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AQUACULTURE: A PROMISING SOLUTION FOR FOOD INSECURITY, POVERTY AND MALNUTRITION IN KENYA

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ABSTRACT

Food insecurity remains one of the most visible dimensions of poverty. The increasing population amid competition for land and water resources means that the global demand for food will continue to increase. In Kenya, the food insecurity trend is worrying as the population is expected to hit 55 million by 2020 against an annually declining arable land per capita and consequent increase in food prices. The Kenyan agricultural sector has failed to either eliminate or reduce malnourishment for poor populations as the annual national production for both staple food and livestock products fall short of national consumption levels. The nutritional deficiency levels remain high among a significant segment of the Kenyan population. With increasing food production challenges such as dwindling capture fisheries and impacts of climate change becoming more eminent, solutions to food insecurity and malnutrition in Kenya must bring about quick results in food availability by stimulating more own-food production. Aquaculture has so far been recognized as an important opportunity to enhance household food security in developing countries. The existing literature reveals scattered but increasing evidence of the contribution of aquaculture to nutritional security through direct fish consumption and income stability among vulnerable groups through involvement in aquaculture value chain linkages. This paper reveals the status of food insecurity, poverty and malnutrition problems and discusses aquaculture initiatives as the remedial solutions. This paper also provides a framework for examining aquaculture's value chain linkages to food and nutritional security and national economic growth by elucidating key pathways concerning the role of aquaculture in household food and income systems. The authors advocate for clear and sustainable national policies for aquaculture development to address food insecurity and poverty questions more sharply. More empirical evidence should be collected on the varied aquaculture opportunities to improve the income, employment and food consumption levels within the poor households.

Key words: KMFRI, MDGs, Aquaculture, Food insecurity, Poverty, Kenya, Malnutrition, Fish, Agriculture

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INTRODUCTION

Recent global hunger statistics indicate that 12% of the global population (842 million people) are unable to meet their dietary energy requirements [1,2]. About 98% of the 842 million hungry people live in developing countries, where the prevalence of undernourishment is highest globally at 14.3% (Table 1) [2]. While the average number of undernourished people has generally continued to decrease in global scale, the sub-Saharan African region has dragged the rate of progress, which now appears insufficient to reach international goals for hunger reduction set by the Millennium Development Goals (MDGs) [3]. Statistically, Africa and especially the sub-Saharan Africa recorded the highest prevalence of undernourishment of 21.2 % and 24.8 %, respectively in 2011-2013 (Table 1) [3]. As the food demands rise due to expanding populations and changing eating habits, the problem is further worsened by the disparities in food growing inequalities within and between regions and effects of climate change.

Nonetheless, the hunger reduction target in developing countries can be met provided that additional hunger reduction efforts are brought on-board. In Kenya, developments in agriculture over the last twenty years have failed to reduce malnourishment for the poorest populations, and a different model focusing on backyard food production is a must. However, food producers are experiencing greater competition for land, water, and energy, and the need to curb the negative effects of food production on the environment is becoming increasingly clear [3,4]. Indeed, there is need for programmes that deliver quick results on food availability by stimulating more own-food production among the vulnerable groups. Aquaculture's meteoric rise during the last two decades provokes both optimism and apprehension among scientists and policy analysts concerned with global food security [5]. There is evidence that aquaculture can create significant income multiplier effects needed to escape the poverty trap through production value chain linkages for smallholder population, which makes the bulk of developing nations [6]. With the favourable climate in Kenya, and the requirement of minimum space and labour for fish pond management, aquaculture is an opportunity to produce nutritious food within a short time. This paper reveals the food insecurity, poverty and malnutrition problems and discusses aquaculture initiatives as the remedial solutions. The paper also brings into perspective the potential national economic gains through aquaculture value chain linkages.

The dimensions of food security and nutrition

Aquaculture, the controlled land-based or open-ocean farming of aquatic organisms such as finfish, shellfish and plants, is the fastest growing food sector globally alongside terrestrial crop and livestock production [7]. Food security is a condition in which people have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [7]. Poverty is generally considered as being one of the major causes of food insecurity [8]. Therefore, poverty eradication is essential to improving access to food. There are four dimensions of food security: availability, access, stability and utilization. These dimensions, and in particular the 'utilization' dimension, embody the food and care related aspects of good nutrition. The determinants influencing the dimensions of food security are summarised in figure 1.

