"Resilient value chains in the blue economy"

The 2nd Annual International Conference & Exposition of the African Chapter of the World Aquaculture Society (AFRAQ2023)

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Welcome Message

Dear colleagues and friends,

Welcome to Lusaka, Zambia, and to Aquaculture Africa 2023! On behalf of the AFRAQ23 Steering Committee and the WAS African Chapter Board, I warmly welcome you to the event at this magnificent Mulungushi International Convention Centre - within a country blessed with great people and amazing natural wonders.

This second Annual International Conference and Exposition of the African Chapter of the WAS is happening in Zambia today and follows the highly successful inaugural Aquaculture Africa 2021 event that took place in Alexandria, Egypt in March 2022, which attracted huge domestic and international participation.

Zambia is regarded as one of the fastest aquaculture producers in Africa, with annual production compliment from as low as 750 tonnes in 1986 to about 75,500 tonnes in 2022. The visibly active, sustainable and resilient aquaculture value chains in the country are evident to the potentials the country's aquaculture sector has in meaningfully contributing to improved food and nutrition security, employment, livelihoods and other economic benefits. We believe fellow African countries can learn lessons from this great country.

According to FAO, world aquaculture production in 2021 reached 126 million tonnes in live weight, which was 2.7% up from the 122.7 million tonnes recorded in 2020. The farm-gate value of global aquaculture now stands at record USD296.5 billion. This includes both aquatic animals and plants. Aquaculture's contribution to world total fish production reached 49.9 percent in 2021.

In Africa, although capture fisheries are still dominant, with an 82 percent share of total fish production in 2021, aquaculture continues to grow modestly, now taking up 18 percent share up from 12 percent over a decade ago. Total aquaculture production from Africa (excluding aquatic plants) was some 2,322 million tonnes in 2021 – which is about 2.6% of world total production. About 92 percent of African aquaculture comes from inland aquaculture.

By far, Egypt remains the largest producer in Africa taking up nearly 68 percent of the continent's production (1,5 million tonnes) in 2021. This is followed by Nigeria (276,000 tonnes or 12 percent) and Uganda follows in third position with a record 139,000 tonnes or 6 percent; and then Ghana taking the fourth position at 89,400 tonnes or 4 percent. These four countries collectively produce about 90 percent of total production in Africa.

Zambia, which is the fifth producer by volume overall, remains probably the fastest in terms of annual growth rate, with its production having increased threefold in a span of 5 years (i.e. from 20,000 tonnes in 2016 to over 75,500 tonnes in 2022). The rapid development of large-scale and small scale investments in fish farms, aquafeeds factories, fish distribution networks - coupled with an enabling policy framework and active institutions have collectively contributed to this impressive growth.

World Aquaculture events are a vital contributor to communication among producers, suppliers, researchers, government and all stakeholders in the aquaculture landscape. The success of these meetings is only possible with support of sponsors and all exhibitors, and we sincerely thank them for their involvement in AFRAQ23.

We also thank the conference organisers and members of the Steering, Program, National Organising Committees - that have been working hard to plan, coordinate and bring the technical program, trade show and associated meetings together.

Special gratitude goes to our host, the government of Zambia through its Ministry of Fisheries and Livestock for welcoming all of us to this great fish producing and consuming nation. It is our hope that all the positive elements out of this event will lead to further transformation of the sector - to even greater heights!
Thank you to all participants for joining us to make this a memorable event.

AFRAQs are scheduled to happen annually. Lets aim to meet again at AFRAQ24 scheduled for Tunisia in November 2024; as we also gear up for a global-scale, World Aquaculture Conference planned for Uganda in 2025.
Enjoy AFRAQ23 in Lusaka.

John Kiremerwa Walakira
President, World Aquaculture Society – African Chapter

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2023 AFRAQ
AQUACULTURE AFRICA

ABSTRACTS

INTEGRATED MULTI-TROPHIC AQUACULTURE/AQUAPONICS SYSTEMS: A PROMISING STRATEGY FOR CYCLING NUTRIENTS AND MINIMIZING WATER CONSUMPTION

Nevine M. Aboushabana*, Ahmed M. Aboseif, Mostafa K.S. Taha, Eman Y. Mohammedy, Hani M. Nazmi, Marwa M. Zaher, Hadir A. Aly, Mohamed A.S. El-Okaby, Mohamed Ashour and Ashraf M. A-S Goda

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Aquaculture in arid and dry locations must focus on utilising as little freshwater as possible due to a scarcity of freshwater resources. Agricultural-aquaculture integration is an excellent alternative technique for lowering nutrient discharge levels, reducing water consumption, increasing profitability, and transforming fish culture wastewater into valuable products. The current study used a solar energy system to operate two separate Integrated Multi-Trophic Aquaculture (IMTA)/ Aquaponics systems (Nutrient Film Technique, NFT, and Floating Raft Systems, FRS) to cultivate Nile tilapia, African catfish, thin-lipped grey mullet, freshwater prawns, freshwater mussels, and a variety of vegetables. The tilapia and catfish were fed only commercial diets and all wastewater from the ponds, including dissolved and solid substances, was delivered sequentially to ponds with other cultured species. Water then flows through the IMTA system's terminal point to the NFT and FRS systems, and returned to the tilapia and catfish ponds. The total biomass gain for aquatic species in the IMTA system was 736.46 kg, compared to 145.49 and 271.01 kg in the tilapia and catfish monoculture systems, respectively. The IMTA system had a cumulative feed conversion ratio (FCR) of 0.90, compared to 1.28 and 1.42, for tilapia and catfish monoculture systems, respectively. Nile tilapia and catfish consumed a total of 571.90 kg of feed, with nitrogen (N) and phosphorous (P) contents of 25.70 and 9.70 kg, respectively, and gained 11.41 and 3.93 kg of dietary N and P, representing 44.40 and 40.46% of dietary N and P retention, respectively. The addition of mullet and prawns to the system increased dietary N and P utilization efficiency to 59.06 and 51.19%, respectively, and the addition of mussels enhanced N and P efficiency to 65.61 and 54.67%, respectively. Finally, the incorporation of FRS and NFT systems raised dietary N and P efficiency to 83.51% N and 96.82% P, and 74.29% N and 79.81% P, respectively. These findings suggest that IMTA, as a bio-integrated food production system, may convert the majority of fish-fed residue into useful products and that this technology is suitable for food production in desert, rural, and urban areas in developing countries.

