Purposive sampling was employed to identify and select Jambiani village as the study area. Random and purposive sampling techniques were used to determine appropriate sample. The village register was employed to select respondents intended for questionnaires while seaweed farmers who aged more than 30 years were selected to form groups for FGD with help of local leaders.

D. Sample Size and sampling frame

Both random and non-random sampling techniques were employed to determine the sample. Simple random sampling was employed to randomly pick 100 seaweed farmers using the latest village register. Purposive sampling was used to form two plenary groups of discussion comprised of seven and five women leaders of seaweed farmer groups respectively. According to Saunders *et al*. (2007) this sample size was considered enough, because a sample size of 30 or more will usually result into a sampling distribution that is very close to normal distribution, and the larger the absolute size of a sample, the closer its distribution will be to normal distribution.

E. Data collection techniques

A mixed approach including quantitative and qualitative methods was used in data collection (Bryman, 2008). Quantitative data were collected through questionnaires that comprised of both closed and open ended questions; and qualitative data collected through Focus group discussions (FGD) (Bitsch, 1998). Climate data for the past three decades (1986-2015) were obtained from Tanzania Meteorological Agency (TMA), seawater temperature data for Zanzibar Island for the past 15 years (2001-2015) was obtained from Institute of Marine Science (IMS).

F. Data analysis

Content analysis was employed to analyse qualitative data from open-ended questions and FGDs dialogue (Stemler, 2001). Quantitative data analysis was done using Statistical Package for Social Sciences (SPSS) version 20 and Microsoft excel software version 2013 to generate both descriptive and inferential analysis.

III. Results And Discussion

A. Demographic characteristics of respondents

Age of respondents varied from 15 years to over 60 years. Age group of 31-45 years was dominant in the area with 51% (Table 1). Majority of seaweed farmers in the area were married 63 % and had no formal education 89% (Table 1). Despite rigorous family responsibilities married women are still actively involved in seaweed farming. This contradicts what is known in Islamic culture which dominates Zanzibar Island, that women are restricted to engage themselves in socio-economic activities (Msuya, 2013a). However, this is a great revolution and a good sign of breaking cultural norms which contribute to women marginalization, poverty and homeless street children. Given that, seaweed farming has enabled women to pay for school fees for their children, buy nice clothes and access to health services Msuya, (2010) since, seaweed farming improves economic status of the members of coastal communities especially women (Msuya, 2006: Eklof *et al*., 2012: Hurtado, 2013: Kronen, 2013).

Majority of surveyed seaweed famers were born in the study village 94% and have lived in the area for at least more than two decades (Table 1). Most of the famers being natives of the village with 25 years experiences of seaweed farming practices in the area provide confidence that, all the environmental and climate changes events occurred in the village within the past 15-20 years ago were witnessed by the farmers as suggested by the dominant age group and more than 20 years of stay in the study village.

Table 1: Demographic characteristics of seaweed farmers in the study area (n=100)

Socio-economic attributes	Response category	Response (%)
Age groups	Between 15-30 years old	22
	Between 31-45 years old	51
	Between 46-60 years old	20
	Above 60 years old	7
Education level	No formal education	89
	Primary education	10
	Secondary education	1
	College education	0
	University education	0
Marital status	Unmarried/Single	27
	Married	63
	Separated	1
	Divorced	2
	Widow	7
Place of birth	Born in Jambiani	94
	Born outside Jambiani	6
Duration lived in Jambiani	Between 1-20 years	44
	Between 21-40 years	38
	Between 41-60 years	12
	More than 60 years	6

B. Seaweed farmers' perceptions on Indicators of Climate Change

The present study intended to understand perception of seaweed farmers on climate change so as to obtain an insight on how they relate the concept in relation to their livelihood activity. Farmers agreed, unprecedented changes in weather and climate occurred within the area through random changes in seawater temperature (89%), different dynamics of ocean wind and waves (85%), changes in blow of (***Kusi***) south-easterly monsoon wind (91%) and (***Kaskazi***) North-easterly monsoon wind (87%) as well as changes in abundance of near shoreline fringing reefs (78%) (Table 2).

Table 2: Percentage response of seaweed farmers on the concept of climate change and climate variables.

