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Exploring Fish Farming Production in the Hasahiesa Locality in Northern Gezira State of Sudan: A Prospect for Food Security

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ABSTRACT

Fish is very important source for human nutrition, securing food, and alleviation of poverty world-widely. This research explore to identify fish farming production in Sudan with reference to Hasahiesa locality in northern Gazeira State, and to discuss the findings within the context of food security and rural development for Sudan. The total population of fifty licensed fish farms was surveyed by a structured questionnaire during November 2019, covering the target period of 2008-2018. The analytical approach was applied on the data obtained. Results revealed that, throughout the target period, mean fish production per a month per a farm was low and fluctuating, and since the year 2015 it declined steadily to research five tons per a month per a farm in 2018 compared to sixteen tons per a month per a farm in 2016 which amounts to a decline by 66%. This refers to numerous constraints including administrative ones such as absence of governmental efforts on fish hatching; improvement of genetic traits, veterinary services of extension and hybridization for new species; and technical constraints associated with cultivated fish; 70% of the farm owners are not ichthyologists; no feasibility studies were done for a farm's location, water soil testing, and preparation of the feed mix. There are also legislative constraints such as lack of regulations and laws concern fish farming sector, obstructing utilization of public property locations such as rivers and the non-enforcement of tax relinquish. There are also many financial constraints such as high cost of operation including fish feeding; tax and ransom, fuel, and veterinary supervision, as well as marketing problems and poor bank financing.

Key words: fish farming, fish production, food security, multiple constraints

1. Introduction

The world is confronted with challenges to secure food for its growing population; provide and increase quality of food; and govern its utilization appropriately. Fish farming could effectively contribute in overcoming these challenges. This is because fish farming is a vital component of food and nutrition of a population; could optimize food sources, and contribute into food security of a country.

It is well recognized that, all countries work to find appropriate ways to secure food for their growing populations and to cope with their changing food consumption trends. This is considered important for any country to help achieving its economic development; social security and stability; and keeping on its surviving. This research takes fish farming through 2008-2018 in Hasahiesa locality in Northern Gezeira State as a case study to see trends of production; relevant operational procedures in this recently introduced sector in Sudan, as well as the main constrains hindering production. This is important since Sudan is seeking for strategic food security, and bettering the nutritional status of its growing population to raise economic growth. By so, the research problem could be stated as: What is the situation of farmed fish production through 2008-2018 and their constraints in the Hasahiesa locality in northern Gezeira State of Sudan?

This research objects to examine farmed fish production in the case study area; outline its constraints; and discuss its findings within food security context for the Sudan. This makes the research significant since fish farming is important source for securing food for both rural and urban settings; the imposed rapidly growing population of Sudan requires looking for more food sources; and the achieving of food security is crucial for the future development of country.

2. Previous studies

There are many studies carried out in different environments concern with different sides of fish farming. In Oyo State, Nigeria**,** there is an indication that fish farming is profitable (Olaoye et al 2013). Similarly, fish production in Ogun State, Nigeria is economically rewarding and profitable, capable of creating employment, augmenting income and improving the standard of living of people (Adewuyi et al. 2010). Farmers across Kenya are again turning to fish farming as a way of production of high quality food, either for their families or for the market, and as a way of earning extra money (Ngugi et al. 2007). The study carried out in Bangladesh by Sangiorova et al. (2020), revealed that integrated rice-fish farming can play an important role in increasing

food production as the integrated farming system is better than rice monoculture in terms of resource utilization, diversity, productivity, and both. Most livestock-fish integration is sound business conducted by entrepreneurs accessing urban markets where the price of fish is relatively low (Little et al. 2003). In the Chinese system of growing fish on manure, intensive fish farming can reduce the cost of fish and maintain the existence of many types of commercial fish, and number of different fishes are grown together, where maximum yields per unit area are higher with high-protein feeds than with manure, but are obtained at a greater cost (Wohlfarth et al 1979). Petersen et al (2002) indicated that, integrated fish farming seems to favor antimicrobial in the pond environment which could be attributed to the selective pressure of antimicrobials in the pond environment and/or to the introduction of antimicrobial-resistant bacteria from animal manure. Integrated fish farming combines livestock (chicken and pigs) production with fish farming where animal manure is shed directly into a fish pond as fertilizer and supports growth of photosynthetic organisms.