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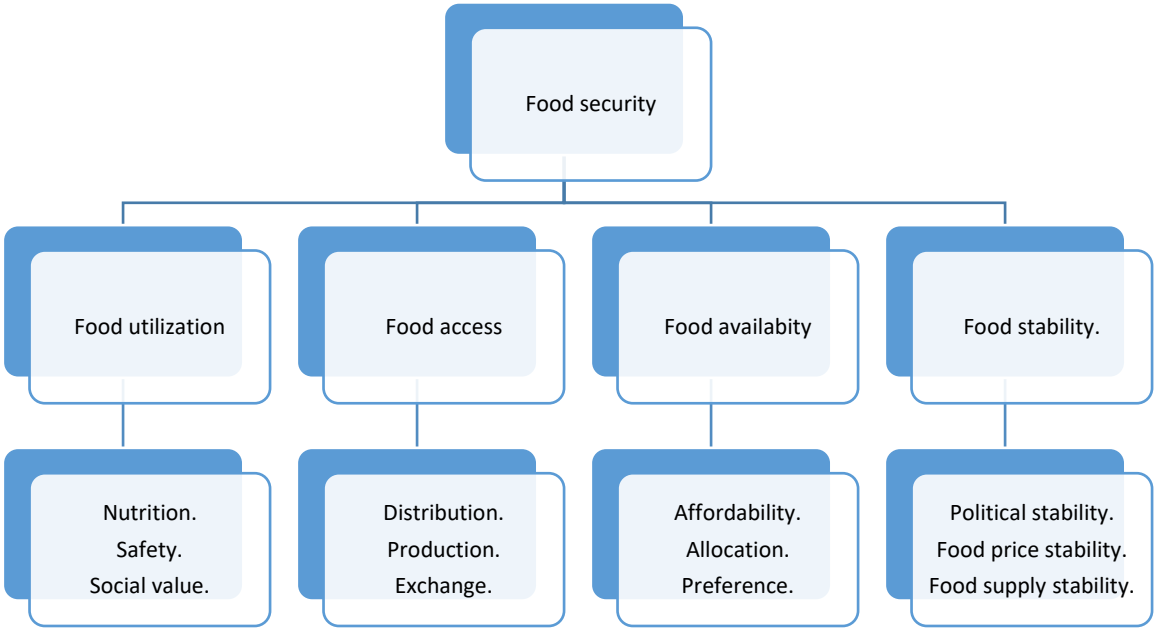

Figure 1: The four dimensions of food security and their determinants (modified from [41])

Nutritive value of fish

Where its rich nutrient content is preserved, fish provides protective effects on a wide range of health issues including obesity, stroke, high blood pressure, and coronary heart disease [8]. In poor countries where high amounts of cereals are eaten, the challenge is that both cereals and other essential nutrients are in short supply. Small fish eaten with head and bone secures the intake of essential minerals, and therefore, forms an important part of a healthy diet. Food fish has a nutrient profile superior to all terrestrial meats [8,9]. It is an excellent source of high quality animal protein, highly digestible energy, omega-3 polyunsaturated fatty acids (PUFAs) and vitamins [1] (Table 2). Unfortunately, in Kenya, albeit with some few exceptions, fish has been only marginally included in the national debate on reduction of micronutrient deficiency, precisely where it could potentially have the largest impact.

Impacts of climate change on Kenyan food production sector

The projected impacts of climate change on staple agricultural crops in sub-Saharan Africa will be worse by 2050 (Figure 2) [10]. In Kenya, the arrival of climate change on the policy agenda is fairly recent and the links between climate change and food security is being explored [11]. Over 75% of Kenya's population earns their living from rain fed agriculture despite perennial droughts [12]. Extreme weather and climate changes influence agricultural production, which is the major economic earner in Kenya [13]. The country faces tremendous developmental challenges in nearly all sectors. For example, poverty is endemic, deforestation is continuing, malnutrition and infant mortality rates remain high. Consequently, the country is plagued by severe food insecurity and has problems feeding its population. The Kenyan National Climate Change Response

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Strategy (KNCCRS) recognises that Kenyans are vulnerable to existing climate change variability because of high dependency on key natural resources and a relatively low adaptive capacity to cope with climate-related impacts. Table 3 illustrates how climate change can affect the dimensions of food security.

