OPEN ACCESS Freely available online

Journal of
Aquaculture Research & Development

Research Article

Social Economic Survey and Feasibility Study to Initiate Cage Fish Farming in Kenyan Coastal Creeks

Holeh GM, Magondu EW, Njiru JM, Tsuma S, Salim A, Muriuki AM, Fulanda A, Kilonzo J, Ochola O, Ndirangu S, Zamu MS, Athoni G, Luyesi J

Kenya Marine and Fisheries Research Institute, Kenya

ABSTRACT

The objective of the study was to determine the feasibility of introducing cage fish farming in the North and Southern Coast of Kenya and the most appropriate species for culture. This was based on socio-economic survey and physio-chemical parameter analysis during the study including the speed of the current, direction, and tidal variation which was done using the Acoustic Wave and Current Profiler (AWAC). Fish identification, phytoplankton productivity and harmful algal determination was also factored to determine favorable species to be cultured and conditions of plankton groups, biomass and diversity where the cage installation will take place. On the socio-economic survey, 34.3% were between the ages of 26-35 forming the majority of the residents respond. 78.4% of respondents were males and 64.7% were primary school drop outs. 83.3% of the respondents had lived in the area of study for over 20 years. 41.2% of the respondents were full time fishermen making fishing their main source of livelihood in their households. 77.5% of the respondents admitted there is a high fish demand of the particular areas having started the fishing job at an early average age of 10-19 years and majority of them (48.53) inherited the fishing techniques from parents. At least 89.55 of fishermen prefer doing fishing as a group and seine net is the most used gear used by the fishermen while 7.5% use long liners and 1.5% dive to fish. Prawns, Chaa (Sesame) and Tuna were the mostly caught fish in the areas. The survey showed that the current speed of Dabaso North coast and Tsunza creek at the South was 0.344 m/s and 0.890 m/s respectively. This was quite a low speed indicating the area is suitable for cage installation. The highest tide in Dabaso, North coast was 2.59 m and Tsunza creek South coast was 4.52 m with lowest tide at 0.72 m and 1.10 m respectively and variation difference of 1.87 and 3.42. In responding to the perception of cage culture in the areas, 93% of the respondents accepted the idea of cage fish farming and both areas had good security as per the respondents. Most conflicts that arose in these areas were due to theft, competition and net destruction. It was observed that the North coast communities were not conversant with cage fish farming and as such, much time was taken explaining about cage fish farming.

Keywords: Cage; Farming; Feasibility; Social economic; Fish; Creeks

INTRODUCTION

Globally fish production from natural stocks has stagnated with most of the fisheries fully exploited. This is alarming as population growth is increasing with projections of 9.6 billion world population by 2050 expecting to be fed with 171 million tonnes of fish [1]. Additionally, Economic Survey reports have shown that there has been a decline in fish landing from both freshwater and marine sources. Further, marine cage culture at the coast of Kenya remains largely unexploited in spite of its immense potential demonstrated in countries in Europe and South East Asia. The nation therefore has a fish production deficit of over 300,000 tonnes per year [2]. Cage farming therefore offers an opportunity for the exploitation of inshore and offshore marine resources to address the issue of national fish supply deficit at affordable capital outlay and contribute to food and nutritional security agenda.

Fish farming has shown to be one of the fastest growing animal production sector in the world, being supported by modernization and intensification of culture systems. New farming technologies are now believed to the sure way that will counter the widening gap between fish demand and supply according to FAO, 2016 [3]. In this regard, expansion of freshwater aquaculture may be limited due to competition for available land and water from agriculture and other uses. With technologies and equipment now being developed to withstand harsh ocean environments, there is an

Correspondence to: Holeh GM, Kenya Marine and Fisheries Research Institute, Kenya, Tel: +254752234450; E-mail: holegladys@gmail.com

Received: October 26, 2020, **Accepted:** November 18, 2020, **Published:** November 25, 2020

Citation: Holeh GM, Magondu EW, Njiru JM, Tsuma S, Salim A, Muriuki AM, et al. (2020) Social Economic Survey and Feasibility Study to Initiate Cage Fish Farming in Kenyan Coastal Creeks. J Aquac Res Development. 11: 11. doi: 10.35248/2155-9546.20.10.617

increasing interest in coastal and offshore marine aquaculture in line with the global blue economy initiative and the sustainable development goals (SDGs).

Cage fish farming in marine waters has largely been practiced in many parts of the world including America, Europe and Asian countries [4]. Among African countries the technology is slowly been adopted with intermittent efforts to establish cage in lagoons in South Africa, Mauritius, Madagascar, Mozambique and Nigeria. In East Africa Cage culture has been done in fresh waters of Lake Victoria by the resource sharing countries of Kenya, Uganda and Tanzania. Production has also been supplemented significantly by cages established in small water bodies. In Kenya marine waters experimental cages for rabbit fish (*Siganus sutor*) and Marine water tilapia (*Oreochromis niloticus*) have been tried in Kilifi creek [5].

In many developing countries food security and sustainable livelihoods are key national challenges that can be addressed by efficient utilization of existing marine resources. Research has shown that mariculture can offer a solution to provide for the overexploitation of natural stocks being experienced currently from the natural waters. Fish cage culture is therefore a technology that provides an opportunity for use of inshore and offshore marine resources for economic development and community livelihoods. The choice of fish species to be cultured, cage design and economic sustainability are critical in designing an adaptable cage culture system. In addition, ecological approaches to aquaculture and marine resources exploitation are important for long term environmental and socio-economic sustainability of the venture.