IN VITRO ACTIVITY OF HERBAL AND CHEMICAL TREATMENTS AGAINST *Saprolegnia ferax* A CAUSATIVE AGENT FOR SAPROLEGNIASIS

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Saprolegniasis is a detrimental fungal- like disease prevalent in the aquaculture industry, seriously causing damage to cultured fish populations and their eggs, leading to high mortality rates with subsequent economic losses. Unfortunately, many existing therapeutics for this disease prophylaxis have proven to be ineffective and have also raised concerns regarding their negative environmental impact. This study compared the efficacy of three medicinal plant extracts and a chemical compound readily available in Ghana to assess their potential as anti-fungal agents against *Saprolegnia ferax*.

The fungistatic and fungicidal properties of plant extracts i.e. *Azadirachta indica* (neem leaf), *Vernonia amygdalina* (bitter leaf), *Terminalia catappa* (Indian almond), and the chemical (potassium permanganate ($KMnO_4$)), were investigated under *in vitro* conditions. This study was carried out within 96 hours at different concentrations ranging from 5 mg/ml to 20 mg/ml. Molten Sabouraud Dextrose Agar, maintained at 45□C, was combined with all treatments at different concentrations in six well-cultured plates. Following that, the mixture was allowed to solidify, and 0.4 mm agar plug was centrally positioned in each plate. Subsequently, the average radial growth of the fungi was assessed at 12, 24, 72, and 96 hours. A two-way ANOVA was used to test for the statistical differences between the treatments and exposure time on radial growth. There was a significant difference among all treatments with *Terminalia catappa* showing the least radial growth (0.02mm) at 96hrs (Fig 1). The results indicate that both *Terminalia catappa* and $KMnO_4$ exhibited complete inhibitory effects on fungal growth compared to the other two plant extracts (Fig 1).

Therefore, in terms of affordability and availability to fish farmers in Ghana, *Terminalia catappa* is recommended as a valuable prophylactic treatment alternative for saprolegniasis under *in vitro* conditions, however, further studies are needed to confirm its safety for fish.

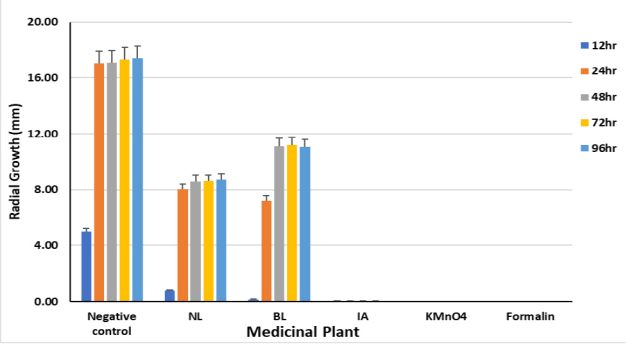

Fig 1: Radial growth measurement over 96hrs of incubation

Note: NL- Neem leaf, BL-Bitter leaf and I.A- Indian Almond

EFFECT OF *Moringa oleifera* LEAF MEAL ON GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF HETEROCLARIAS

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Introduction: Aquaculture is the fastest-growing food production sector in the world. However, the cost of fish feed has been a major constraint for aquaculture production. The study investigated the effects of replacing soybean meal with *Moringa oleifera* leaf meal in the diet of Heteroclarias fingerlings.

Methodology: Four iso-nitrogenous diets (40% crude protein) were formulated using locally available feedstuffs while *Moringa oleifera* leaf meal was substituted at varying levels (0%, 15%, 30%, and 45%). Nine fingerlings were randomly allocated in duplicate for each treatment and fed 3% body weight for a period of 56 days.

Results: The results showed that the fish had better growth and nutrient utilization when fed with *Moringa oleifera* leaf meal. The best results were observed when 45% of soybean meal was substituted with *Moringa oleifera* leaf meal. The cost of feeding fish with *Moringa oleifera* leaf meal was not significantly different from the control diet, but the growth was better.

Conclusion: *Moringa oleifera* leaf meal could be a potential alternative to soybean meal in fish diets, especially for Heteroclarias fingerlings without comprising the fish growth.