Variable	**Percentage response**					
Awareness on climate change	Yes	93				
	No	7				
		Seawater temperature	**Ocean waves**	**Kusi**	**Kaskazi**	**Loss of fringing reefs**
Changes in stated climate variables	Yes	89	85	91	87	78
	No	11	15	09	13	22
Pattern of changes in stated climate variables	Increasing	97.75	71.76	93.37	84.58	NA
	Decreasing	2.25	18.82	6.63	15.42	NA
Onset of the changes in stated climate variables	Past 1-10 years	60	59	64	78	81
	Past 10-30 years	34	36	25	16	19
	More than 30 years	6	5	11	08	00

Our findings indicated that, local seaweed farmers perceived an increase in intensity of ocean waves (71.76%), increase in intensity of South- easterly monsoon wind (*Kusi)* (93.37%), prolonged duration for persistency of North-easterly monsoon winds *(Kaskazi)* (84.58%), disappearance of near shoreline fringing reefs (78%) as well as elevation of seawater temperature (97.75%) as indicators of climate change in the study area (Table 2).. However, majority agreed that, they have noticed the on-set of all these changes during the past 1-10 years. With the exception of increased ocean waves and seawater temperature the rest of the indicators are documented for the first time by this study as the indicator of climate change among seaweed farmers in Jambiani village. The aspect of stronger ocean waves was also reported by Makame (2013) who conducted his study among fishermen and seaweed farmers of Kiuyu Mbuyuni and Matemwe villages, Unguja Island.

To complement the argument raised, a particular seaweed farmer testified that
"*…….we are now experiencing long duration of persistent north-easterly monsoon winds starting late November and ending up in March, contrary to what existed many years ago i.e from December to February.*"

Our findings shows that, seaweed farmers are conversant with climate change and are aware of the environmental changes that have been occurring, despite high level of illiteracy (89%) in the area (Table 1). This is possibly due to their long duration of stay in the area mostly over 20 years (Table 1) that enables familiarization with their working environmental conditions. Moreover, higher percentage of respondents while referring to higher seawater temperature and stronger ocean waves suggests that, the intensity of climate change has become stronger and noticeable during the past 10 years. Such that, it is within this period that small changes in climatic parameters have been continually occurring diverging from the usual pattern most notably, seawater temperature and ocean wave intensity. Ask (2006) reported that, higher *Cottonii* and *Spinosum* die-off are expected in environmental condition where monsoon winds have changed. This coincides with the previously reported changes in the blow of monsoon winds in the study village.

(a) Seawater and terrestrial temperatures trends in Unguja Island, Zanzibar

To confirm seaweed famers' perception on the climate change and variability in the study area, analysis of 15 years seawater temperature and terrestrial temperature data for the past 30 years was made. Figure 2 and 3 shows annual trend in seawater temperature and terrestrial temperature for 15 years (2001-2015) and 30 years (1986-2015) respectively.

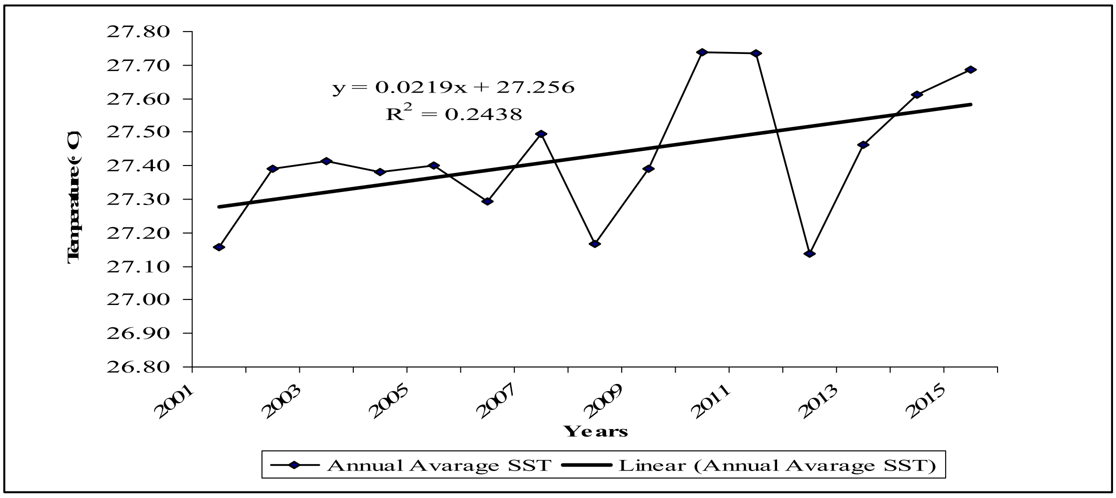

Figure 2: Average annual Seawater Temperature for Western Indian Ocean from 2001-2015.