Cage culture has proved to be a profitable aquaculture system in many countries. It has shown to be a relatively complex engagement in terms of technological and ecological perspectives which warrants for in depth baseline data on different environmental parameters and social economic assessment before initiation of any interventions. Therefore, the present paper details results of feasibility study on cage farming in Kenyan coastal creeks to assess the social economic survey, phytoplankton, fish identification and environmental status of the proposed pilot sites in Kilifi (North) and Kwale (South) counties of Kenya.

MATERIALS AND METHODS

Study site

The study was done in Dabaso Kilifi county (North coast) and Comtouch (South coast) of Kenya (Figure 1).

Data collection

A well-structured questionnaire consisting of three sections (Socio-economic background sections, area of specialization and perception of cage culture section) was administered to 102 respondents in the two coastal counties. The socio-economic background part assessed the demographic characteristics of respondents: Name, contact, gender, highest level of education, main source of income and the duration in years lived in the area. Data was primarily collected through personal observations, one on one interviews and focus group discussions. This was done to four different sets of respondents: Fish mongers, tourists, boat riders and fishermen.

The response in some of the indicators like experience in fish trading were corded as 0-4 years, 5-9 years, 10-14 years, 15-19 years and over 20 years, Yes or No cording's were indicated where a specific choice

Figure 1: Map showing the feasibility study sites.

was made on changes of fishing activities, thoughts about cage fish farming and conflicts with users on the creek. Word clouds were used to analyze unstructured questions visualizing responses that are mostly preferred. The physico-chemical parameters were to identify potential hindrances that may impede the cage construction and its operation. The two sites were selected based on the community experience in working with cages.

The data collected provided insight on the intertidal range, currents and waves, temperature and species available in the area. The Global Positioning System (GPS) coordinates marked the cage culture position and socio-survey coverage. The fish abundance was also calculated per area of station in order to establish the site carrying capacity.

Social economic survey

The socio-economic survey aspect was to gauge the community perspective about cage fish farming and its adaptability once it is initiated in both study areas. The data was collected using a semi-structured questionnaire which was administered to fish farmers, fish mongers, fishermen, boat riders and touristic people living alongside the North and South Coast beaches.

Primary data were entered in Microsoft Excel computer package 2010, coded, cleaned up and transferred to statistical package (SPSS) for social science analysis. Qualitative data were coded and analysed using Descriptive Statistics of Frequencies of the Statistical Package for Social Scientists (SPSS) and R based on the fact that the variables used in the study were all categorical. These resulted to performance frequency analysis, chi-square test of association, Logistics modelling and comparison of predictive accuracy with the random forest and decision tree models. Word clouds are popular when analysing text for insight and in case of an unstructured text analysis as discussed by Cao N, et al. [6]. Bonney S, et al. [7] used word clouds to demonstrate the literature review content that discuss on strategies which improve financial performance. In this study, word clouds were used to visualize the statements from the respondents that are more frequent in the choice-less questions. The most frequent word used was displayed in a larger text than the rest. Furthermore, conjoint analysis was implemented on the use of cages for fish farming.

Current speed, direction and tidal variation

Acoustic Wave and Current profiler (AWAC) from Norway, Nortek group was deployed within Dabaso creek in Kilifi County, and Tsunza creek in Kwale County at (03.34070°S 039.98409°E) and (04.04719°S 039.56123°E) respectively. Tidal variation, current speed and direction data collection and retrieval were done using AWAC AST software, while quality control of the data was done using storm-64 software. The current speed and direction were measured in (m/s) and in degrees respectively. The data was analyzed and visualized using MATLAB, R2015a.

Fish identification

Fish count (survey) was carried out before fish cage setting to determine which species and their size are found in the particular study sites and also to have an idea on the fish species favorable to culture in the areas.

Phytoplankton productivity and harmful algal determination

Sampling containers were pre-labelled suitably for each station then using a water bucket, water was drawn from the sampling site and passed into a twenty (20) microns phytoplankton net.

The collected residue was passed into the pre-labelled sample bottles and fixed with 0.5-1 ml of acidified lugol's solution then a thorough washout of the net was done to transfer all cells into the sample bottles. This process was repeated to get a replicate sample for each station and same repeated for all points and stations. Collected samples were taken to the laboratory for filtration and standardization while observing the necessary protocols. Sample qualification and quantification was done using a sedge wick-rafter counting cell under a compound inverted microscope, where a standard volume (1 ml) of the sample was filled into the counting cell, a standard magnification 200x total magnification was used and this was repeated thrice for every sample and its replicate [8].

Generated data was first entered into hardcover counter book and later transferred to an excel sheet for appropriate data processing. Sample Identification and enumeration was attained by doing several sets (millilitres) of identification and counts to attain a better precision and use of internationally recognized identification reference materials during the taxonomic identification [9,10].

RESULTS AND DISCUSSION

Socio-economic survey of respondents

Socio-demographic characteristics of respondents: The attributes that were most influential to a respondent when dealing with cage culture practice were;

Investment decision to Cage Culture Farming practice (Cage choice): Yes, No

Fish Demand: High, Low

Education level: No Education, Education

Age group: <25, 26-35, 36-45, 46-55, >56

Length of stay: 0-4 years, 5-9-years, 10-14 years, 15-19years, Over 20 years

Location: Dabaso, Tsunza creek

All combinations were equal to multiplication of number of attributes in each level in this case 2*2*2*5*5*2=400. The combination necessary was then used for research.