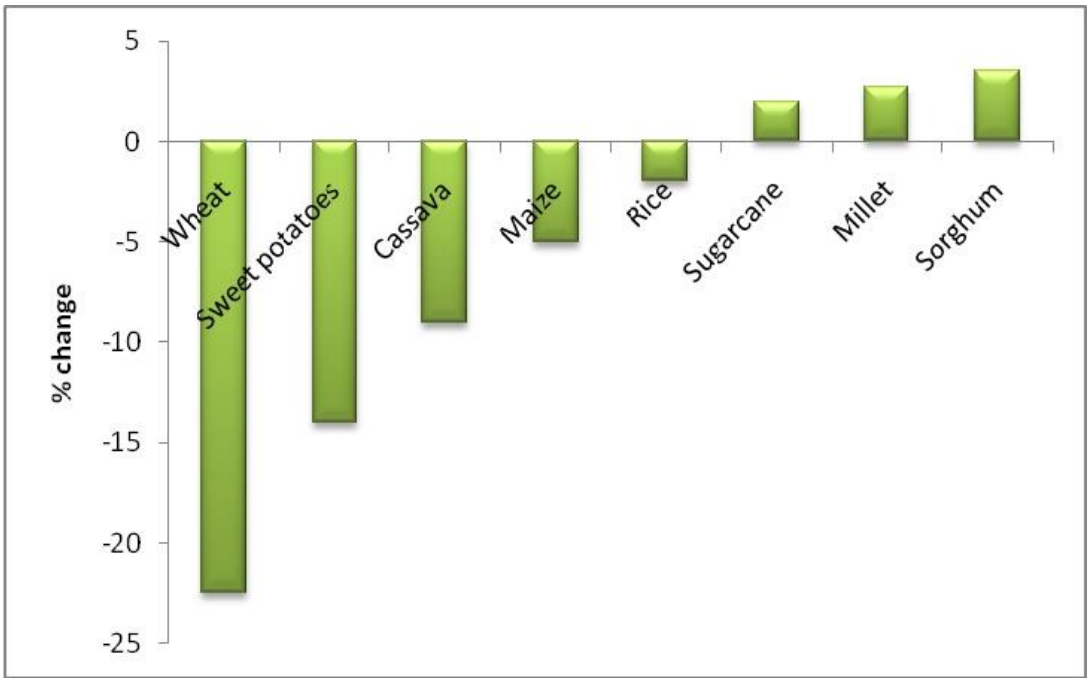

Figure 2: Yield changes projected by crop as a result of climate change, 2050, sub-Saharan Africa (percent change) Adapted from [10]

Food insecurity, poverty and malnutrition; the current situation in Kenya

The prevalence of undernourishment in Kenya has been increasing over the years and the country is unlikely to achieve the MDG hunger target by 2020. This could be attributed to retarded food production capacities failing to match population growth, which, with an annual rate of 2.9%, is among the highest in the world [14]. With the declining food production per capita and challenges of unequal food distribution in Kenya, about one-third of the population are chronically undernourished [14].

Over the years, the Kenyan government has strived to achieve national, household and individual food security throughout the country albeit with minimal success. The economic review of agriculture indicates that more than 60% of the Kenyan population lack access to adequate food due to poverty, which stands at 46% [14]. The average national supply for staple foods in Kenya is as follows; maize: 2.4 million tons yr^{-1} against a national requirement of 3.1 million tons yr^{-1}, wheat: 360,000 tons yr^{-1} against national requirement of 900,000 tons yr^{-1}, rice: 120,000 tons yr^{-1} against national requirement of 280,000 tons yr^{-1} [14]. Livestock products including milk, beef, mutton, goat meat, pork, poultry and eggs are produced in insufficient quantities to match growing demand. For example, on average, 4 billion litres of milk are produced annually against local demand of 4.1 billion litres. The meat sub sector is dominated by red meat (beef, mutton and goat) accounting for over 70% of the meat consumed locally while

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white meat (pork, fish and poultry) makes up the remaining 30%. The annual production of red meat is 430,000 tons yr $^{-1}$ against national requirement of 450,000 tons yr $^{-1}$ while white meat is 40,000 tons yr $^{-1}$ against requirement of 42,000 tons yr $^{-1}$ [14]. The production figures of the major agricultural food items pose a gloomy picture of the Kenyan food industry. The soaring costs of farm inputs, energy costs and erratic weather patterns have negatively affected national food security. Despite having high potential of unlocking the malnutrition problems in the country, fish farming has been neglected. This could be the forgotten asset with utmost capacity to solve the myriad food insecurity challenges. Food security, rural development, and poverty alleviation are closely linked. The current percentage of Kenyans living below the international poverty line of 2 USD day $^{-1}$ is 67.2% [15].

In Kenya, the nutrition situation in Turkana, Baringo (East Pokot), Mandera, Wajir West, Tana River, Mandera, Garissa and Samburu areas has deteriorated significantly to critical levels, where 1 out of 4 children is acutely malnourished [15]. Due to poverty, lack of food and other essential resources for survival, 33% of children under the age of five are stunted (low-height-for age), 22% of these children are wasted (low-weight-for age) while 43% of the total population is chronically undernourished [15]. This calls for immediate and urgent scaling up of nutrition service delivery structures to effectively target households with nutrition vulnerability [15,16]. The deterioration in the nutrition situation in these areas is attributed to the current declining food security situation, drought and chronic vulnerabilities.

The Kenyan fisheries sector

Kenya has about 600 km stretch of ocean coastline and multiple freshwater bodies dotted in the country [17]. The Kenyan coastal capture fisheries sector comprises mainly artisanal practices while offshore marine waters are exploited by foreign vessels. Therefore, Kenya depends mainly on freshwater inland capture fisheries for local fish supply. Currently, Lake Victoria accounts for 92% of national fisheries production while marine capture fisheries consist of 4% [17]. Unfortunately, the Lake Victoria fishery is facing imminent collapse due to uncontrolled pollution problems. Fish stock sizes, catches and landings have drastically declined within the last two decades and many indigenous fish species are close to extinction [18,19]. This decline in fish stocks threatens the survival of nearly a million people in Kenya who directly or indirectly depend on the lake's fishery resources [20]. With the clear indications of dwindling wild fish catches in freshwater systems and inability to exploit our exclusive economic zone (EEZ), aquaculture stands out as the unexploited saviour to provide cheap and the highly needed quality proteins to suppress malnutrition disparities in Kenya.