Table 1. Growth and Nutrient Utilization of Heteroclarias fingerlings

Parameter	Treatment 1 (0%MOM)	Treatment 2 (15%MOM)	Treatment3 (30%MOM)	Treatment 4 (45%MOM)
MINW (g)	59.45 ± 0.78^{b}	61.30 ± 1.70^{ab}	63.40 ± 0.570^{ab}	66.25 ± 3.18^{a}
MFW (g)	67.80 ± 2.83^{b}	77.90 ± 8.63^{b}	77.70 ± 0.28^{ab}	88.75 ± 0.78^{a}
MWG (g)	8.35 ± 3.61^{b}	13.60 ± 6.93^{ab}	14.30 ± 0.85^{ab}	22.50 ± 2.40^{a}
DWG (g)	0.15 ± 0.06^{b}	0.25 ± 0.12^{ab}	0.26 ± 0.04^{ab}	0.40 ± 0.11^{a}
INL (cm)	9.73 ± 0.07^{a}	9.85 ± 0.18^{a}	10.09 ± 0.11^{a}	10.04 ± 0.28^{a}
FL (cm)	10.38 ± 0.12^{a}	10.57 ± 0.03^{a}	10.58 ± 0.29^{a}	10.75 ± 0.10^{a}
SGR (%/day)	0.10 ± 0.04^{b}	0.16 ± 0.06^{ab}	0.17 ± 0.01^{ab}	0.24 ± 0.01^{a}
FCR	17.32 ± 6.85^{a}	12.25 ± 5.61^{a}	10.30 ± 0.56^{a}	7.30 ± 0.95^{a}
K	5.57 ± 0.25^{b}	6.34 ± 0.68^{ab}	6.59 ± 0.52^{ab}	7.15 ± 0.13^{a}
SR (%)	94.45 ± 7.86^{a}	94.45 ± 7.86^{a}	100 ± 0.00^{a}	100 ± 0.00^{a}
PWG (%)	14.09 ± 6.25^{b}	22.04 ± 10.69^{ab}	22.56 ± 1.54^{ab}	34.09 ± 5.27^{a}

Means value in the same row with different superscripts are significantly different ($p<0.05$)

KEYS: **MINW=** mean initial weight, **MFW=** mean final weight, **MWG=** mean weight gain, **DWG=** daily weight gain, **INL=** initial length, **FL=** final length, **SGW=** specific growth rate, **FCR=** feed conversion ratio, **K=** condition factor, **SR=** survival rate, **PWG=** percentage weight gain.

EFFECT OF VEGETABLE OIL AND PALM OIL ON THE NUTRITIVE QUALITY OF DEHYDRATED SHREDDED FISH MUSCLE (DANBUN-KIFI)

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Introduction: The research was aimed to determine the effect of vegetable oil and palm oil on the nutritive value of dehydrated shredded fish muscle (Danbun kifi); a term popularly applied to beef meat (Danbun nama).

Methodology: Two oils; vegetable oil (T_1) and bleached palm oil (T_2) were used to fry the 'Danbun kifi'. The two treatments of Danbun kifi were stored in room temperature for a period of four weeks and on weekly basis were subjected to organoleptic assessment.

Results: The results revealed that there were significant differences ($p<0.05$) in the proximate composition of the two treatments. However, organoleptic assessment has showed that there was significant difference between dehydrated shredded fish muscle (Danbun kifi) fried with vegetable oil and palm oil.

Conclusion: The shredded fish muscle fried with vegetable oil had better nutrient content and more preferred by consumers. This research work embraces an alternative form of local fish preservation and suggests a value addition to the perishable fish biomaterial. Further work is required to investigate the non-inclusion of oil in the frying of the shredded fish muscle and establish the shelf-life of the newly developed product.

Table 1. Proximate composition of fresh samples and dehydrated shredded fish muscles

Parameter	**Fresh fish (T1)**	**Shredded fish with vegetable oil (T2)**	**Shredded fish with Palm oil (T3)**
Moisture	82.70±0.28	$4.92±0.02^{b}$	$5.12±0.04^{a}$
Crude protein	12.48±0.02	$31.98±0.03^{a}$	$26.93±0.07^{b}$
Ash	1,02±0.02	$5.55±0.03^{a}$	$4.80±0.02^{b}$
Lipid	1.68±0.12	$35.58±0.75^{a}$	$35.58±0.75^{a}$

Mean value in the same row with different subscripts are significantly different ($p<0.05$)

HAEMOPARASITES AND HAEMATOLOGICAL STUDIES OF FARMED *Clarias gariepinus* (Burchell,1822) IN IBADAN, SOUTHWEST, NIGERIA

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Parasitic diseases are regarded as one of the challenges facing the fish productivity in both natural and farmed environments. The growing field of aquatic science has been recognized to alleviate the global poverty and reduce food insecurity due to world growing population. It is view of this, the study, investigated the haemoparasites and haematological indices of farmed *Clarias gariepinus* in Ibadan Southwest Nigeria. A total of 405 *Clarias gariepinus* was used to determine the haemoparasites and haematological indices in the study area. A prevalence of 60(14.81%) was recorded. The highest infection was 32(7.90%) among the male fish, and 28(6.91%) in the female. The haemoparasites recorded were *Leucocytozoan* sp 8(1.98%), *Haemoproteus* sp 16(3.95%), *Plasmodium* sp 15(3.70%) and *Babesia* sp 11(2.72%) in the fish sample. The prevalence of mixed the infections were between *Haemoproteus* sp and *Plasmodium* sp in 9 fishes (2.22%), the *Plasmodium* sp and *Babesia* sp in 1(0.25%) fish sample. The overall mixed infection was 6(1.48%) among male fish while it was 4(0.99%) among female. The prevalence of *Haemoproteus* sp was 9(2.22%) and 7(1.73%) in male and female fish respectively. However, *Leucocytozoan* 8(1.98%) was found all through in male fish, *Plasmodium* sp infection only was found in 9(2.22%) female fish and 6(1.48%) in male fish. Male and female fish were infected with *Babesia* infection with prevalence of 4(0.99%) and 7(1.73%) respectively. The distribution of mixed haemoparasitic infections in the case of *Haemoproteus* and *Plasmodium* sp reference to sex showed 4(0.99%) and 5(1.23%) in male and female fish respectively, while 1(0.25%) male was infected in the case of *Babesia* and *Plasmodium* infections. There is no significant difference ($p>0.05$) in Packed cell volume(PCV), Red blood cell (RBC), White blood cell WBC, heterophils, monocytes, basophils between infected and uninfected fish, also no significant difference existed in the morphometrics of infected and infected fish.