Random selection of rows was used to satisfy the combination and that is 18 rows as seen below through random selection of rows i.e., 18 combinations as displayed in the Table 1. The simulated data of the respondents' ratings is given to each combination (Table 2).

The just concluded study showed that 78.4% of the respondents were males and 21.6% were females. 34.3% of respondents were between the age of 26-35 which is the class with majority of the respondents. This showed that most respondent were young who can be productive, innovative and energetic to have investments in the area. This finding is in contrary to the study of Silviyunan et al. [11] who analyzed floating net cages in Laut Tawar Lake Aceh Province and reported age group of 35-44 were the most productive.

Table 1: Display of combinations of data.

Randomly selected rows	Fish cage culture choice	Fish demand in the area	Respondent literacy	Respondent Age group	Duration of stay in the area	Location
5	Yes	High	Yes	26-35	5-9-years	Dabaso
9	Yes	Low	Yes	36-45	Over 20 years	Dabaso
20	No	Low	Yes	26-35	15-19 years	Dabaso
42	Yes	Low	Yes	<25	15-19 years	Tsunza
44	Yes	Low	No	26-35	5-9 years	Tsunza
45	Yes	High	Yes	36-45	10-14 years	Tsunza
48	No	High	Yes	36-45	0-4 years	Tsunza
51	Yes	Low	Yes	26-35	0-4 years	Dabaso
52	No	Low	Yes	<25	Over 20 years	Dabaso
54	Yes	High	Yes	46-55	Over 20 years	Tsunza
60	Yes	Low	No	>56	5-9 years	Dabaso
63	Yes	Low	No	>56	10-14 years	Dabaso
65	Yes	Low	No	36-45	15-19 years	Dabaso
69	Yes	Low	Yes	<25	0-4 years	Dabaso
70	Yes	High	No	26-35	Over 20 years	Dabaso
71	Yes	Low	Yes	46-55	10-14 years	Dabaso
90	Yes	Low	Yes	>56	Over 20 years	Tsunza
97	Yes	Low	No	<25	Over 20 years	Tsunza

Table 2: Socio-demographic data of respondents.

Indicator	Variables	Statistics (Percentage %)
Phone numbers	With phone	66.7
	Without phone	33.3
Gender	Male	78.4
	Female	21.6
Age of respondent	<25	18.6
	26-35	34.3
	36-45	20.6
	46-55	12.7
	>56	13.7
Education level	No Education	14.7
	Primary	64.7
	Secondary	9.8
	Diploma/Certificate	1.0
	Degree	7.8
Main source of income	Fishing	69.6
	Fish Trading	15.7
	Boat Riding/Transport	8.8
	Employed	2.0
	Any Other	2.9
Duration of residence	0-4 Years	1.0
	5-9 Years	5.0
	10-14 Years	3.0
	15-19 Years	6.0
	Over 20 Years	85.0

The study was dominated by males (78.4%) and in this it is evident that men play a big role in the development of fisheries in Kenyan Coastal counties. This is in line with [12] who found males to be majority (88.7%) in his study to investigate social-status of the fish farmers of Floating net-cages in Lake Maninjau, Indonesia but in Lake Kanji in Nigeria their male did not play a major role in fisheries development [13].

14.7% of the respondents were not educated, 64.7% were primary school drop outs, 9.8 of respondents were senior high school graduates and. 8.8% had acquired certificate, Diploma and Degree courses. The highest number of respondent (64.7) as indicated were primary drop outs and could not be able to adopt innovations. This was in contrary to the study of Pontoh et al. [14] in the analysis of fishery business on floating cage in Tandengan village and found that most respondents were junior high school graduates. 69.6% obtain their income from fishing, 15.7% on fish trade business and 8.8 in boat riding. This would clearly show fishing to be the main occupation in the area devoting their time in it with different length of experience. 83.3% of the respondents have lived for over 20 years in the area under study. This is the class with majority of the respondents thus the responses were majorly based on long term dwellers.

Reasons for fish business: Respondents gave reasons on why they started selling fish and it was for income purposes others said as a business and others did it for their family. Gradually overtime, changes have occurred in the areas of study and these have affected the state of fishing business. The word cloud below touches on the contending issues.

Reasons for changes in fishing activity: Respondents gave reasons on factors bringing changes to their income of the fishing activities and the word cloud displays enough touching on bypass construction, mangroves and change over to Motorcycle business locally referred to as *bodaboda.*

Main source of income for residence: The study investigated the main source of income of the residents and from the word cloud output there is fishing from the wild, selling fish, palm tree tappers and bodaboda riding. These combined activities were the main

source of money in the study area with 41.2% of respondents being full time fisherman. This means that the main focus of the coastal community residents is on the fishery.

Kind of change occurred on prices and amount of fish: According to this research, 17.6% of the respondents experienced negative changes on the amount and prices of fish while 2.9% experienced a positive change. 79.4 percent of respondents were not very sure of change experienced in the area.