The potential of aquaculture development in Kenya

Between 1950 and 2006, the Kenyan annual aquaculture production never exceeded 2,000 MT yr $^{-1}$ (Figure 3) [21]. Until 2009, about 7,500 fish farmers, mostly from the Rift Valley and Central provinces, held about 7,500 production units in an estimated area of 722.4 ha [21]. Recognizing aquaculture as one of the viable options for revamping the country's food sector, the Kenyan government funded the national farming program in 2009 to stimulate economic development, foster economic recovery and alleviate poverty [21]. The program aimed to increase production of farmed fish to 20,000 MT in the

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medium term and above 100,000 MT in the long term [21,22]. In the first year of the program, more than 27,000 fish ponds were constructed nationally [22]. This triggered an immediate short-term demand for about 28 million certified tilapia and catfish fingerlings and over 14,000 MT of formulated fish feeds [22]. The ripple effect of the program shifted demand for seed fish and feed to over 100 million and 100,000 MT, respectively [22]. By 2011, the national aquaculture production was estimated at 12,000 MT y^{-1} (Figure 3), equivalent to 7% of the total production of captured and cultured fish and valued at $ 21 million [22]. The production is projected to hit 100,000 MT y^{-1}, representing 50% of national fish production, in the next 10 years. This presents a lucrative opportunity for aquaculture development in the feed and seed fish sectors, which unfortunately, still suffer from basic problems.

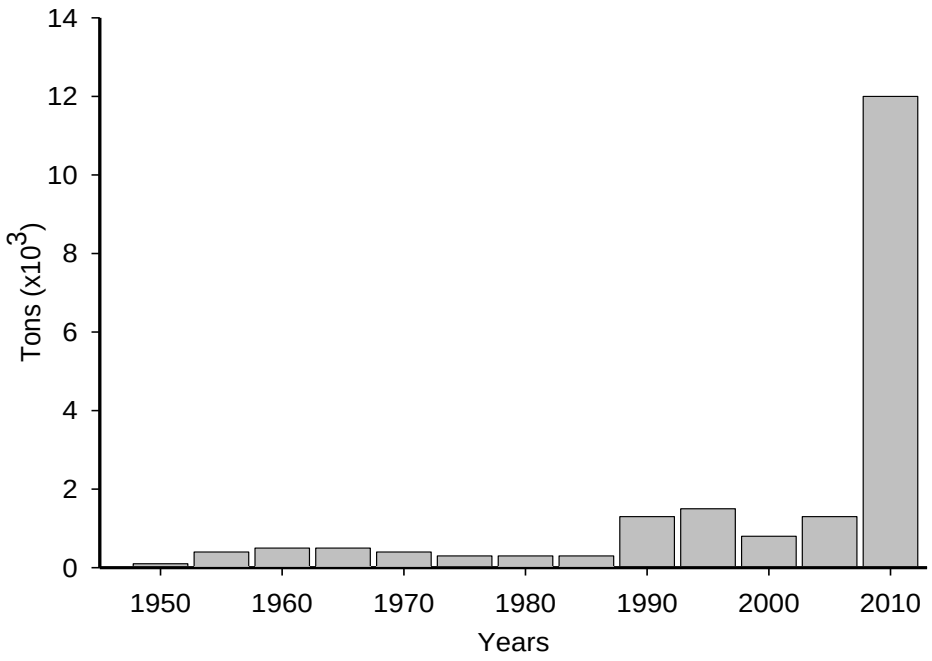

Figure 3: Reported aquaculture production in Kenya (from 1950 - 2010); Fishery Statistics, Aquaculture production. Source: [3]

Although most parts of the country are suitable for aquaculture (Figure 4), only about 0.014% of the 1.4 million ha of potential aquaculture sites are used for aquaculture and about 95% of fish farming is on a small scale [22]. This means a large opportunity is still missed for better incomes and food supply for the rural population through aquaculture practices. The Kenyan aquaculture sector is currently dominated by freshwater fish production. With the growing competition for freshwater, there is need for a paradigm shift to marine aquaculture, thanks to the vast marine water resources. Indeed, for Kenya to register significant growth in terms of food fish production, the vast marine waters must be exploited. The major problem with marine fish larviculture is the lack of proper food that contains all the essential nutrients required by fish larvae, which has led to mass mortalities up to 100% [23]. Recently, a permanent population of *Artemia franciscana* has been reported at the Kenyan coast [24]. *Artemia* is a live food with excellent nutrition for the development of marine fish larvae [24]. This is an excellent opportunity to

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increase food production and create employment through enhancing emerging mariculture initiatives, such as mullet, milkfish, and prawns, which seem to perform better in ponds than in natural waters [25]. Culture of shrimp and shellfish, such as mussels, oysters, and abalone, has not been initiated. Kenya has the opportunity to exploit this opportunity and join other world leaders in the global *Artemia* cyst trade [26].