According to Chou et al (1997) commercial marine fish farming in Singapore is mainly the culture of economically important food fish species in floating cage nets, and trash fish is still the main feed used for the farming of finfish because it is cheap and readily available. The review results by Yang et al. (2021) show that the most significant contribution of deep learning is its ability to automatically extract features including live fish identification, species classification, behavioral analysis, feeding decisions, size or biomass estimation, and water quality prediction. Currently, inland aquaculture production in Latin America is insignificant compared with output from inland and marine fisheries (Kapentsky et al 1997). The fishing industry has a special role in the development of agricultural economy. Fish farming in cages is currently very important and is a promising and economically profitable form of growing marketable fish (Sangiorova et al. 2020). Harvesting fish in irrigation systems, sometimes involving some form of husbandry or even culture, is a practice at least dates back two millennia. Although seldom recorder, it seems to have been widespread in the tropics and subtropics, especially in rice fields (Fernando et al 2000).

In Ghana, the main constraints identified as affecting the profitability of subsistence fish farming were the relatively low prices of fish and low levels of output which could be improved through better farming practices (Asmah, 2008). High stocking densities of homogeneous subsets of fish greatly enhance diseases transmission opportunities in Finland (Pulkkinen et al 2010). Fish are always susceptible to a variety of lethal diseases caused by different types of bacterial, fungal, viral and parasitic agents. The unscientific management practices such as over feeding, high stock densities and destructive fishing techniques increase the probability of disease symptoms in aquaculture industries. According to the FAO each every year several countries such as India, China, Norway, etc. face a huge loss in aquaculture production due to mainly bacterial and viral diseases (Banerjee et al. 2017). According to Karakassis et al. (2005), that in the long term, fish farming waste could cause a 1% increase in nutrient concentrations in contrast to other anthropogenic activities which might double the Mediterranean nutrient pool. The current amount of residue generated from fish rearing suggests that this will be a decisive factor in sustainability of fish farming in coming years. Due to the great intensification of fish farming, the amount of residue deposited into the rearing tanks has increased significantly (Lazzari et al. 2008). In Bangladesh, rice monoculture cannot provide a sustainable food supply without a cost-term environmental sustainability (Sangiorova et al. 2020). There are a host of problems facing the growth of Kenya's fish farming industry. These constraints include; uncoordinated promotion of fish farming through many institutions, government, research institution, etc. and there are no comprehensive policies of fish farming and legislation are inadequate, therefore, there is no significant growth in fish industry and the farmer is left confused by many extension officers who visit and give varying information (Shitote et al 2012).

3. Theoretical framework

Fish farming is a form of aquaculture in which fish are raised in enclosures to be sold as food. These "aquafarms" can take the form of mesh cages submerged in natural bodies of water, or concrete enclosures on land (Animal Welfare Institute, 2023). Fish farming could also refer to commercial production of fish in an enclosure or, when located in a body of freshwater or marine water that is penned off from the surroundings water by cages or open nets (Encyclopedia, 2019).

Among major food production sectors, world aquaculture shows the highest growth rate, providing more than 50% of the global seafood market (El-Atab et al 2020). Aquaculture production of finfish has seen rapid growth in production volume and economic yield over the last decades, and is a key provider of seafood (Fore et al. 2018). In thirty one countries including all major producing ones, where between 5.5 and 6.0 million metric tons of shrimp, finfish, and crayfish cultured production are represented, which accounts for about 90% of the world's total (Brown, 2012). Today, about half of fish consumed globally are raised in these artificial environments. Commonly farmed species include salmon, cod, trout and halibut. It is the fast growing area of animal food production. Semi-intensive aquaculture, particularly in the tropics, accounts for nearly 70% of the finfish production of the world (Tacon, et al. 1997). It also contributes to the nutrient loading of the Mediterranean region (Karakassis et al. 2005). It well recognized that, seafood derived from wild fish as well as harmed fish has always been an important source of protein in the human diet and it was estimated that 30% of fish for human consumption comes from aquaculture (Hastein et al. 2006).