The reasons for the change have to do with seasons, price, demand, supply, rainfall and tides as seen in the word cloud. Averagely out of the 38 stated prices of the types of fish sold, the price per kilogram is at ksh. 255 (2.5 US dollars). The price of the most demanded type of fish range from ksh. 200 (2US dollars) to ksh.400 (4US dollars) per kilogram. The prawns are sold at ksh. 400 (4US dollars) per kg.

Main occupation and demand of fish in the area: This research established that 41.2% of the respondents were full time fisherman and 25.5% being part time fishermen in the two areas. Apart from a large number of those who could not respond on the demand question, 77.5% declared that fish demand was very high in the area. The fish that is on high demand is the Red snapper and White snapper (Chaa). This is the same fish that the respondents thought it could be cultured in cages in their area (Figure 2).

How the respondents learnt about fishing: It was observed that a big percentage (32.35%) of the respondents learnt fishing from parents and mostly between the ages of 10 to 19 years. 10.78% got the fishing idea from friends while 18.63% got it from the community they are living. The results are in contrary with that of Ibemere et al. [15] who indicated friends and fellow farmers to be the main source of information to upcoming fishermen.

Duration in which respondents have been undertaking fishing: There is an average of 11 years' experience for fishing among the respondents. This would show a potential of development of cage fish farming in the areas once initiated for increase production. Human resource is key in aquaculture development. In his study, [14,16] stated that rural areas human resource played a key role in implementation of aquaculture operations. Most respondents (89.55%) preferred doing fishing as a group. A group of two persons was mostly preferred to support each other in seining and net holding during fishing (Figure 3).

In reference to Table 3 above, this research established that 93.1% of the respondents preferred cage fish farming while 7% were not so sure of the outcome of farming fish on cages. It was observed that only two cages were in existence in the coastal area supported by the National Research Fund (NRF) hence the communities

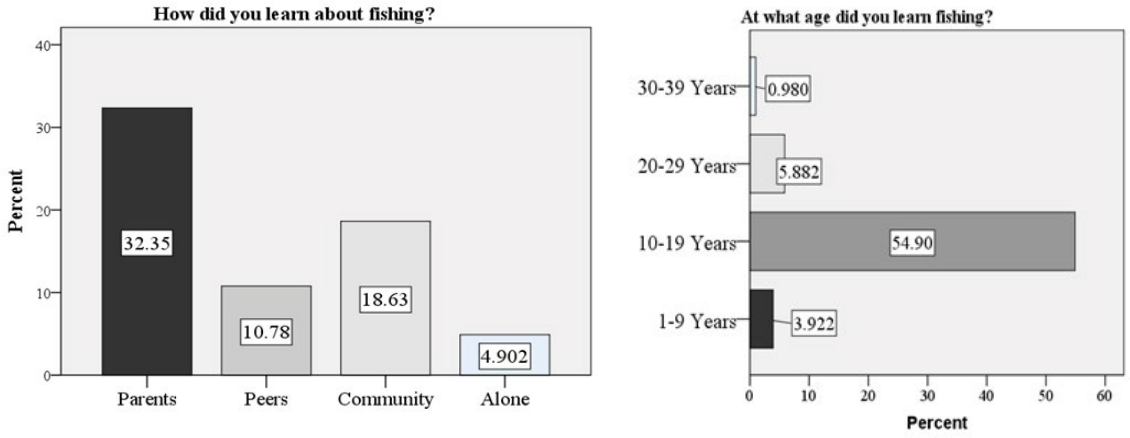

Figure 2: How the respondents learnt about fish farming (2) age respondents learnt fish farming.

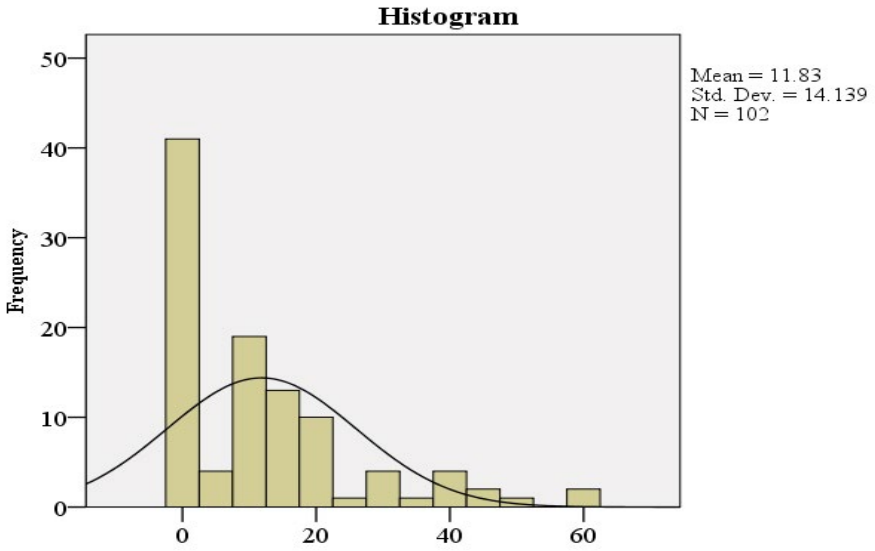

Figure 3: Duration in years in which respondents have been undertaking fishing.

were not conversant with cage culture aspect. Majority obtained their little knowledge on cage culture after the establishment of the two cages in the North and South coast of Kenya hence the practice among the community could be substandard compared to the rest of the world. There is also a necessity of training and exposure by professional fishing bodies and extra media influence with majority of respondents basing their choice of cage culture on income and as a job market. Other activities that majorly take place along the creek include tourism, mangrove planting and transportation services (Table 4).