Source: Institute of Marine Sciences (IMS), Zanzibar, 2016.

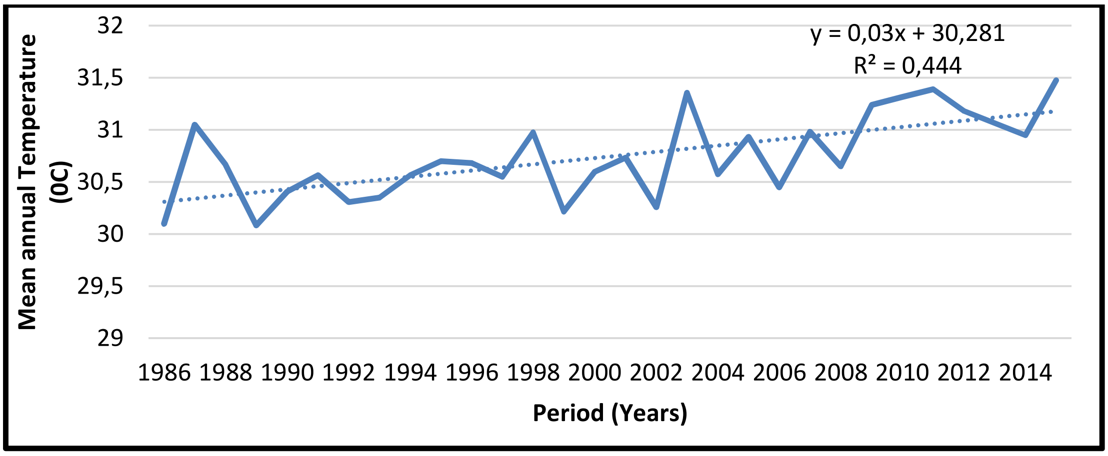

Figure 3: Changes in maximum terrestrial temperature for Unguja station (1986-2015)

Source: Tanzania Meteorological Agency, 2017

Unguja Island measured 27.75^0 C and 27.13° C maximum and minimum surface seawater temperature respectively, during the past 15 years, which is overall gradual increase in surface seawater temperature by 0.62 ^{0}C. Moreover, study revealed consistent increase in terrestrial temperature (Figure 3), from 30.1°C to 30.25° C for 16 years (1986-2002). Further increase by 1.22° C was observed for the period of 13 years from 30.25° C in 2002 to 31.47° C in 2015, with the future trend projected to increase further. This implies that, warm ocean water impedes growth and thus affects production of seaweed. Study revealed that, during the past 12 years (since 2002) when onset of seawater and terrestrial temperature elevations in Zanzibar were observed, the drop in seaweed production in Zanzibar also started. This is contrary to suggested optimum surface seawater temperature for cultivation of seaweed being 25 °C to 27 °C (Erika, 2011). This implies that, the year 2002 is marked as the year when sharp drop in seaweed production level in Zanzibar was noticed. This is further supported by increased terrestrial temperature (Figure 3). It important to be noted that during midday spring low tide, temperature in tidal pools and seaweed farms located in intertidal shallow waters experience higher temperature up to 37 °C depending on the season (month) of the year and conditions of the cloud cover (Buriyo, Personal communication).

(b) Ocean wave intensity trends in Unguja Island, Zanzibar

Meteorological data that meant to confirm seaweed farmers understanding and perception on ocean waves in the study area was examined. However, ocean waves height data for the past 30 years are unavailable, thus data for only five years (2011-2015) were secured. Figue 4 shows average monthly ocean wave height for Unguja Island station for 5 years from 2011 to 2015. Finding showed that, Unguja Island experiences big wave height from June to September, which becomes smaller from February to April. This suggests that, off-bottom seaweed farming during cooler period of May to August would be suitable for seaweed production. However, stronger ocean waves as well as stronger South-easterly monsoon pose a challenge to most coping and adaptation strategies during that period. Therefore, the influence of environment related challenges should be taken into consideration during seaweed farm set-up and maintenance through farm set-up in deep water where impacts of ocean wave are minimal and through routine farm inspections.