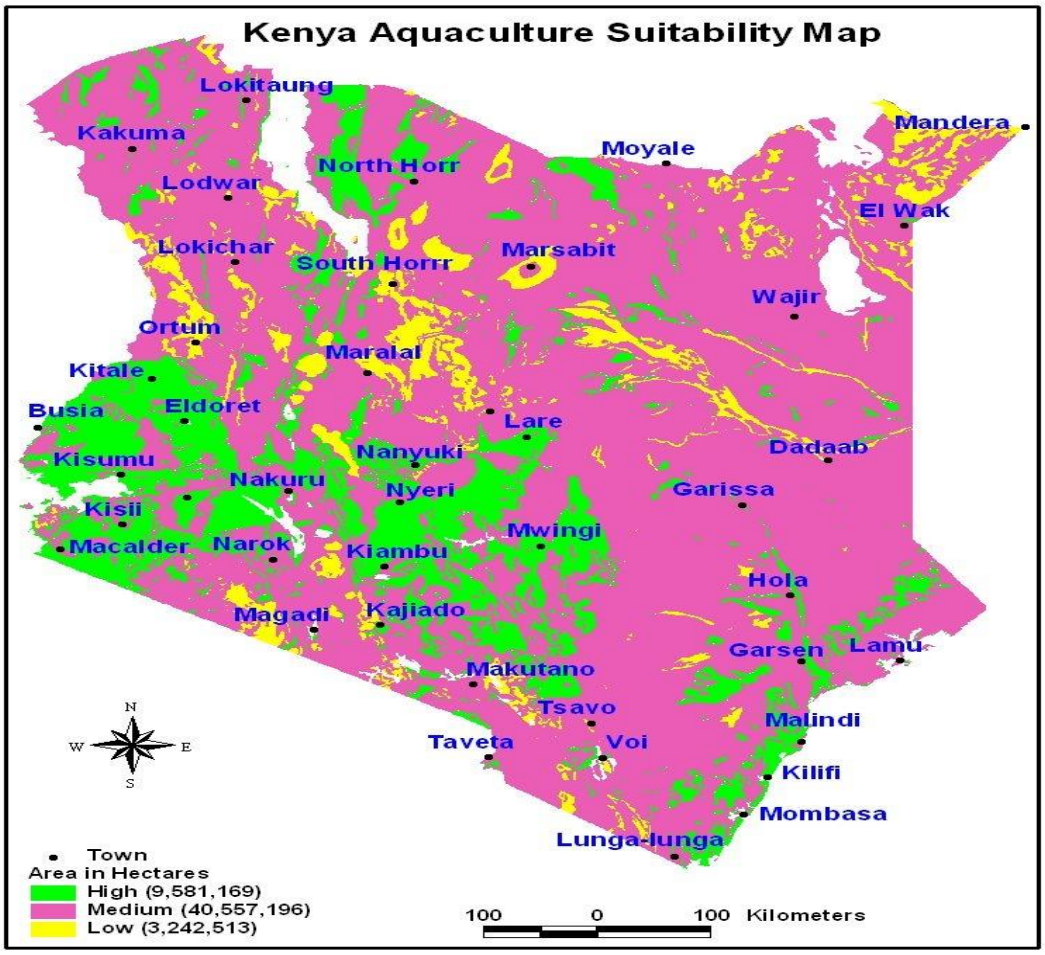

Figure 4: The Kenyan aquaculture suitability map (Adopted from [42])

Role of aquaculture in Kenyan food insecurity

In Asia, aquaculture has recorded strong growth [27]. Replicating this growth in areas such as Kenya, where it has not occurred could bring major benefits. Future gains may also come from better stock selection, large-scale production technologies, aquaculture in open seas and the culture of a wider range of species [28]. In the context of the rural poor, aquaculture often complements catches from traditional fisheries and becomes an attractive and important component of rural livelihoods in situations where increasing population pressures and environmental degradation limit catches from wild fisheries [28]. Aquaculture provides year-round fish supplies and incomes for producers and thus has the potential to reduce pressure on wild fish stocks [29]. Rather than being a means to secure nutritional gains and income directly for the poorest smallholder farmers, aquaculture is a means to increase domestic fish supply to low-income consumers,

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employment opportunities and support local economic multipliers [29]. The government agencies must ensure a paradigm shift in aquaculture development policy from perceiving aquaculture as an income generating opportunity for the poorest, towards meeting national fish supply demand gaps and ensuring a supply of fish to lower income consumers. Aquaculture can also benefit the landless from utilization of common resources, such as cage culture, culture of molluscs and seaweeds, and fisheries enhancement in communal water bodies [29]. Agricultural by-products, such as manure from livestock and crop residues, can serve as fertilizer and feed inputs for small-scale and commercial aquaculture. Fish farming in rice fields not only contributes to integrated pest management, but also management of vectors of human medical importance [29,30]. Furthermore, ponds become important as on-farm water reservoirs for irrigation and livestock in areas where there are seasonal water shortages [30].