HYBRID FISH SMOKING KILN: A CLIMATE-SMART APPROACH TO SUSTAINABLE PRACTICES

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The traditional methods of smoking fish often have health hazards, hence the need for this innovative solution. This study, therefore, presents a hybrid fish smoking kiln that combines solar and electric power sources to provide a more environmentally friendly and cost-effective method of smoking fish. The fabrication of the smoking kiln was carried out at The Federal University of Technology, Akure, Nigeria to optimize energy usage of the smoking process, minimizing waste and maximizing energy efficiency. The study further outlines the construction materials, design specifications, and operational procedures of the hybrid kiln. The study shows that the hybrid kiln is efficient, capable of smoking large quantities of fish, reducing smoking time, and improving the quality of the final product. This kiln promotes sustainability in fish processing, supporting environmental conservation and socioeconomic development in fish farming communities.

The weight loss of the fish sample being calculated was used to determine the smoking efficiency. The smoking kiln was tested by using catfish *clarias gariepinus* of an average moisture content of 62.5% within an average period of 5 hours, the average final weight of the dried fish was 0.24 Kg. with a desirable golden-brown colour. Additionally, the fish processing time was reduced compared to the traditional drum oven method, and the temperature of the heat supplied was significantly higher. The overall carbon footprint of the food preservation process is minimized, leading to a more sustainable operation. Solar energy is clean and renewable, producing zero greenhouse gas emissions during its generation.

The acceptability of the hybrid smoking kiln was evaluated by conducting a survey of users' opinions and experiences. The survey showed that 71% found the hybrid smoking kiln to be safe, easy to use, more cost-effective and improved health outcomes compared to traditional smoking methods. Despite the numerous benefits, the study reveals that hybrid fish smoking kiln is not affordable. However, as solar technologies continue to advance and become more affordable, integrating solar power with electric heating in smoking kilns will be an attractive climate-smart option for sustainable fish and food preservation practices.

Table 1: Performance evaluation of hybrid smoking kiln

Replicates	Initial weight (kg)	Final weight (kg)	Time(hours)	Moisture content (%)	Temperatu
1	1.5	0.75	5	50	80
2	1.7	0.95	6	44	86
3	1.3	0.55	4	57	100
4	1.5	0.55	5	63	100

Source: Fisheries and Aquaculture Technology, Teaching and Research Farm, FUTA, 2023

ASSESSMENT OF HOUSEHOLD LIVELIHOOD DIVERSIFICATION AND FISHERIES CONSERVATION STRATEGIES AMONG FISHERMEN IN COASTAL AREAS OF OGUN STATE, NIGERIA

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This study assessed the association between household livelihood diversification and fisheries conservation policies among fishermen in coastal areas of Ogun State, Nigeria by adopting a multistage sampling procedure. The sample size was 90 fishermen from six randomly selected fishing communities (Abureji, Agbalegiyo, Ilamo, Imosan, Iseku and Wharf) along the coastline in Ogun State, Nigeria. Data were collected using pre-validated interview schedule and subjected to descriptive and inferential analytical techniques. Results revealed that majority of the fishermen were married (98.9%), in the age bracket of 41-60 years (71.1%) with mean age of 49 years, had household size of 6-15 persons (91.1%) with mean household size being 9 persons, from extended families (90.0%), either either no formal (43.3%) or only primary education (41.1%), were non-members of social groups (62.2%), and had no other occupations (93.3%).

It was also reported that there was generally low level of household livelihood diversification across the fishing communities. Gill nets were the most commonly used fishing gears across the fishing communities (80.0%). This was followed by seine nets (63.3%), traps (56.7%) and trawl nets (53.3%) while fish aggregating devices (35.6%), cast nets (37.8%) and hook and line (24.4%) were the least used fishing gears in the study locations. Results further revealed that coastal fishery was characterised by conflicts among water users (64.4%), absence of protected fishing areas (81.1%), and experience of water pollution (36.7%). Majority (71.1%) of the fishermen across the study locations agreed with closed season policy as a coastal fisheries conservation strategy. This was followed by gear restriction (30.0%). Results of Chi-square analysis revealed that there were significant associations between level of household livelihood diversification and fishermen's agreement with gear restriction (χ^2 = 15.545, df = 5), and closed season (χ^2 = 11.214, df = 4). The study concluded that coastal fisheries is in a poor state and that it could be improved through the introduction of gear restriction and closed season policies. The study recommended that youths in the coastal areas should venture into fishing, and that government and non-governmental agencies should organize sensitization programmes on fisheries conservation policies across the coastal areas in Ogun State.