From the study, it was revealed that Comtouch Tsunza had a good security area with majority (36.3%) indicating good as the level of security. This was based on production of previous crab cages installed near the shore. 23.5% of participants in Dabaso were not so sure of the security in the area since no cages have been installed before but had experienced minor conflicts within their creeks. 24.5% of the respondents have had conflicts within the creeks (Table 5). The conflicts in the creek were observed from the word cloud surrounding majorly on boats, nets and equipment. These were as a result of theft, competition of resources, and destruction.

The survey observed the methods used to solve the conflicts along the creek: reconciliation, mutual agreement, Consultation, and negotiations were conspicuous.

Conjoint analysis

The combinations of levels that bring about the concept of cage culture usage are profound because they consist of a respondent who has a different business attitude and not really cage farming,

Table 3: Community perspective on cage culture.

Variables		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	95	93.1	93.1	93.1
	No	7	6.9	6.9	100.0
	Total	102	100.0	100.0	

Table 4: Level of security of location of study (Dabaso and Tsunza creek).

Variables			What Is the level of security in this area				Total
			Not Applicable	Good	Fair	Poor	
Location of study	Dabaso	Count	**0**	**24**	**14**	**13**	**51**
		% of Total	0.0%	23.5%	13.7%	12.7%	50.0%
	Tsunza	Count	**2**	**37**	**7**	**5**	**51**
		% of Total	2.0%	36.3%	6.9%	4.9%	50.0%
Total		Count	**2**	**61**	**21**	**18**	**102**
		% of Total	2.0%	59.8%	20.6%	17.6%	100.0%

Table 5: Conflict experience in the areas.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No Response	8	7.8	7.8	7.8
	Yes	25	24.5	24.5	32.4
	No	69	67.6	67.6	100.0
	Total	102	100.0	100.0	

Table 6: Utility estimates.

Attributes	Levels	Utility Estimate	Std.Error.
Cage Choice	Yes	1.58907	1.70284
	No	-0.88118	0.88099
Fish demand	High	-0.21895	0.29816
Edu Level	Yes	0.22960	0.25973
Age	<25	-0.67240	1.09873
	26-35	-0.17029	0.34538
	36-45	0.07716	0.39480
	46-55	-0.03505	0.32678
Duration of stay	0-4 years	0.47405	1.31458
	5-9-years	-0.27392	0.41607
	10-14 years	-0.28776	0.41068
	15-19years	-0.06788	0.41644
Location	Dabaso	-0.18922	0.23076
Constant		6.12118	0.56965

lives in a high fish demand area, between the age of 46 to 55 years, stayed in the study area for 15 to 19 years and preferably lives in Dabaso region. These are the choices that favored the preference of cage culture farming in this study (Tables 6 and 7).

Current speed, direction and tidal variation

From the graphs above (Figure 4), the Dabaso creek water current was low with a maximum current speed of 0.344 m/s and spreads towards North West direction. The spread was due to wind blowing over the surface water. Tsunza creek indicates a maximum current speed of 0.890 m/s towards East North East (ENE) with a dominating ebb.

The low maximum current speed of Dabaso and Tsunza creeks was an indication of a suitable place for cage installation. According to Norwegian fish cage site classification, current speed should not exceed 1.5 m/s [17] because it can cause the cage to move if not well fitted with heavy weights.

The hydrodynamics characteristics of currents shown by Dabaso characterizes the currents as directional current, due to its spreading, while the one for Tsunza creek characterizes the currents as unidirectional currents due to its asymmetry shape. Exposed site would have a better hydrodynamics, with a resulting lower environmental impact, better fish welfare and a better product quality. A sheltered and protected site would be less exposed to waves and currents, which implies reduced maintenance and costs [18].

The graph above shows tidal variation at Dabaso in Kilifi County and Tsunza creek in Kwale County (Figure 5). The results indicated tidal variations in Neap. In Dabaso, the highest tide was 2.59 m while the lowest was 0.72 m. The tidal fluctuation/difference was 1.87 m. In Tsunza creek, the highest tide was 4.52 m while the lowest was 1.10 m. The tidal fluctuation/difference was 3.42 m.

The tidal variation that is preferred/recommended for adequate water exchange that will enable the flow of nutrients through the cage is 2 m-3 m. Site with tidal fluctuation/difference that is 4 m or above is not recommended since it can cause uplift of the cage and move if the ropes holding the cage from the bottom are not long enough, while site with tidal fluctuation/difference of 1 m or less could not drained or filled properly [19]. Therefore, the Tsunza creek site is recommended for fish cage due to its adequate water exchange for the flow of nutrients, and temperature distribution.

Fish identification results

Different fish species were identified from the study sites and the different methods used for harvesting them the results were presented in the Table 8.

Phytoplankton productivity and harmful algal determination

The Dabaso site was characterized by some known freshwater/brackish water phytoplankton species though at a very low cell density compared to the marine species and several benthic diatoms like *Lyrella*, *Navicula* and *Licmophora*. This could reflect some freshwater entry point therefore it was recommended that a sampling point is to be made at close proximity to any probable freshwater source in any subsequent survey. The area was also characterized by several benthic diatoms like Lyrella, Navicula and Licmophora which could reflect a shallow sampling environment mostly during low tides (Table 9).