In general terms, aquaculture can benefit the livelihoods of the poor either through an improved food supply and/or through employment and increased income [30]. However, at present, little or no hard statistical information exists concerning the scale and extent of rural or small-scale aquaculture development in Kenya. After the national fish farming program mentioned previously, many regions especially central Kenya and Kisii regions have recorded high aquaculture growth with added benefits through integration and value addition techniques (Figure 5). Despite the lack of information concerning the role of rural aquaculture, there is one sure benefit of consuming fish, and that is the nutritional and health benefit to be gained from its valuable nutritional content [30]. Aquaculture can particularly benefit diseased, weak or vulnerable groups within the community (for example HIV/AIDS infected, pregnant and lactating women, infants and pre-school children) who need both nutritious food and income.

Figure 5: Aquaculture transforming life in rural areas of central Kenya; Highland green algae Farm in Kirinyaga County (picture by J.M. Munguti)

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Aquaculture value chain linkages and national economic growth

About 40% of the Kenyan population are unemployed [31]. The estimated tax revenue missed from this population segment is quite significant. Employment at farm level includes people operating hatcheries, nurseries, grow-out production facilities, and part time and occasional labours hired to work for aquaculture production. Employment at other links along aquaculture value chains include people working as input suppliers, middle traders and domestic fish distributors, processors, and exporters and vendors. In the case of the small scale operators, aquaculture is often a family based activity, where part of the production may be retained for household-consumption [32].

In other studies, authors have provided a framework for examining aquaculture's linkages to food and nutritional security by highlighting the key role of aquaculture in household food and income systems in developing countries (Figures 6 and 7) [32]. While the degree of inclusion of fisheries and aquaculture in poverty reduction strategy plans has been assessed [33], a series of policy briefings that link the sector to issues and policies in poverty reduction and vulnerability, national economic planning and trade, HIV/AIDS response and gender mainstreaming have not been articulately addressed, yet significant positive impacts can be achieved [34].

Based on examples from Asian countries, aquaculture has provided steady growth over the last decade with regard to employment, income and consumption, thus improving nutrition and purchasing power of the locals [34]. Indeed, a healthy population has the capacity to improve on work performance, which is healthy for the country's economy. Even though there is potential for fish farming in Kenya, there is no long term plan for aquaculture and this makes it difficult to quantify fish production targets. The development and wider adoption of aquaculture can be seen as a significant basis for improving household food security and other needed welfare [35]. The support for a mix of small-scale and large-scale aquaculture accelerates its role in promoting macroeconomic growth [36]. Deeper analysis is needed before causal linkages can be inferred and poverty and food security benefits for aquaculture can be claimed [37].

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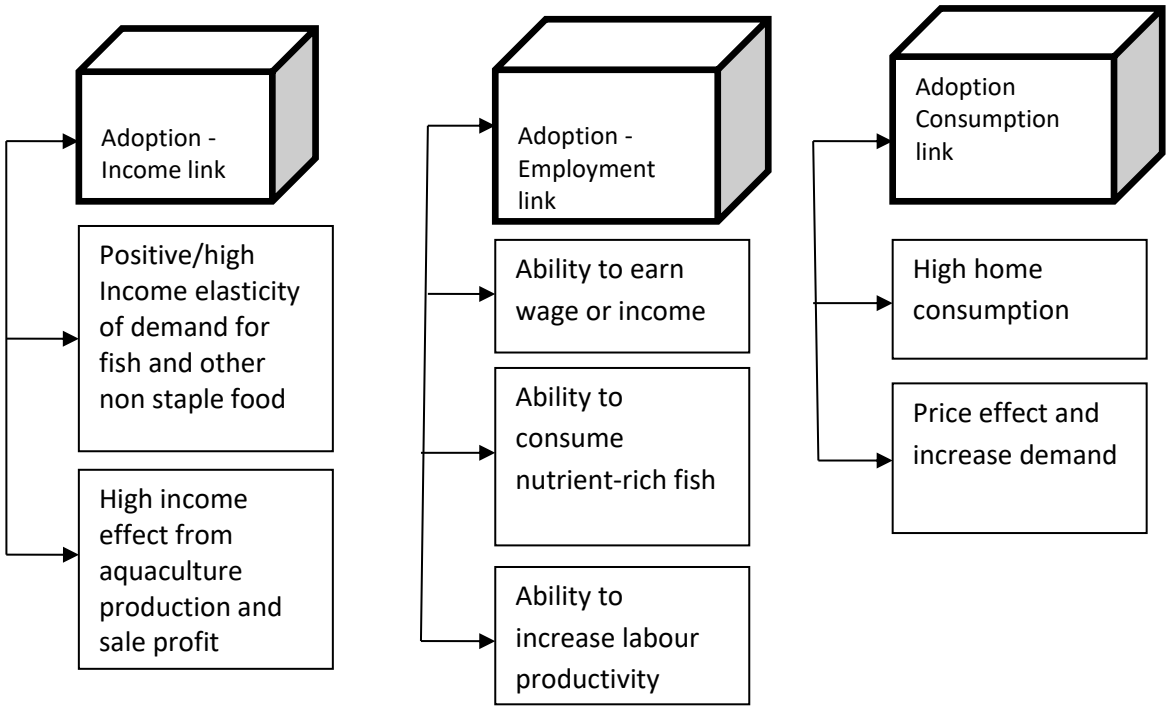