The depletion of many marine fisheries has created a new forward motion to expand seafood production through fish farming, or aquaculture (Goldburg et al. 2005). Marine and many inland fishery resources are heavily exploited or overexploited, and although there is potential for increasing production from inland fisheries through intensification, development of aquaculture holds the most promise in the long run term for improving food security through increasing the supply of fish (Kapentsky et al 1997). Consequently, global aquaculture is on the rise, growing more than 5% over the past decade, which holds good avenues for the world's food supply (Powell, 2003). Therefore, offshore fish farming is predicted to increase in the near future driven by lack of coastal space (Holmer, 2010).

4- The study area, research methods, sources and analysis of data

Hasahiesa locality, lies between latitudes 14 36 – 14 48, longitudes 33 12- 33 25, stretches close to the Blue Nile and into the Gezeira scheme, one of the famous irrigated schemes in the world (**figure 1)**. Its area is 4159337 square kilometer divided into seven administrative units, connected through some main roads such with other parts of Sudan and with several minor roads with interior of Gazeira scheme, besides the railways, river and air transport. Its topography is a flat clayey plain with a gentle slope of 1:500 meters and 1:1000 meters directing from southwest to northwest; and characterized by tropical climate of semi arid with summer rains of 16"/year where 86% falls during August and September, and a mean summer temperature of 35-40 C^0 and a mean winter temperature of 29-35 C^0. The majority of the population practice agriculture as the main economic activity, besides animal keeping. There are some major industries of cotton yarn and oil food production besides commerce activity.