A list of potential harmful algae was obtained from the study

Table 7: Summary of the current speed and direction.

Location/Site	Maximum depth	Current Speed (m/s)	Direction
Dabaso	2.0 m	0.3440	NW
Tsunza	4.1 m	0.8900	ENE

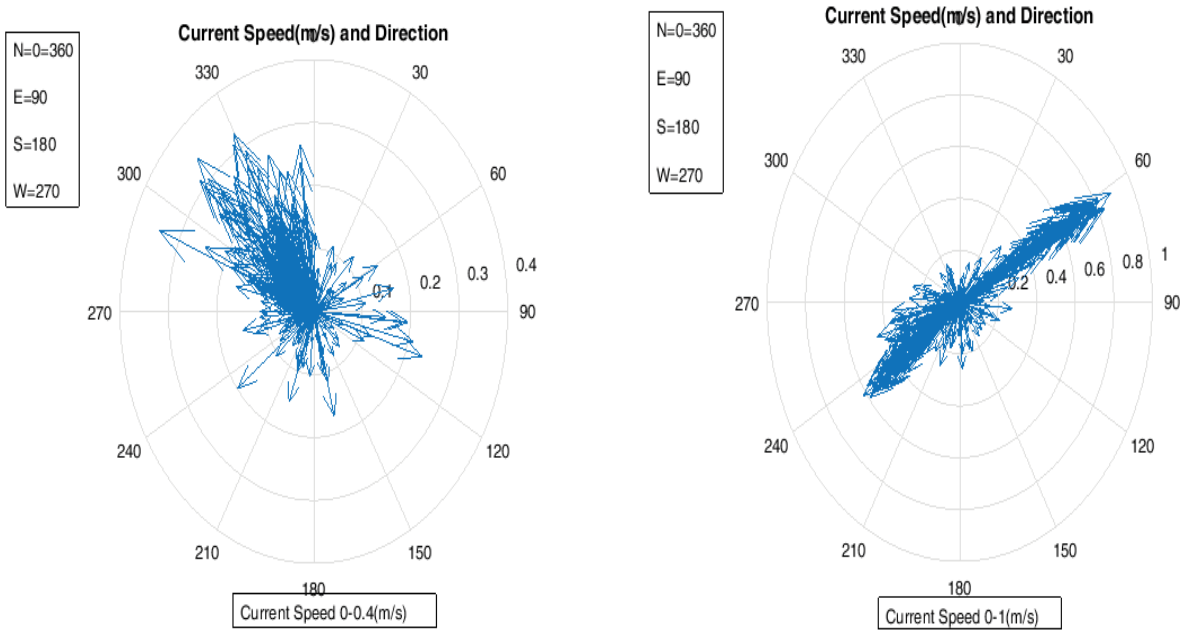

Figure 4: Graph showing ocean current speed and direction at Dabaso and Tsunza Creek.

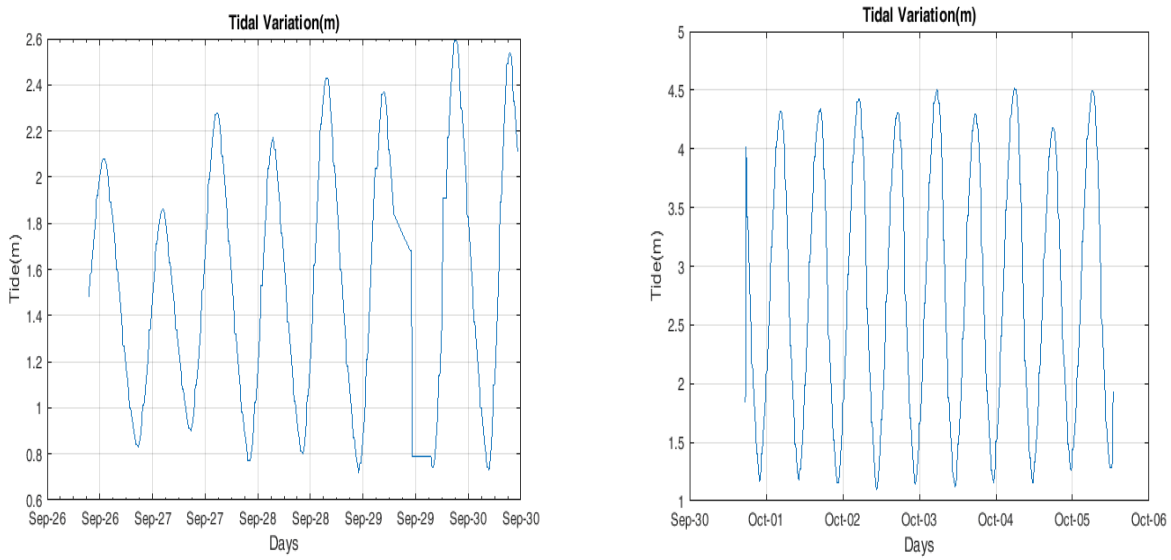

Figure 5: Graph showing tidal variation in Dabaso, North Coast and Tsunza creek South Coast.

Table 8: Identification of different dominating fish species in the study sites.