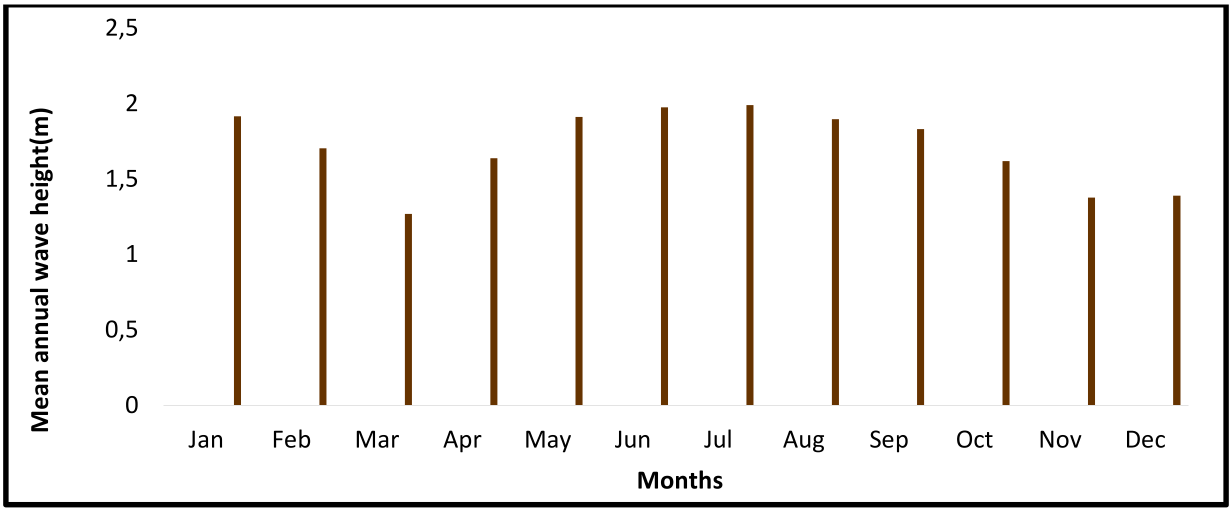

Figure 4: Changes in average monthly wave height for Unguja Island for the past 5 years (2011-2015).

Source: Tanzania Meteorological Agency, 2016.

C. Distribution of respondents on monthly changes in seawater temperature and ocean waves.

Assessment for hot and cold months as well as months with stronger and weaker ocean waves was performed and results are presented in Table 3. Meteorological data that meant to confirm seaweed farmers understanding and perception on terrestrial temperature (Figure 4) that has known influence on seaweed growth Msuya, (2012) was examined against farmers' response on subject matter under study.

Study findings indicated that, hotter period in term of surface seawater temperature is from December to February, while cooler period is from May to August (Table 3). This implies that, the period for elevated seawater temperature corresponds with the period for hot season (*Kiangazi)* and North-easterly monsoon seasons (Erika, 2011: Makame, 2013). This suggests that, period with elevated terrestrial temperature corresponds with higher seawater temperature while low terrestrial temperature corresponds with lower seawater temperature. This observation is further confirmed by the meteorological data presented in Figure 4 that, the area experiences higher terrestrial temperature from December to March. During this period, the area experiences extreme higher seawater temperature and prevailing of weaker North-easterly monsoon. The same trend in seasonal pattern is also reported by McClanahan (1988). Furthermore, lower terrestrial temperature is experienced from May to August when seawater temperature is also lower. However this period is associated with strong South-easterly monsoon wind (Figure 4 and Table 3).

While referring to ocean waves, the area experiences stronger ocean waves between June and September and becomes weaker between January through April (Table 3). This means, stronger ocean waves occurs during cool

(*Masika)* season when the area experiences lower terrestrial and seawater temperatures with domination of South-easterly monsoon winds. Meanwhile weaker ocean waves occur during hot (*Kiangazi)* season when seawater and terrestrial temperature are high with domination of North-easterly monsoon wind. The same seasonal pattern coincides with that reported by McClanahan (1988).