Figure 6: A framework for analysing aquaculture's linkages to food and nutritional security
Source: [30]

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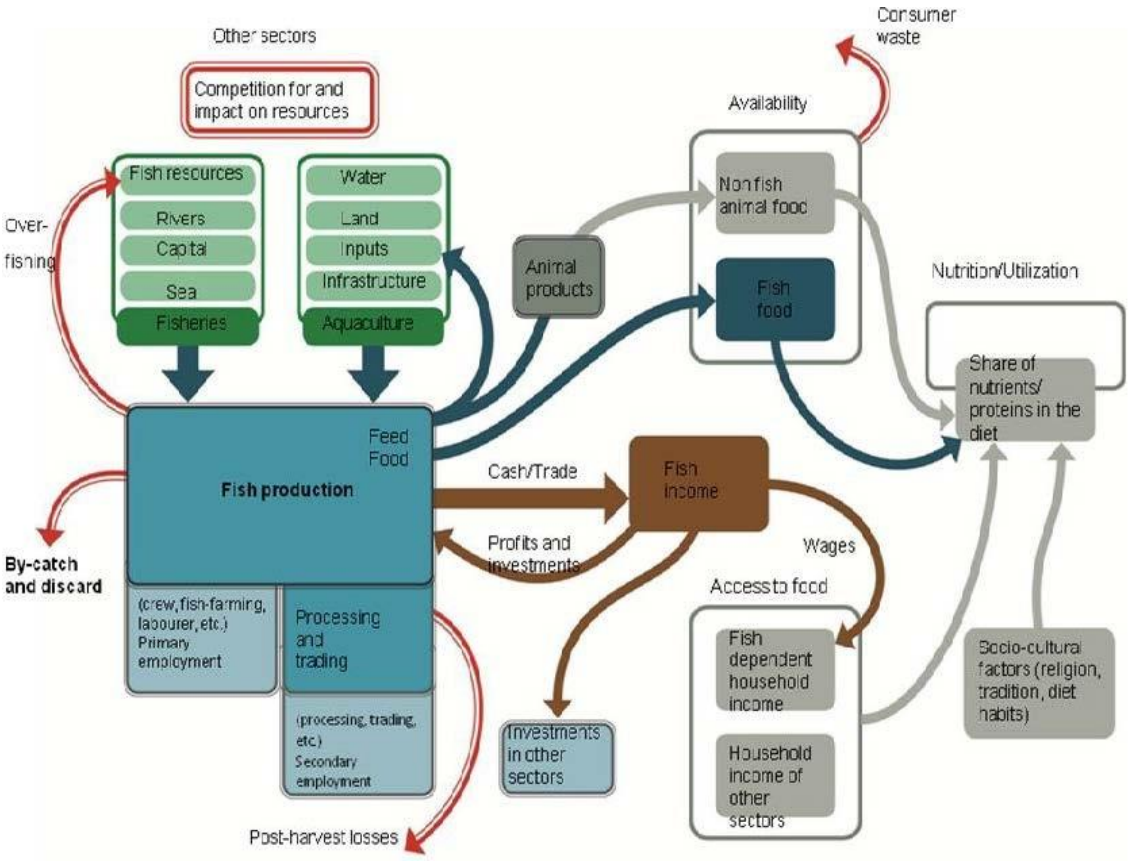

Figure 7: The different pathways by which fish contributes to food security and nutrition
Source [39]

CONCLUSION

The opportunities provided by the diversity of aquaculture systems characterized by a wide range of cultured species can contribute important elements of stability to Kenya's food portfolio only if and when the aquaculture value chain linkages are established. However, as the aquaculture sector develops and becomes more technologically sophisticated and potentially takes integrated dimension, social inequities are likely to develop in terms of income generation and access to fish for food [37]. In addition, the ability of aquaculture to add resilience to Kenyan food supplies will depend on how the sector develops in terms of species composition, feed inputs, and system design and operation and whether such development can offset the negative externalities associated with existing terrestrial crop and livestock systems and capture fisheries. If not designed and managed to address environmental damages and social injustices, aquaculture is likely to make the global food system less resilient.