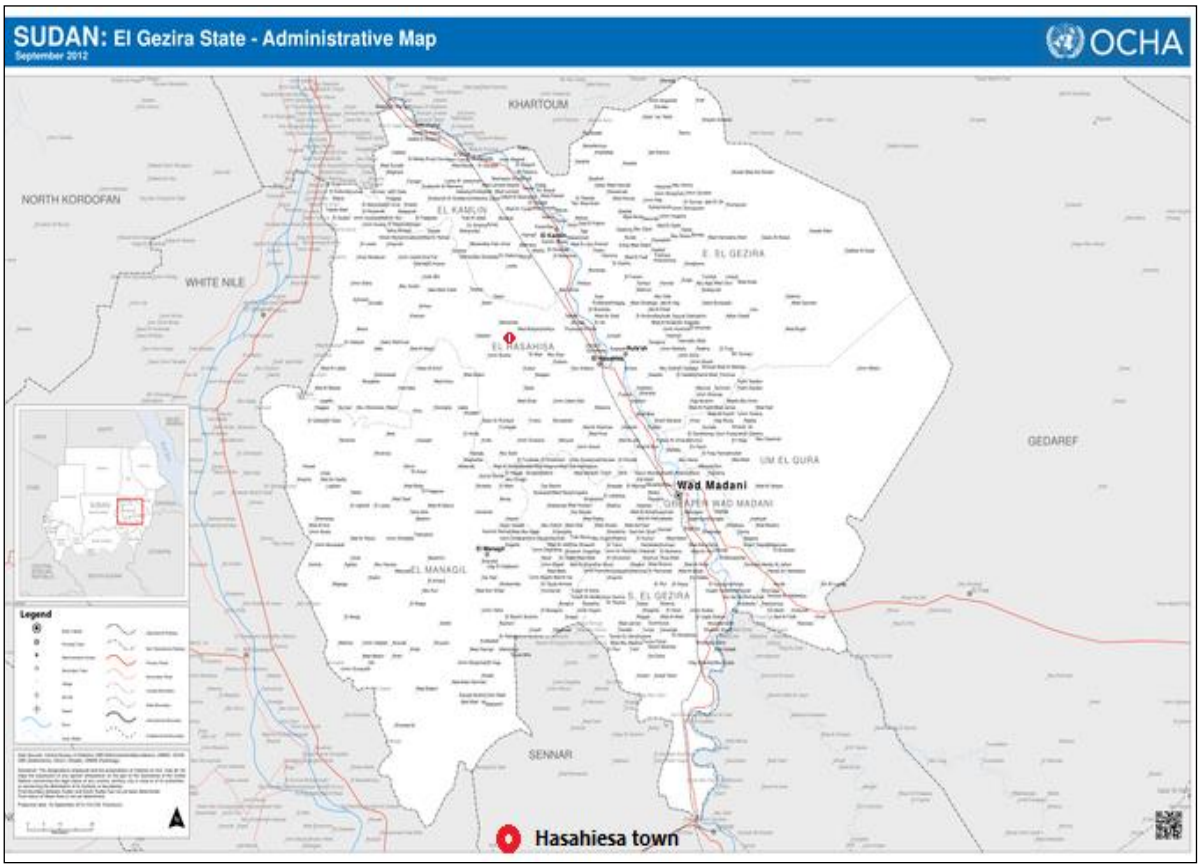

Figure 1: Location of Hasahiesa locality in the Gezeira State

Source: OCHA

The target population is the licensed fish farms in the Hasahiesa locality in the northern Gezeira State, Sudan. Their number is 50 licensed farms distributed within its seven administrative units. A structural questionnaire was designed, directed to the owners of the 50 licensed fish farms. It consists of two parts:

a- Part one: deals with general information about the interviewees included sex; age; educational level; years of experience; etc.

b- Part two: deals with information about production of farmed fish through 2008-2018, management of farms, operational procedure of fish farming, marketing, and main production constraints.

This questionnaire formed the source of primary data of this research, while secondary data included documents review relevant to the study available on scientific sites. Analytical and descriptive methods were done by applying SPSS. The nearest neighbor analysis index was calculated to determine the distribution of licensed fish farms in the study area.

5. Fish farming production in the study area

5.1 Elements of fish farming production

The general characteristics of the fish farms owners, with reference to the prevailing characteristic are that, the majority are males (96%); aged 40-49 year old (34%); 44% university graduate; 34% veterinarian; and 44% has less than 5 years experience. 70% of the farms employ 1-2 laborers who aged less than 50 years (79%); 45% a secondary year graduate; 21% a university graduate; 50% has less than 5 years experience; mean annual income in 2018

was 42,000 Sudanese Pound. Self- financing is the main source for a farm operation as confirmed by 90% of the farms owners. Light trucks transport production (60%) to be marketed in Khartoum, WD- Medani, and small in neighboring towns.

The general distribution of fish farms in the study area is uneven as confirmed by the value of the nearest neighbor analysis index which equals 0.7. The geographic distribution within the seven administrative units ranks Hasahiesa first; Tabat second and Wd-Habouba third. The number of farms becomes fewer westwards due to remoteness from the Blue Nile which is the main source of water for fish farms, and also to food habits of the communities living there, where some do not prefer fish in household food budget. Generally, the distribution of the farms is coincided with water availability along the Blue Nile and groundwater.

The geographic and relative location of the study area is good for investment in fish farming where its closeness to the Blue Nile secured the sustainability waters for farms and marketing of production in big urban centers such as Khartoum complex and Wd-Medani the capital of Gezeira State, as well as purchasing of input supplies via crossing main roads. Fieldwork results revealed that, 66% of the farms lie close to a transportation road or a water source; 24% lie close to a water source only; 4% close to a market or a water source, 6% close to a village or water source. This is because; one of the perquisites of licensing a fish farm is to be close to a water source. Source of water for farms as indicated by farm owners s including wells (62%), the Blue Nile (19%), or both (28%) which guarantee the supply of water all along the production season.