Table 3: Number of seaweed farmers responded on monthly changes in seawater temperature and ocean waves

Climate variables		Month											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Temp.	**H**	29	23	06	0	0	0	05	03	05	04	15	28
	L	0	0	0	09	18	11	17	14	07	01	0	0
Ocean wave	**S**	0	0	03	01	08	27	13	25	20	01	02	0
	W	11	28	19	12	06	0	0	0	01	0	0	0

Note: These are multiple responses from 100 seaweed farmers.
H High **L** Low **S** Strong **W** Weak

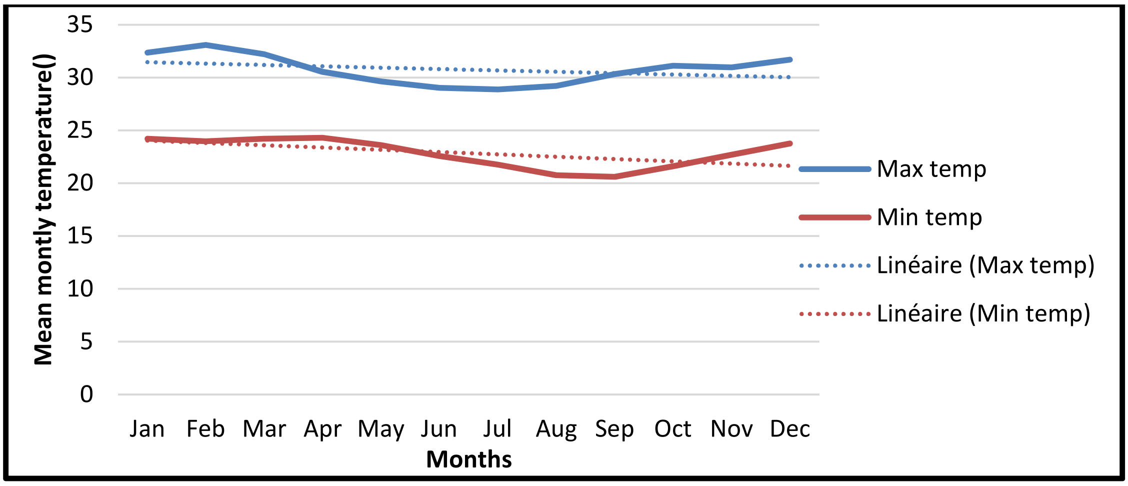

Figure 5: Changes in average monthly terrestrial temperature for Unguja Island for the past 30 years (1986-2015).

Source: Tanzania Meteorological Agency, 2016.

D. Impacts of elevated seawater temperature and increased strength of ocean waves on seaweeds and seaweed farming practices

The influence of seawater temperature and ocean waves on seaweed cultivation practices during farm set-up and maintenance were analysed and results are tabulated in Table 4.

Table 4: Percentage distribution of respondents on the impacts of elevated seawater temperature and strong ocean waves on seaweed farming

Variable	Response (%)	
Does elevated seawater temperature affect seaweed	Yes	84
	No	16
Does stronger ocean wave affect seaweed	Yes	73
	No	27
Common seaweed species farmed	Spinosum	95
	Cottonii	5

Water depth for seaweed cultivation	Shallow water	100
	Deep water	0
Seaweed farming technique	Off-bottom technique	98
	Floating line technique	2

Our findings indicates that, 84 % and 73 % of respondents acknowledged the impacts of elevated seawater temperature and increased intensity of ocean waves on seaweed cultivation respectively (Table 4). Higher percentage of respondents in this case, means that, seaweed farmers are not only aware of the concept of climate change and its indicators but also, capable to link observed changes in weather and climate with the field performance of seaweeds since, 95% of seaweed farmers prefer to cultivate *Spinosum species.* This support the facts that, it is through pronounced environmental instabilities (Table 3) that seaweed farmers prefer to cultivate fairly environmental tolerant (Erika, 2011) and higher weight per unit size *Spinosum* species in the study area (Erika, 2011). Failure of *Cottonii* species to grow due to environmental factors paved the room for more *Spinosum* cultivation (Erika, 2011; Msuya, 2011).