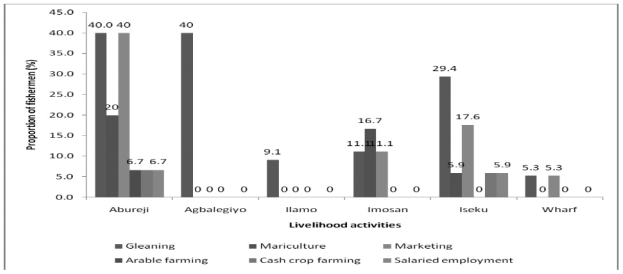

Figure 1: Livelihood activities of fishing households by fishing villages

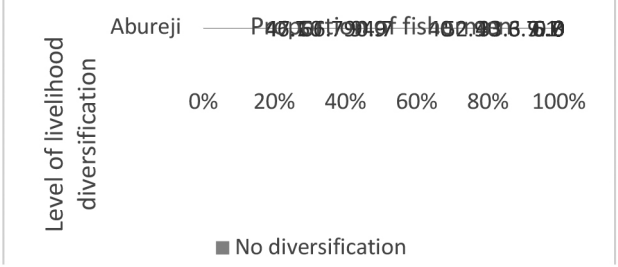

Figure 2: Levels of fishing household livelihood diversification by communities

Coastal fisheries conservation

LENGTH–WEIGHT RELATIONSHIP OF *Tilapia mariae* IN LOWER OGUN RIVER, AKOMOJE WATER RESERVOIR, NIGERIA

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[3]Department of Agricultural Science Education, Osun State College of Education, Ilesa

Some aspect of biology of *Tilapia mariae* from lower river Ogun, Akomoje water reservoir with emphasis on the length weight relationship and the well being of the species were investigated. Mean standard lengths of the fish sample were ranged from 13.12±0.61cm in male, while female ranged from 19.83±0.76. The species from the water body revealed negative allometry growth pattern. There was variation in condition factor (k) for both sexes. The well being of the females revealed better condition than the males in all months of study. The sex ratios of *Tilapia mariae* in the Reservoir was 1:3.12 (M:F), with highest abundance of females in September 1:3.17 and October showing the least 1:2.05 (M:F). The study concludes that there are large population of algae in the water body.

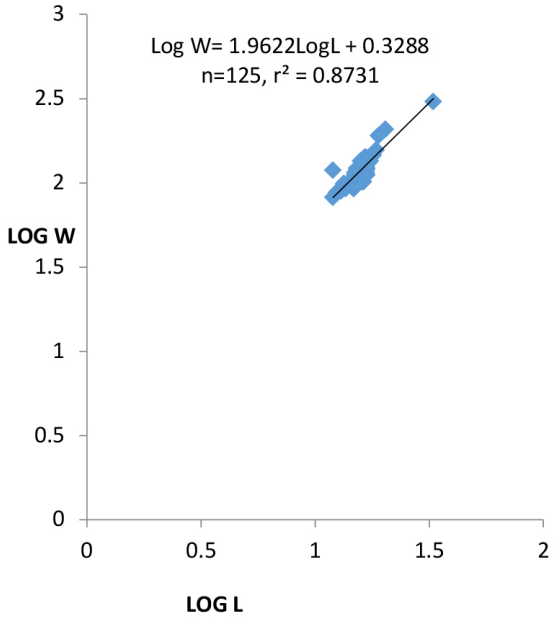

Figure 1: The length- weight relationship for *Tilapia mariae* in Akomoje water Reservoir.

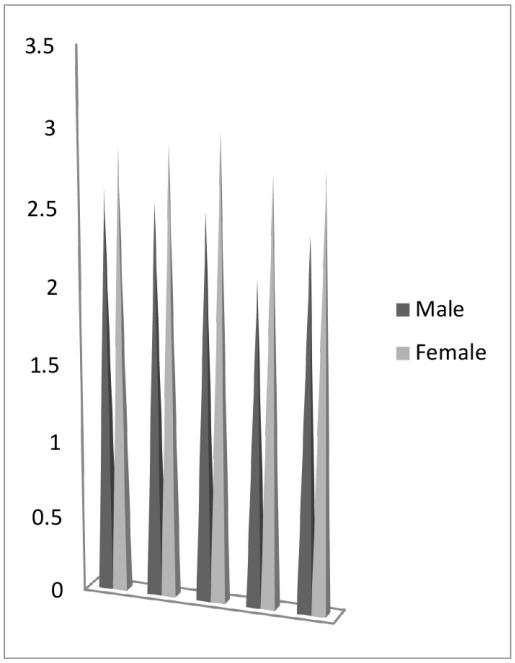

Figure 2: Monthly Variation in Condition Factor (K) for Male and Female *Tilapia mariae* in Akomoje water Reservior.

PHYSICO-CHEMICAL PARAMETERS STUDY IN ORIYANRIN LOWER OGUN RIVER

Adeosun, Festus Idowu[1]; Adeosun, Olamide Modinat[2]; Oyekanmi, Funmilayo Bosede[3] and Moradeyo, Olusola Stephen[1]

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The aims of carrying out this experiment were to determine the water quality and to investigate if various human and ecological activities around the river have any effect on the physico-chemical parameters of the rivers. Water samples were collected from three stations on the surface water of Oriyanrin lower Ogun river for a period of 8 months (February to September, 2019). Results showed that temperature ranged 27.2-32.6°C, transparency (0.61-1.04m), pH (5.4-7.9), total dissolved solids (799-2000 mg/L), electrical conductivity (1714-3999 µS/cm), salinity (15.0-34.8%), Nitrate (2.49-3.23 mg/L) dissolved oxygen (5.40-8.3mg/L) and alkalinity (3.0-73.3 mg/l). The study conclude that the physico-chemical parameters agreed with the limits set by both national and international bodies for drinking and fish growth.