The fish farms in the study area take the form of concrete enclosures on land. Therefore, it is a perquisites for a issuing of a license is to build an appropriate basin floor to prevent water dissemination beneath; safe from organic pollutants; accessible; and remote from residential areas. The clayey soil of the study area used in fish farms, positively contributes into success of fish farming as indicated by 96% of the farm owners since it is characterized by low porosity and capability to keep water. 62% of the farms use clayey soil, 30% use silt, and 8% use a mixture of both types. In addition, surface flatness and gentle slope of the study area ease charging and discharging of fish farms' basins as they depend utterly on streamlined discharge which reduces the cost of production.

Climatic factors are vital elements into success of fish farming in the study area which has long hours of solar illumination exceeding 9 hours/day from February to May, and 6-7 hours/day during June to September which betters feeding; and reproduction environment; and the health status of fish. Similarly, temperature positively contributes as confirmed by 66% of the respondents. There are 60% of the respondents indicated to the dreadful influence when temperature falls during the rainy season when fish lose desire for feeding. They also indicated to the rainfall influence as it raises basins' water level, increase dissolved Oxygen in water, and raise sub-soil water level. This is as well as winds which increase dissolved Oxygen in water and help decay of organic matter as indicated by 89% of the respondents.

The suitable type of farmed fish type determines the success or failure of a farm. Fieldwork results depicted that Nile tilapia *"Oreochromis niloticus"* is cultivated by 50% of the farms, while cat fish "*Claris gariepinus"* by 26%, and both are considered as the most preferred types of farmed fish by consumers and producers. Farms produce either Nile Tilapia *"Oreochromis niloticus"* or Cat fish "*Claris gariepinus"* or both and this could be referred to various reasons. Nile Tilapia *"Oreochromis niloticus"* is tasty, boneless, could feed on organic remnants; easily reproduced; bears extreme temperature fluctuations; and resists diseases. Cat fish "*Claris gariepinus"* also, is tasty; easily reproduced; resist diseases; financially profitable and highly affordable by consumers. Both species rapidly reproduced, enable for diversification of production particularly as they reach marketable biomass within 4 to 6 months. The Centre for Fish Research which was established in Khartoum with six branches in some major cities in Sudan, tested fish farming experimentally and proved suitability of Nile Tilapia *"Oreochromis niloticus"* and *cat fish* "*Claris gariepinus"* to be most suitable fish type to be farmed in such an industry (Hot, 1959).

5.2 Fish farming production trends: 2008-2018

Mean fish farm production by a farm per a month in tons is shown by figure (2) covering the target period 2008-2018. The mean production in 2008 per a farm was nine tons per a month, and was considered promising since it was a newly introduced experience in the study area. In 2009 production declined to eight tons, and smoothly increased through 2010 to fourteen tons, sixteen tons in 2011, and eighteen tons in 2012. In 2013 production declined to eleven tons because some farms were either producing small amounts not exceeding a ton; or some others were no longer producing. In 2014 production improved to sixteen tons and similarly increased in 2015 to seventeen tons. However, since the year 2015 fish production started to decline from fifteen tons in 2016 to then to twelve tons in 2017 and quickly dropped to five tons in 2018. Generally, fish farming production in the study area depicted a non-stable and a fluctuating pattern of production.

This fluctuation and quick dropping of fish farming is due to attacks of predators such as URL (40%) and waterfowl (38%) and frogs (6%) and snakes (2%), and the influence of temperature rising (14%). Combat of predators is executed rotationally as indicated by 28% of the respondents; or do it when necessary as confirmed by 72%; or by re-pumping of water into basins; or by applying ventilation; or by damping covers when temperature rises. They combat snakes and frogs by cleaning grasses and applying pesticides, while for waterfowl combat they apply damp covers on basins by nets or raise basins' water level, while for URL they siege basins by barbed wires, clean grass, and use traps.