Species caught	Fishing Method	Site found
Emperor (Changu)	Fishing line	Dabaso and Tsunza
White Snappers (Chaa)	Gill net	Dabaso and Tsunza
Rabbit fish (Tafi)	Gillnet	Dabaso
Red snapper (Kiunga)	Fishing line	Dabaso and Tsunza
Groupers (Tewa)	Fishing line	Dabaso and Tsunza
Zebra fish (Gangu)	Fishing line	Dabaso
King fish (Kole kole)	Gillnet and fishing line	Dabaso
Parrot fish (Pono)	Gill net	Dabaso
Goat fish (Mkundaji)	Gill net	Dabaso and Tsunza
Sweet lip (fute)	Fishing line	Dabaso
Crabs	Modified hook	Dabaso and Tsunza
Squids	Gillnets	Dabaso and Tsunza
Prawns	Beach sein net	Tsunza and Dabaso
Robsters	Scoop nets	Tsunza

Table 9: Phytoplankton species recorded from Dabaso and Tsunza creek sites.

Class	Taxa	Total Species	(Total Count) L
Chlorophyta	Pediastrum	1	31.25
Chlorophyta	Coelastrum	1	31.25

but none of the stations indicated counts reaching harmful levels. Examples of these dinoflagellates included; *Scrippsiella sp. Prorocentrum quinquecorne, Prorocentrum sp., Alexandrium sp., Scrippsiella Sp., Peridinium quinquecorne, Oscillatoria sp., Peridinium sp., Anabaena sp., Pseudo-nitzschia sp., Prorocentrum micans, Gonyaulax sp., Gymnodinium sp., Lyngbya sp.,* (Table 10) [20].

CONCLUSION AND RECOMMENDATIONS

The just concluded research indicated that initiating cage culture in the areas would play an essential role in diversity and enhancement of livelihood. Majority of the communities obtain their income from fishing thereby cage fish farming would be an asset to the coastal communities. It was also observed that the Dabaso communities were not versant with the cage fishing thus much time was taken explaining to the interviewees on what cage fish farming is. Training on cage fishing should be undertaken in both Dabaso and Tsunza creek.

The Dabaso cage site should be readjusted to a place where there is adequate water exchange with the tidal variation between 2 m-3 m. The chain underwater holding the weight at Tsunza creek, must be set parallel to the current direction as shown on the current speed graphs to avoid cage movement. The width of the cage in case of a rectangular cage must face the direction of the current flow to reduce the surface area exposed to the current flow, and hence reduce impacted force on the cage by the current.

Table 10: List of phytoplankton genera recorded from sampled site at Dabaso and Tsunza creek.

Dabaso			Tsunza		
Group	**Genus**	**Plankton**	**Group**	**Genus**	**Plankton**
Bacillariophyceae (Diatoms)	*Cymatopleura*	*x*	*Bacillariophyceae (diatoms)*	*Bacillaria*	*xxx*
	Chaetoceros	*xxx*		*Nitzschia*	*xxx*
	Navicula	*xx*		*Thalassionema*	*x*
	Lyrella	*x*		*Pseudonitzschia*	*x*
	Pleurosigma	*xx*		*Haslea*	*x*
	Surirella	*x*		*Surirella*	*xx*
	Scrippsiella	*xx*		*Thalassiosira*	*xx*
	Nitzschia	*xx*		*Coscinodiscus*	*x*
	Bacteriastrum	*xx*		*Navicula*	*x*
	Haslea	*xx*		*Chaetoceros*	*x*
	Thalassiosira	*xx*		*Meuniera*	*x*
	Thalassionema	*xx*		*Flagilaria*	*x*
	Melosira	*x*		*Nitzschia sigma*	*x*
	Cyclotella	*xx*		*Pleurosigma*	*x*
	Nitzschia closterium	*x*		*Entomonies*	*x*
	Lauderia	*xx*		*Nitzschia reversa*	*x*
	Corethron	*x*		*Lyrella*	*x*
	Gyrosigma	*x*		*Chyclotella*	*x*
	Nitzschia acicularis	*x*	*Dinophyceae (Dinoflagellates)*	*Scrippsiella*	*xxx*
	Skeletonema	*x*		*Prorocentrum micans*	*x*
	Dactyliosolen	*x*		*Protoperidinium*	*x*
	Biddulphia	*x*		*Gonyaulax*	*x*
	Coscinodiscus	*x*		*Peridinium quinquecorne*	*x*
	Thalassiophysa	*x*		*Prorocentrum micans*	*x*
	Nitzschia sigma	*x*		*Gonyaulax*	*x*
	Streptotheca	*x*		*Alexandrium*	*x*
	Licmophora	*x*		*Akshiwo*	*x*
	Lithodesmium	*x*		*Peridinium*	*x*
	Triceratium	*x*		*Gymnodinium*	*x*
	Pseudonitzschia	*x*	*Dictyochophyceae (Silicoflagellate)*	*Dictyocha fibula*	*x*
	Eucampia	*x*	*Flagellate*	*Euglena*	*x*
	Plagiodiscus	*x*			
Dinophyceae (dinoflagellates)	*Alexandrium*	*x*			
	Peredinium quinquecorne	*xx*			
	Peridinium	*x*			
Cyanophyceae (Cyanobacteria)	*Oscillatoria*	*x*			
	Anabaena	*x*			
Chlorophyceae (Chlorophyta)	*Pediastrum*	*x*			
	Coelastrum	*x*			
Dictyochophyceae (Silicoflagellate)	*Dictyocha fibula*	*x*			