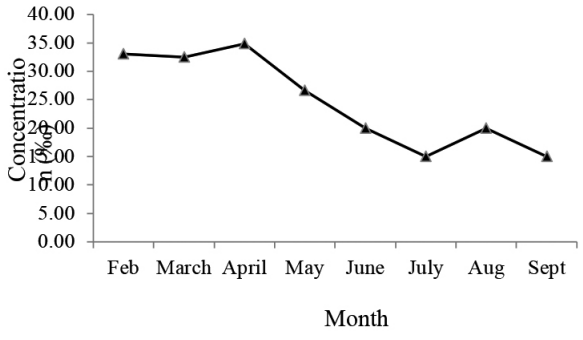

Figure 1: Monthly mean variation of salinity in oriyanrin Lagoon, Abeokuta, OgunState

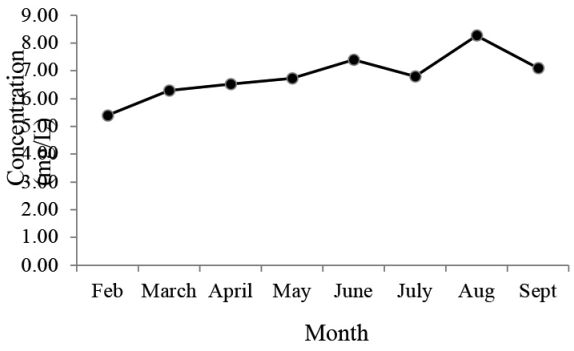

Figure 2: Monthly mean variation of dissolved oxygen in oriyanrin Lagoon, Abeokuta, OgunState

EFFECT OF VARYING DIETARY LEVELS OF LC-PUFA AND WEANING TIMES ON THE SURVIVAL, GROWTH AND DIGESTIVE ENZYME ACTIVITY OF THE AFRICAN BONYTONGUE (*Heterotis niloticus*) FRY

Adjei-Boateng, Daniel*; Ofori-Darkwah, Prince; Edziyie, Regina Esi; Agbo, Nelson Winston, and Lund, Ivar

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Limited information on appropriate weaning time to dry feeds and dietary requirements has been a challenge to the commercial culture of the African bony tongue (*Heterotis niloticus*) and has remained a major cause of the low survival rates and growth of fry. This study was conducted to determine the optimal weaning age and the effect of high and low phospholipid composition and polyunsaturated fatty acids (LC-PUFA) content in two experimental weaning diets, on the digestive enzymatic activity of *H. niloticus* fry. The two weaning diets were isonitrogenous and isolipidic (49%CP and 20%L) but differed in content with respect to level of phospholipids and the LC-PUFAs, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The two diets thus had different inclusion levels of soy lecithin (phospholipids) and Algatrium DHA70 (a glyceride product high in DHA and EPA). The diets were labelled, LD-(Low-dietary; phospholipids -5.97%, DHA-0.66%, EPA-0.41%) and HD-(High dietary; phospholipids -24.32%, DHA-3.04%, EPA-0.75%). Fry were fed *Artemia nauplii* until 15, 25, 35, 45, 65 or 85 days after hatching (DAH) respectively, and then co-fed with *Artemia* and one of two extruded dry feeds for an additional 7 days after which *Artemia* feeding was withdrawn. Fry were weaned to one of the two weaning diets at 22, 32, 42, 52, 72, or 92 DAH and maintained on the diets for a further 10 days. A control group was kept on *Artemia nauplii* throughout the experiment. The trial was performed as a 2×6 factorial experiment with each treatment in triplicate in a flow-through system, with a daily water exchange of 200%. Fry were fed the experimental diets 3 times a day to apparent satiation. The results showed that the survival rate of fish on both diets LD and HD increased significantly ($p < 0.05$) with age; from 0% for diets at 15 DAH to a higher survival of rate of 41.6±3.9 % and 70.0 ±3.33% for LD and 69.4±3.9 % and 80.0± *9.4* for HD at 65 and 85 DAH respectively. However, this was lower than the survival (mean 80.0±9.42 and 93.3% at 65 and 85 DAH, respectively) obtained by the control, which was maintained on *Artemia*. Final mean weight, weight gain and survival rate were significantly improved ($p < 0.05$) for fry fed the HD diet, which had a higher supplementation of dietary phospholipids and LC-PUFA´s (HD vs LD). Moreover, the digestive enzyme activity ($p < 0.05$) differed across the weaning ages with a decreasing trend for all enzyme with increasing fish age. The study revealed that *H. niloticus* requires a long adaptation period to dry feeds as fry weaned at 85 DAH (3.77±0.07g) had a lower survival than fry fed *Artemia* for the entire period. Additionally, an evaluation of growth and survival demonstrated beneficial effects in the inclusion of LC-PUFAs and phospholipids in their diets.

A RETROSPECTIVE STUDY (2018-2020) OF BACTERIAL AND FUNGAL ISOLATES OF DISEASED CATFISH CASES ACROSS ANIMAL CARE LABORATORIES IN NIGERIA

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Aquaculture plays a significant role in fulfilling the nutritional requirement of a growing population and contributes to the economic growth of Nigeria. However, catfish farming in Nigeria has faced various challenges, with diseases being a major setback. This retrospective study from 2018-2020 aims to review the commonly isolated bacteria and fungi organism of catfish from submitted samples and the seasonal variation of cases from our laboratories in Ogere, Lagos, Asaba, Ibadan and Abuja. A total of 357 cases were recorded. The most prevalent recorded was *Vibrio parahaemolyticus* (151 cases; 42.3%); followed by 110 cases (30.8%) of *Aeromonas hydrophila*. Fungal isolates of *Aspergillus flavus*, *A. niger*, and *Candida albican* (3.9, 2.5, and 3.6%, respectively) were also made. A comparison of the rainy season cases (196 cases, 54.9%) was statistically significantly different (p□0.05; Chi-square analysis) from dry season (161 cases; 45.1%). Overall, the retrospective study provides valuable insights into the bacterial and fungal pathogens isolated from catfish in Nigeria. However, these findings also highlight the need for improved disease detection and correlation with other culture issues (e.g. water quality and parasite infestations), better disease diagnosis techniques, and management strategies. With the help of the American Soybean Association/World Initiative for Soy in Human Health (ASA/WISHH), Animal Care Services is both receiving and conducting training to better detect causative problems that lead to mortalities in the Nigerian catfish industry.