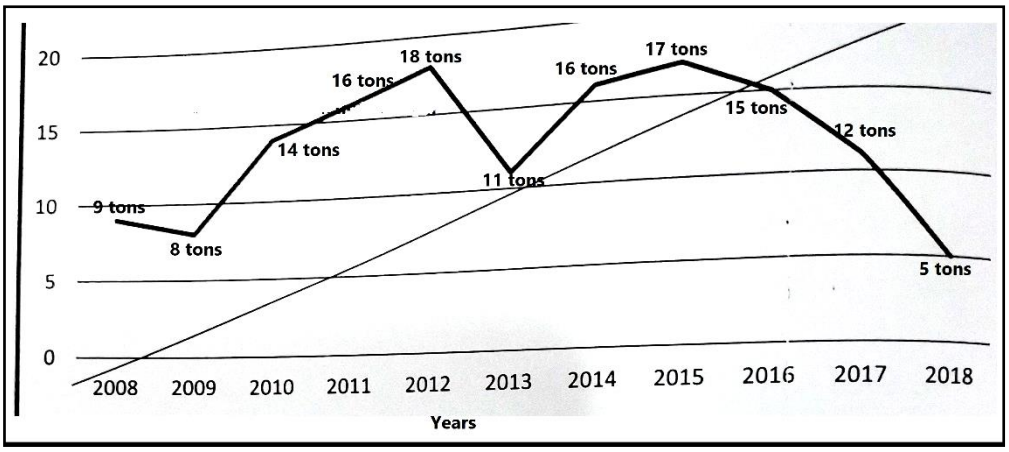

Figure 2: Fish farms production 2008-2018

Source: Fieldwork survey 2019

5.3 Fish farming production constraints

Fluctuation and declining of farmed fish production could be due to several reasons and constrains. Some of the main reasons are those due to difference in a farm area; volume of farmed fish; feeding patterns; and type of farmed fish where difference in productivity leads to difference in production. Constraints are administrative, legislative or financial ones. Administrative constraints include lack of governmental support on fish hatching; improvement of genetic traits, veterinary services of hybridization for new species. There are some administrative constraints associates with high loss of cultivated fish (30%), unhealthy cultivated fish (10%) or stunted cultivated fish (60%). Due to these problems the owners of the farms (60%) tend to get cultivated fish from its natural source which is the Blue Nile. There is also a serious defect at the administration farm level where the majority (70%) of the farm owners is not ichthyologists opposite to 12% who are ichthyologists, while few farms (18%) of farms employ ichthyologists. Ichthyologists are aware with scientific and technical sides of fish farming such as feasibility study of location, soil and waters testing, etc. This appears where soil testing, as a prerequisite for a fish farm investment, is not done by 70% of the farms' owners; and while only 30% of them did water analysis before establishing a farm, there is 82% of the farm owners do not care for periodic water testing to monitor its quality. This is because the majority (80%) of farm owners does not possess measurement devices which threaten the farmed fish as deficiency in dissolved oxygen leads to fish death.

There are also many problems associated with a reliable source of fish feeding as confirmed by 86% of the farms' owners. The risks come from direct purchase from the markets (28%) which provide a feeding of either the remnants of poultry slaughterhouses or remnants of poultry bowels. Other farms' owners (32%) purchase from a specialized firm with a high price amounts to 18000-24000 S.D. per a ton, where two ton produces one ton of a fish, while others (40%) work to prepare fish feeding in their farm. Another administrative constraint associates with remoteness between fish farms and feed firms which increase the cost of transport, in a situation where there is only one firm in Gezira State and some others in Khartoum State which is far by 180 Km. Therefore, 40% of the farms used to feed fish on feed prepared in the farm which requires an ichthyologists to prepare the mix correctly. Here, 80% of the fish farms do not analyze the prepared mix in the farm due to lack of technical experience, and only 20% arrange with an ichthyologists. Some other farm owners (60%) prepare the feed mix with whatever available material such as dry bread or light sorghum, or establishing an oil press to use its remains for fish feeding (75%). The high cost of a proper mix and high electricity fee in the industrial sector, among others, have driven farms' owners to change the pattern of fish feeding. There is a lack of extension service (26%) which has led to prevalence of technical faults (74%) such as choice of suitable cultivated fish, fertilizer, disease diagnosis, farm design, and water quality follow-up.