NB: 'x' indicates presence; 'xx' indicates dominating genera

The productivity of the Dabaso and Tsunza creek areas was good but a recommendation is hereof made for enhancement of water exchange of the Tsunza creek due to presence of more dinoflagellates than diatoms, while the opposite should be the ideal situation, first, Diatoms are the real primary producers with some dinoflagellates and other aquatic creatures (zooplankton) depending on these diatoms and other alga for food. Secondly dinoflagellates are one of primary candidates for harmful algal blooms mostly non-toxic

but harmful bloomers, more than diatoms. It is recommended that fish count (survey) should be done during neap tide in creeks and mangrove areas because most time the water is not clear like in coral reefs areas.

ACKNOWLEDGMENT

The authors would like to thank the Director KMFRI and management for facilitation through RV. Mtafiti kitty that enabled us to undertake the study successfully. Assistance given by all the participating staff from KMFRI, laboratory technicians and interns is greatly acknowledged. We appreciate the stakeholders from both Dabaso and Tsunza for availing themselves during the startup meeting, their enormous support in the field during search for a suitable cage site and deployment of current meter. The field guides from the two study sites who assisted during collection of social economic data are very much appreciated. The reviewers of this article are thanked for their useful comments.

REFERENCES

1. FAO. The State of World Fisheries and Aquaculture 2018- Meeting the Sustainable Development Goals. Licence: CC BY-NC-SA 3.0 IGO, Rome. 2018.
2. Kenya National Bureau of Statistics (KNBStats). Economic survey report. 2020.
3. FAO. The state of world fisheries and aquaculture 2016. Contributing to food security and nutrition for all. Rome, Italy: FAO. 2016; 200.
4. Halwart M, Moehl JF. FAO Regional technical expert workshop on cage in Africa, Entebbe, Uganda, 20–23 October 2004. Rome, Italy: FAO. FAO Fisheries Proceedings. 2006; 6: 113.
5. Hecht T, McCafferty J, Gitonga N, Gatune C, Oellermann L. Mariculture scoping study with respect to Kenya Marine water (unpublished).
6. Cao N, Cui W. Introduction to text visualization (Atlantis Briefs in Artificial intelligence (1)) 1st ed. 2016.
7. Bonney S. Strategies to Improve the Financial Performance of State-Owned Enterprises in Ghana. Walden Dissertations and Doctoral Studies. 2015; 1773.
8. Karlson B, Cusack C, Bresnan E. Microscopic and molecular methods for quantitative phytoplankton analysis. 2010.
9. Cronberg G, Annadotter H. Manual of aquatic cyanobacteria: A photo guide and a synopsis of their toxicology. Copenhagen: International Society for the Study of Harmful Algae. 2006.
10. Tomas CR, Throndsen J, Heimdal B. Identifying Marine Phytoplankton/Edition 1. 1997-2020 Barnes & Noble Booksellers, Inc. 122 Fifth Avenue, New York, NY 10011. 1997.
11. Silviyanun. Analysis of floating net cage fish farming in LautTawar Lake Aceh Province, Indonesia. Thesis, Department of Geography Education Faculty of Social Sciences, State University of Medan. 2013.
12. Syandri H. Social status of the fish farmers of floating net-cages in Lake Maninjau, Indonesia. Journal of Aquaculture Research and Development. 2015; 7: 1-5.
13. Nwabeze GO, Ifejika PI, Tafida AA, Ayanda JO, Erie AP.. Gender and fisheries of Lake Kanji, Nigeria: A Review. Journalof Fisheries and Aquatic Science. 2013; 8: 9-13.
14. Pontoh O. Analysis of fishery business on floating net cages in Tandengan Village Minahasa Regency, North Sulawesi. Pacific Journal. 2012; 2: 1424-1428.
15. Ibemere IF, Ezeano CI. Status of fish farming in rivers state, Nigeria. Journal of Fisheries and Aquatic Science. 2014; 9: 321-329.
16. Shyam R, Saha GS, Safui L, Eknath AE, Adhikari S. Status and economy of community fish farming in rural Odisha. Indian Journal Fisheries. 2013; 60: 59-67.
17. Lovatelli A, Aguilar-Manjarrez J, Soto D. Expanding mariculture farther offshore: technical, environmental, spatial and governance challenges. FAO Technical Workshop, 22–25 March 2010, Orbetello, Italy. FAO Fisheries and Aquaculture Proceedings No. 24. Rome, FAO. 2013; 73.
18. Sagerman J, Hansen PH, Wikstrom SA. Effects of boat traffic and mooring infrastructure on aquatic vegetation: A systematic review and meta-analysis. Scientific reporte nature research. 2019; 49: 517-530.
19. Devlin AT, Jay DA, Talke SA, Zaron ED, Pan J. Coupling of sea level and tidal range changes, with implications for future water levels. Sci Rep. 2017; 7: 17021.
20. Hallegraeff GM. Harmful Algal Blooms: A Global Overview. In: Hallegraeff, M., Anderson, D.M. and Cembella, A.D., (Eds.), Manual on Harmful Marine Microalgae. Monographs on Oceanographic Methodology, 2nd Edition, IOC-UNE-SCO, Paris. 2003; 25-49.