Table 1. Bacterial and fungal isolates from Nigerian catfish farm disease cases 2018-2020.

ISOLATED ORGANISM	2018	2019	2020	TOTAL	Percentage
Vibrio parahaemolyticus	37	70	44	151	42.3%
Aeromonas hydrophila	59	31	20	110	30.8%
Salmonella typhmurium	12	10	6	28	7.8%
Other bacteria	11	10	11	32	8.9%
Aspergillus flavus	7	5	2	14	3.9%
Aspergillus niger	4	5	0	9	2.5%
Candida albican	9	3	1	13	3.6%
Total	139	134	84	357	

Table 2. Seasonal distribution of fish disease cases in Nigerian catfish farms

Season	2018	2019	2020	Total	Percentage
Nov □Mar (Dry Season)	88	45	28	161	45.1%
April □Oct (Rainy Season)	51	89	56	196	54.9%

PREVALENCE OF PARASITIC INFECTIONS OF FARMED NILE TILAPIA AND THEIR CORRELATION WITH POND WATER QUALITY PARAMETERS IN KERICHO, BOMET AND NAKURU COUNTIES, KENYA

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A cross-sectional study was conducted to determine the occurrence of ecto- and endo-parasites of farmed Nile tilapia (*Oreochromis niloticus*) in Kericho, Bomet and Nakuru counties, Kenya. A total of 220 live tilapia were sampled from fish farms from Kericho (90), Bomet (60) and Nakuru (70) for postmortem examination and parasite identified using standard methods. Dissolved oxygen, pH, and temperature of water were measured *in situ*. Two liters of fish pond water were collected and taken to Government Chemist for spectrophotometry chemical analysis of phosphates, nitrites, nitrates, ammonia, salinity, turbidity, electrical conductivity, alkalinity and suspended solid particles. Over 39% (39.54%, 87/220) of tilapia were infested by one or more parasite species. Ectoparasites recovered were protozoan ciliate species; *Trichodina* on skin and fins; *Riboscyphidia* and *Epistylis* on the skin. Others, were monogenean *Dactylogyrus* species recovered from the gills and crustacean copepods recovered from the skin. Endoparasites included trematodes *Diplostomum* and *Euclinostomum* species recovered from the eyes and kidneys, respectively. In the abdominal cavity, there were *Contracaecum* while the intestines had the nematodes *Paracamallanus* and *Camallanus* species; and the thorny worms (*Acanthocephalus* species) Prevalence of parasites per county were; Kericho 48.89% (44/90), Bomet 33.33% (20/60), and Nakuru 32.86% (23/70). Earthen ponds had a significantly higher (52.5%; 42/80) parasite infection relative to liner (35.45%;39/110), plastic tank (30%, 3/10) and concrete (15%, 3/20) ponds ($p<0.05$). All water quality parameters were significantly different in all counties (One-way ANOVA, $P<0.05$) except salinity, sulphate, and nitrites ($p>0.05$). Sulphate had positive association of 1 ($p<0.05$) with *Riboscyphidia*, *Epistylis*, *Trichodina*, *Contracaecum*, *Diplostomum*, *Dactylogyrus*, *Paracamallanus* and *Camallanus* species. Electrical conductivity correlated with *Trichodina*, *Euclinostoum*, and *Acanthocephalus* species. Temperature, pH, nitrate, and phosphate had very strong association of (0.80-0.99, $p<0.05$) with most of the parasites. Phosphate and pH had moderately association of 0.6-0.79 ($p<0.05$) and were correlated with *Dactylogyrus*, *Camallanus,* and *Diplostomum* species, respectively. Farmers are advised to monitor parasitism and water quality parameters and practice good aquaculture husbandry individually or through extension officers to mitigate parasitic infections.

COMPARISON OF WATER EXCHANGE AND AERATION FOR GROWING NILE TILAPIA FRY IN TANKS TO 2 GRAM SIZE: A DEMONSTRATION FOR HATCHERY PRODUCERS IN GHANA