There are also, legislative constraints where the Decree of management and development of fish wealth in Sudan for the year 1975, did not put great concern to fish farming sector, since it was recently introduced in country. Also, there are no regulations concern with protecting, organizing, and encouraging the utilization of some public natural locations such as rivers, lakes, lagoons for fish farming. The farms' owners who prefer to keep farmed fish in submerged cages and fences in these natural water bodies are confronted with governmental administrative sovereignty of Ministry of Irrigation and Administration of River Transport on these natural resources. Similarly, the issued formal regulations for tax relinquish were not enforced and in turn, investment in this sector was slowed down. In addition, regional regulations enforce tax; however, do not conditionally require a prior feasibility study for a farm and by this way, a big farm means a more compulsory tax. This is done with no consideration to the government rule issued in 1999 to govern fisheries in Sudan, including fish farming, and was amended in 2003. It encouraged investment in fish farming sector, exempted partially or completely tax and fees imposed by local administrations, allocated land for farms; facilitated banks' loans; and provided instructional services (General Administration of Fish and Aquatic Live, 2017).

According to the fieldwork results, there are also financial constraints such as high cost of fish feeding (50%); high tax and ransoms (20%); high fuel cost (10%); high cost of veterinary supervision and follow up (8%); high land rental fee (4%); laborers' wages (4%), cultivated fish (2%); and buying of nets and fishing necessities (2%). Fieldwork results also, revealed that the cost of production in fish farming is higher than in natural resources as confirmed by 82% of the farm owners. This reflects on the price of marketed fish of both sources where customers automatically prefer to buy the affordable one.

Generally, cost of production was less than the price of marketed fish however, in last the years they became almost similar. This means that there is no added value for a farm owner in a situation where 80% of the farms are completely self-financed and banks finance only by 20% in the form of loans. Production is also complicated by marketing constraints such as the tendency of farms' owners to market their production immediately following the end of growth season which overflows markets by huge amounts, leading to drop of price; fluctuation of prices and demand; controlling fish marketing by powerful traders; nonexistence of transformational fish industry to absorb any surplus in production; and lack of national marketing plans or regulations controlling markets. Also, community preferences of red meat to fish influence fish price by 14%. This is because the community is basically a livestock keeper.

6. Discussion

The fieldwork results in Hasahiesa Locality, Northern Gezeira State, agree with many previous studies outlined in this research. The profitability of fish farming in the study area, regardless of its constraints, is similar to that in Oyo State (Olaoye et al 2013) and Ogun State, in Nigeria which is economically rewarding and profitable, capable of creating employment, augmenting income (Andewuyi et al. 2010). It also holds a similarity of the research done by Sangiorova et al. (2020), who revealed the role of integrated rice-fish farming in increasing food production in Singapore (Chou et al 1997). Some of the financial constraints of farm fish production in the study area could be similar to those in Ghana, which were the relatively low prices of fish and low levels of output (Asmah, 2008); similar to indications by Banerjee et al. (2017) bacterial and viral diseases; and to Nicholson et al. (2017) work where diseased fish were examined from eight farms in different areas of the Nile delta, and detected *Aeromonas* species and, for the first time, the presence of TilV in Egyptian tilapia aquaculture; and to the study of the influence of great intensification of fish farming done by Lazzari et al. (2008); and to Kenya's fish farming industry constraints such as uncoordinated promotion of fish farming through many institutions, government, research institution, etc. absence of comprehensive policies (Shitote et al 2012).