RECOMMENDATIONS

Developing nations encouraging aquaculture growth should focus on building flexible and heterogeneous production systems that derive fish feeds from agricultural products

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as efficiently and equitably as possible. Appropriate national aquaculture policies should be put in place for a flexible and resilient food portfolio. Aquaculture should not be viewed as an isolated technology but should be considered as an aspect of a holistic approach to rural development. Promoting and increasing aquaculture productivity will not only contribute towards increased production of nutritious food to reduce food security, but will also allow the country to produce a surplus for export [38,39,40]. Finally, more empirical evidence should be collected on the varied opportunities aquaculture provides to improve the income, employment and food consumption levels within the poor households.

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Table 1: Undernourishment around the world (1990 – 2013) adopted from [2]

Regions	Number of undernourished (millions) and prevalence (%) of undernourishment				
	1990-1992	2000-2002	2005-2007	2008-2010	2011-2013
World	1015.3	957.3	906.6	878.2	842.3
	18.9%	15.5%	13.8%	12.9%	12.0%
Developed countries	19.8	18.4	13.6	15.2	15.7
	<5%	<5%	<5%	<5%	<5%
Developing countries	995.5	938.9	892.9	863.0	826.6
	23.6%	18.8%	16.7%	15.5%	14.3%
Asia	751.3	662.3	619.6	858.5	552.0
	24.1%	18.3%	16.1%	14.7%	13.5%
Africa	177.6	214.3	217.6	226.0	226.4
	27.3%	25.9%	23.4%	22.7%	21.2%
Sub-Sahara Africa	173.1	209.5	212.8	221.6	222.7
	32.7%	30.6%	27.5%	26.6%	24.8%
Latin America	65.7	61.0	54.6	50.3	47.0
	14.7%	11.7%	9.8%	8.7%	7.9%
Oceania	0.8	1.2	1.1	1.1	1.2
	13.5%	16.0%	12.8%	11.8%	12.1%

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Table 2: The nutrient content of fish and other foods (per 100g)

Local name	Proteins (g)	Fats (g)			EPA (g)	DHA (g)	Ca (mg)	Fe (mg)	Zn (mg)	Vitamin A (RAE)
		Total lipids	Total saturated	Total Poly unsaturated						
Fish										
Common carp	17.83	5.60	1.08	1.43	0.24	0.11	41	1.24	1.48	9
Catfish	15.60	7.59	1.77	1.57	0.07	0.21	9	0.50	0.74	15
Tilapia	20.8	1.70	0.77	0.48	0.01	0.11	10	0.56	0.33	1
Prawn	-	1.13	0.37	0.02	0.01	0.06	-	-	-	-
Milkfish	20.53	6.73	1.67	1.84	-	-	51	0.32	0.82	30
Other animals										
Beef	14.30	30.00	11.29	0.70	-	-	24	1.64	3.57	0
Chicken	14.70	15.75	3.26	3.34	-	-	19	1.11	0.78	0
Chicken eggs	35.60	9.94	3.10	7.56	0.004	0.037	171	3.23	1.11	140
Cow milk	3.28	3.66	2.28	0.14	-	-	119	0.05	0.37	33
Plant sources										
Cassava	1.40	0.28	0.28	0.048	-	-	16	0.27	0.34	1
Rice	2.69	0.28	0.28	0.323	-	-	10	1.20	0.49	0
Beans	8.67	0.09	0.09	0.278	-	-	35	2.22	0.86	0
Carrots	0.93	0.17	0.04	0.117	-	-	33	0.30	0.24	835
Kales	3.30	0.70	0.70	0.338	-	-	135	1.70	0.44	769
Spinach	2.86	0.39	0.39	0.165	-	-	99	2.71	0.53	469

*RAE - Retinol Activity Equivalent; Ca – Calcium; Fe – Iron; Zn – Zinc; Source: [40]

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Table 3: Climate change impacts and consequences for food systems [35]

Climate change impact	Direct consequence for food systems
Increased frequency and severity of extreme weather events	• Crop failure and reduced yields • Loss of livestock • Damage to fishes and forests • Destruction of agricultural inputs, such as seeds and tools • Either an excess or decrease of water • Increased land degradation and desertification • Disruption of food supply-chains • Increased costs for marketing and distributing food
Rising temperatures	• Increased evapotranspiration, resulting in reduced soil moisture • Greater destruction of crops and trees by pests • Greater threats to human health (e.g. disease and heat stress) that reduce the productivity and availability of agricultural labour • Greater threats to livestock health • Reduced quantity and reliability of agricultural yields • Greater need for cooling/refrigeration to maintain food quality and safety • Greater threat of wildfires
Shifting agricultural seasons	• Reduced quantity and quality of agricultural yields and forest products • Either an excess or shortage of water • Greater need for irrigation
Sea level rise	• Damage to coastal fisheries • Direct loss of cultivable land due to inundation and salinisation of soil • Salinisation of water sources

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