Moreover, All (100%) interviewed seaweed farmers locate their seaweed plot in shallow intertidal water, among which 98% practice off-bottom farming technique (Table 4). In this case, both farms location and farming technique expose seaweeds to the negative effects of higher temperature especially during hot season. This is attributed to low investment cost (Msuya, 2012) which limit farmer's capacity to hire boat to set their farms in deep and cooler water, and the fact that most farmers are female who cannot work in deep water. Although the intertidal water is easily accessible but is extremely exposed to increased seawater temperature and powerful ocean waves.

Nevertheless, our study investigated ability of seaweed farmers to link various observed uncertainties in their daily farming practices to perceived climate change indicators. Seaweed farmers mentioned various impacts of warm seawater and stronger ocean waves on seaweed plants. First and foremost, the problem of epiphytes and other marine algae (locally known as *Ushava*) was suggested to dominate the area and reported to invade and tangle seaweed plants, which in turn create competition for nutrients with seaweeds. This problem has also been reported to occur in Muungoni village (Erika, 2011). Seaweed farmers also reported on the emergencies of newly and rarely occurring algal species in the area that are black in colour, and observed to cause skin irritation to farmers when they came into contact. Elevated seawater temperature was ascribed to bleaching of seaweeds. This was attributed to warm water since, seaweeds were observed to lose their natural colour turned whitish with poor physical quality. Furthermore, seaweeds decomposed massively during hot season when ocean water was warmer, during which seaweeds became soft and slippery hence, susceptible to rope detachment.

Lastly, stunted growth of seaweeds was reported to occur mostly during the period of warm ocean water that resulted to low seaweed yield. This reflects poor performance of seaweed industry in conditions of persistent seawater warming, and calls for researchers, private sector and the government to work together so as to come up with alternative coping and adaptation strategies for seaweed farming communities who will be soon at crossroad due to climate change impacts.

With regards to increased strength of ocean waves, farmers reported mostly the up-rooting of mangrove pegs and the breakage of growing seaweeds from their rope induced by stronger waves. Results from Table 3 and Figure 4 indicate that, there is a coincidence in farmer's response to strong waves with data from TMA.

In general, the study found that most of seaweed farmers are much more aware on the effects of elevated seawater temperature than strong waves on seaweed field performance. This in turn suggests that, the magnitude of elevated seawater temperature impacts on seaweed growth are profoundly intense compared to that of ocean waves.

IV. Conclusion And Recommendations

Analysis of over 15 year's seawater temperature, 30 years terrestrial temperature and wave height data clearly show the trend of climate change in the study area. This is consistent with seaweed farmers' perception and observation on the subject. According to seaweed farmers, climate change and variability are identified by elevation of seawater temperature, increasing strength in ocean waves, increased south- easterly monsoon wind (*Kusi)*, persistence of north-easterly (*Kaskazi*) monsoon winds and disappearance of fringing reefs over the past ten years. Changes in weather condition was reported to be associated with prevalence of seaweed diseases, dominance of destructive algae and epiphytes (locally known as *Ushava*), poor growth rate and quality of produced seaweeds, breakage and detachment of growing seaweed plants from ropes, that explain reduced seaweed production level in the study area.

The study recommends that, it's time, for serious investment on seaweed farming industry especially investment of modern equipment's that will facilitate cultivation of seaweed in deep water which is fairly resistant to environmental and climate changes since farmers are aware of the changes in weather and climate and also capable to identify perceived climate change indicators in their daily cultivation practices. Also, investment through introduction of insurance schemes in seaweed industry motivates more seaweed farmers into farming including young and older men who are energetic and capable to locate their farm into deeper seawater, thus less climate change harms and hence, improved seaweed production.

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REFERENCES

[1] Ask, E.I. (2006) Cultivating Cottonii and Spinosum: A "how to" guide, In: A.T. Critchley, M. Ohno and D.B. Largo (eds.) World Seaweed Resources – An Authoritative Reference System. ETI Information Services, UK. 80 pp.

[2] Bitsch, V. (1998). Focus Group Discussion as a Research and Extension Method: The Case of Personnel Management Issues in Horticultural Business. Acta Hortic. 655, pp 461-469.

[3] Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R., Yanda, P. (2007). Africa. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Editors), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contributions of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge UK, pp 433-467.

[4] Brown, O., Hammill, A., & McLeman, R. (2007). Climate change as a new security threat: implication for Africa. International Affair 83 (6): 1141-1154.