Sudan owns a complex of river systems, seasonal valleys, reliable rain water, and the Red Sea coast with approximately 480 km. These are secure sources for fish and fish farming. Therefore, it could be stated that fisheries resources of Sudan could have an important role in food security and poverty alleviation in both rural and urban Sudan, particularly as Sudan is confronted with challenges to secure food and promote the nutritional status, and alleviate poverty of its rapidly growing population. Fish farming could unquestionably contribute into securing food in Sudan although little is known about the nutritive value of the Nile fish (Idam et al. 2023). The experience of fish farming in Hasahiesa Locality in the Northern Gezeira State is a good example, conditionally overcoming the constraints outlined earlier. This could be further supported by Ismail's study in the Gezeira State which confirmed that, fish farming has an important role in food security (Ismail, 2014). The study done on Nile Tilapia by Idam et al (2023) show that, Nile Tilapia from concrete ponds has higher level of nutritive value than eastern ponds farms except fiber contents in higher eastern ponds farms, and there was highly significant difference in nutritive value of fish between the two types of ponds (Idam et al. 2023). Nile tilapia from Nile environment had significantly lower levels of cholesterol and triglycerides than that from ponds. There were significant differences in all water quality parameters. Nile River and well water had significant differences in H2S. Nile River aquaculture environment is an immediate environment in relation to ponds environment (Idam et al. 2019). Our study revealed that, Nile Tilapia *"Oreochromis niloticus"* and *cat fish* "*Claris gariepinus"* were the most suitable fish type to be farmed due to many reasons already outlined in the text, and consequently determines rates of demand and consumption. This is similar to the situation in Juba town, South Sudan State, where the most preferred fish species and products, purchasing points, motivation and constraints, and information accessibility are influencing fish consumption among households (Alosias, et al 2022).

Great effort is required before fish farming can boost food supply in the Sudan (Yousif, 1987). Here, Sudan could benefit from others' experiences which confirmed the positive contribution of fish farming in overcoming these challenges facing the Sudan. Fish, as a source of rich food for poor people can play an important role in improving food security and nutritional status where more than 200 million Africans eat fish regularly. Fish may also be the sole accessible and/or affordable source of animal protein for poor households in urban and peri-urban areas (Bene et al. 2023). From these experiences that could benefit Sudan is that of Oyo State, Nigeria, where significant level of profit obtained from fish farming had potentially alleviated poverty there (Olaoye et al 2013). In drought risk areas of Zimbabwe, Mwenezi district, the implementation of fish farming as an innovative and economic strategy for promoting food security and dietary diversities among vulnerable households has revealed that fish farming was well embraced by local communities as it led to improvements in food security, household income and employment regeneration (Shava etal 2017). In areas with little or no access to markets in central Cameroon, the number of fishponds and fish farmers can be increased and yields improved, increasing local food supplies on small-scale farms (Brunnett et al 2011). The impact of fish farming on household food security and livelihood of fish farming and non-fish farming households in Siaya County in western Kenya avail fish as food hence improved food and nutrition security to curb incidences of under-nutrition in pre-school children and lactating mothers (Nguka et al. 2017). The Government of Ghana and international NGOs have been encouraging the adoption of fish farming to alleviate poverty and food insecurity through training workshops, financial contributions and creation of a fisheries ministry. The results suggest that fish farming households have higher nutritional quality and frequency of food consumed than the non-fish farming households through direct consumption. The probability of adopting fish farming increases with wealth, location, ecological zone and household size but, decreases with household income per capita (Akuffo et al. 2019). There are also many economic returns of fish farming as confirmed by research done in Osun State, Nigeria where shows higher revenue to large, medium, and among small-scale farmers in that order (Agboola, 2011).

Conclusions

This study performs an analysis of fish farming production in Hasahiesa Locality in the Northern Gezeira State of Sudan. The results suggest that there are good elements of production including physical and human ones; however, production is fluctuating and declining due to administrative, legal, financial, and technical constraints. Regardless of these constraints, the study area is promising in fish farming production if responsible authorities worked to overcome them. The expected positive roles of fish farming in securing food and improving nutritional standards for the Sudan's population is documented by empirical studies world widely and this should be included in future food and strategies of the country.

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