[5] Bryman, A. (2008) Social Research Methods. 3rd. edition. Oxford University Press. 696 pp.

[6] Eklof J.S., Msuya F.E., Lyimo T.J and Buriyo A.S (2012). Seaweed farming in Chwaka Bay: A sustainable Alternative in Aquaculture? In people Nature and Research in Chwaka Bay, Zanzibar, Tanzania, de la Torre-Castro, M. and T.J Lyimo(eds). Pp 213-233.

[7] Ericksen, S., Aldunce, P., Bahinipati, C. S., Martins, R. D., Molefe, J. I., Nhemachena, C., O'brien, K., Olorunfem, F., Park, J., Sygna, L., Ulsrud, K. (2011). When not every response to climate change is a good one: Identifying principles for sustainable adaptation. Climate and Development, 3(1): 7-20.

[8] Erika, D. (2011). "Seaweed Farmer Education: Is it enough to sustain the Industry? Analyzing the Status of Stakeholder Investment in Muungoni and Jambiani, Unguja". Independent Study Project (ISP) Collection. Paper 1195, 31 pp.

[9] Hayashi, L., Hutado Q., A., Msuya, F. E., Bleicher-Lhonneur, G., & Critchley, A. (2010). A Review of Kappaphycus Farming: Prospects and Constraints. In J. Seckbach, R. Einav, & A. Israel (Eds.), Seaweeds and their Role in Globally Changing Environments, pp 251-280.

[10] Hurtado, A. Q. (2013). Social and economic dimensions of carrageenan seaweed farming in the Philippines. In D. Valderrama, J. Cai, N. Hishamunda & N. Ridler, eds. Social and economic dimensions of carrageenan seaweed

[11] (ICMZ) Intergrated Coastal Zone Management (2009). The status of Zanzibar Coastal Resources toward the Development of Integrated Coastal Management Strategies and Action Plan. Department of Environment/MACEMP.

[12] IPCC, (2007a). Climate Change 2007: Impacts, Adaptation and Vulnerability. Cambridge: Cambridge University press, UK, pp 34-250.

[13] IPCC, (2007b). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hansen, Eds., Cambridge University Press, Cambridge, UK, pp 315-356.

[14] IPCC, (2007c). "Summary for Policymakers" Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Inter-governmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller

(eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp 2-10.

[15] IPCC, TAR (2001). Climate Change 2001: Impacts, Adaptation and Vulnerability, IPCC Third Assessment Report, Cambridge University Press. International Panel on Climate Change (2007). Climate change: synthesis report summary for policymakers, Workgroup contribution to the fourth Assessment Report at IPCC Plenary, XXVII: pp 12-17.

[16] Kothari, C.K. (2004). Research Methodology: Methods and Techniques 2nd Revised Edition, New Age International (P) limited, New Delhi, 401 pp.

[17] Kronen, M. (2013). Social and economic dimensions of carrageenan seaweed farming in the Solomon Islands. In D. Valderrama, J. Cai, N. Hishamunda and N. Ridler, eds. Social and economic dimensions of carrageenan seaweed farming. Fisheries and Aquaculture Technical Paper No. 580 Rome, pp147-161.

[18] Lyimo, J.G., Ngana, J.O., Liwenga, E.T., & Maganga, F. (2013). Climate change, impacts and adaptations in the coastal communities in Bagamoyo District, Tanzania. Environmental Economics, 4(1): 63-71.

[19] Makame, O.M. (2013). Vulnerability and Adaptation of Zanzibar East Coast Communities to Climate Variability and Change and Other Interacting Stressor. PhD Thesis, Rhodes University.

[20] McClanahan, R.T (1994). Seasonality in East Africa's coastal waters. Marine Ecology Progress Report. 44:190-199.

[21] Msuya, F.E. (2006). "The Impact of Seaweed Farming on the Social and Economic Structure of Seaweed Farming Communities in Zanzibar, Tanzania." In A.T. Critchley, M. Ohno & D.B. Largo (Eds.), World Seaweed Resources: An Authoritative Reference System. Amsterdam: ETI information services, Wokingham, UK, p 27.

[22] Msuya, F.E. (2006a). The seaweed Cluster Initiatives in Zanzibar, Tanzania. In Mwamila B.L.M and Temu A.K (editors). Proceedings of the 3rd Regional Conference on Innovation Systems and Innovative Clusters in Africa, pp 246-260.

[23] Msuya, F.E., & Salum, D. (2007). Effect of cultivation duration, seasonality, nutrients, air temperature and rainfall on carrageenan properties and substrata studies of the seaweeds Kappaphycus alvarezii and Eucheuma denticulatum in Zanzibar, Tanzania. Technical report WIOMSA-MARG I No. 2007–06, 23 pp.

[24] Msuya, F.E. Shali, M. Sullivan, B. Crawford, B. Tobey, J & Mmochi, A (2007a). A comparative analysis of two Seaweed Farming methods in Tanzania. Sustainable Coastal Communities and ecosystems Program. Coastal resources Center, University of Rhode Island and the Western Indian Ocean Marine science association. 27pp

[25] Msuya, F.E (2011). The impact of seaweed farming on the socioeconomic status of coastal communities in Zanzibar, Tanzania. World Aquaclture Society 42 (3): 45-48.

[26] Msuya, F.E. (2012). A Study of Working Conditions in the Zanzibar Seaweed Farming Industry. Women in Informal Employment. Available at www.wiego.org accessed on 19/05/2016.

[27] Msuya, F.E. (2013). Effects of stocking density and additional nutrients on growth of the commercially farmed seaweeds Eucheuma denticulatum and Kappaphycus alvarezii in Zanzibar Tanzania. Tanzania Journal of Natural and Applied sciences, 4 (1): 605-612

[28] Msuya, F.E. (2013a). Social and economic dimensions of carrageenan seaweed farming in the United Republic of Tanzania. In D. Valderrama, J. Cai, N. Hishamunda & N. Ridler, eds. Social and economic dimensions of carrageenan seaweed farming. Fisheries and Aquaculture Technical Paper No. 580. Rome, pp 115–146.

[29] Msuya, F.E, Buriyo, A., Omar, I., Pascal, B., Narrain, K., Ravina, J.J.M., Mrabu, E., Wakibia, J.G. (2014). Cultivation and utilisation of red seaweeds in the Western Indian Ocean (WIO) Region. Journal of Applied Phycology, 26 (2): 699-705.

[30] Mustelin, A., Asseid, B., Haji, T., Khamis, M., Klein, R., Mzee, A., & Sitari, T. (2009). Practical measures to tackle climate change: Coastal forest buffer zone and shoreline change in Zanzibar-Tanzania. Department of Geography University of Turku, Finland, 106 pp.

[31] Mustelin, J., Klein, R., Assaid, B., Sitari, T., Khamis, M., Mzee, A. & Haji, T. (2010). Understanding current and future vulnerability in coastal settings: community perceptions and preferences for adaptation in Zanzibar, Tanzania. Population & Environment, (31): 371-398.

[32] Obura, D., Suleiman, M., Motta, H., & Schleyer, M. (2000). Status of Coral Reefs in East Africa: Kenya, Mozambique, South Africa and Tanzania. In:Wilkinson C. (ed.) Status of Coral Reefs of the World: 2000. Australian Institute of Marine Science, Queensland, Australia.

[33] Revolutionary Government of Zanzibar (RoZ), Ministry of Agriculture, Natural Resources, Livestock and Fisheries (2016).

[34] Saunders, M., Lewis, P., & Thornhill, D. (2007). Research Methods for Business Students. 4th edition. Prentice Hall, London. Pearson Education Limited. pp. 226.

[35] Shaughnessey, J., Zechmeister, E., & Zechmeister, J. (2000). Research methods in Psychology. Boston: McGraw Hill.

[36] Stemler, S. (2001). An Overview of Content Analysis. Practical Assessment, Research and Evaluation.

[37] Tanzania Meteorological Authority (2016). Secondary Ocean and terrestrial temperature and ocean wave.

[38] Trono, G.C & Valdestamon, R.G (1994). New aspects in the Ecology and Culture of Kappahycus and Eucheuma. The Korean journal of phycology. 9(2): 205-216.

[39] URT (2008). United Republic of Tanzania state of the environment report, Division of Environment, Vice-President's Office, Dar es Salaam, Tanzania, pp. 292.