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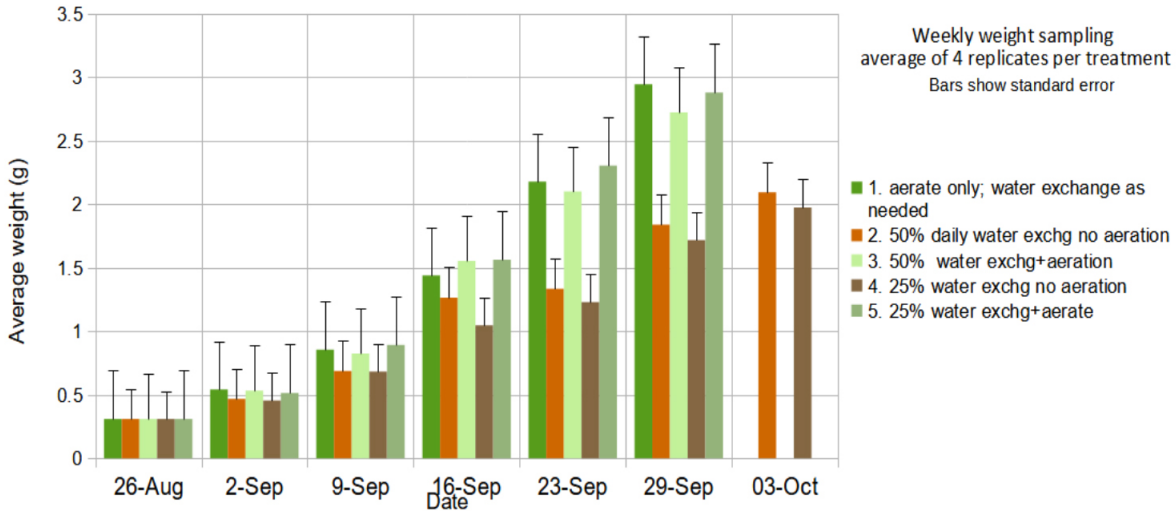
In Ghana, farmers growing fish in ponds and tanks often choose to exchange water to supply additional oxygen and remove fish wastes. However, water does not contain much oxygen (about 0.0008%) whereas air contains 20.9% oxygen. Therefore, fish farmers in other parts of the world have realized that aeration is a much more effective means to supply oxygen, compared to water exchange. However, at some point, water exchange is necessary to remove metabolites such as ammonia. A series of trials was run on a private farm to demonstrate to the farm and to others the trade-offs between aeration and water exchange. Each of 20 outdoor tanks containing 1 cubic meter of water were stocked with 1000 tilapia fry of 0.3 grams. Five treatments of 4 replicates each were run. The treatments were as listed in the table and figure below. Aeration was turned off during the day for treatments 1, 3 and 5. Fish were fed 3 time per day to satiation. Twice daily measures of dissolved oxygen and temperature were made on most days, whereas pH and total ammonia were measured twice weekly.

Total daily feed input reached 60g per cubic meter water volume, which is about 6 times the recommendation for static water non-aerated tilapia ponds. Fish growth was superior in all of the aerated treatments, compared to the non-aerated. Morning dissolved oxygen was much lower in the non-aerated treatments and, in the latter part of the trial, was frequently below 1mg/l. Total ammonia was not different between treatments.

Treatment	Average AM D.O.(mg/l)	Average PM D.O.(mg/l)	% of readings below 1mg/l
1: Aeration & water exchange as needed	7.12±0.05	7.12±0.13	0
2: No aeration; 50% daily water exchange	1.58±0.07	5.45±0.11	51/216=23%
3: Aeration & 50% daily water exchange	7.33±0.05	8.04±0.02	0
4: No aeration; 25% daily water exchange	1.20±0.05	4.60±0.07	91/216=42%
5: Aeration & 25% daily water exchange	7.47±0.03	7.91±0.09	0



CONTRACT FARMING : A SOLUTION TO SCALE SMALLHOLDER AQUACULTURE IN MADAGASCAR?

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Madagascar ranks as one of the lowest countries for fish consumption per capita in the African region, less than 5kg kg per inhabitant and per year, less than half of the average consumption for the sub-Sahara African region (11 kg/ person/year).

Low consumption of fish in Madagascar has several root causes, of which the limited aquaculture value chain development is one. Although demand for aquaculture products is high, aquaculture supply only a limited volume to the domestic market.

With limited access to quality inputs and other key constraints (low transportation network, high import taxes), the sector was, until recently, stagnating with high production, market, and financial risks for investors.

Several models of aquaculture value chain integration mostly in South and Southeast Asia and for oriented toward export markets have proven to reduce those risks.

On the east coast of Madagascar, a cooperative union named Tilapia de l'Est operates along the tilapia value chain through contract farming with the local farmers and sell the fish to the local markets.

We use Tilapia de l'Est Cooperative as a case to illustrate that contract farming could be a pathway to reduce production, market and financial risk in a non-conductive environment for aquaculture business development.

We argue that such model can be successful and achieve development outcomes in a context where aquaculture value chain is nascent and faces strong structural constraints. Hence, contract farming in aquaculture can play a positive role in increasing local fish supplies, create jobs and alleviate poverty through employment and increased incomes for smallholder farmers.

We hypothesis that this buyer-driven model could be replicated and contribute to the growing increase in small sized aquaculture enterprises in Madagascar.

AQUAFEEDS AND ALTERNATIVE FEED INGREDIENTS

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Aquafeeds have been the main sustainable platform for the aquaculture industry in Africa, as they provide essential nutrients needed for the growth, health and productivity of the farmed fishes. Without high-quality aquafeeds, it would be challenging to meet the increasing global demand for farmed fish. Conventional feedstuffs like fish meal, soybean meal, groundnut meal, maize and cowpeas used for preparing aquafeeds are becoming scarcer and more expensive, due to issues of sustainability, competitive use by humans and livestock, resource availability, cost-effectiveness and the effect of climate change thus making the use of aquafeeds unsustainable. Consequently, the use of conventional animals and plant feedstuffs in fish nutrition may no longer be sustainable. Therefore, there is a need to explore alternative fish feed ingredients that are locally available, low-cost, nutritious and sustainable to reduce dependence on traditional raw materials. This paper, therefore, provides an overview of the current challenges with the use of raw ingredients in aquafeeds and explores the potential benefits and challenges associated with alternative ingredients. It also discusses the role of alternative fish feed ingredients in the sustainable development and promotion of commercial aquaculture in Africa

Traditional raw ingredients like fishmeal, fish oil, maize and soybean meal have been widely used in aquafeeds due to their high protein and lipid content. However, the limited availability of traditional fish ingredients and the high cost of import pose significant challenges to the aquaculture industry in Africa. In addition, the use of conventional fish feed ingredients has led to water pollution, habitat degradation, and the depletion of fishery resources especially the reliance on fishmeal obtained from wild-caught fish contributes to overfishing and disrupts the marine ecosystem. A variety of alternative raw feed ingredients have shown promise in aquafeeds. These alternatives offer a sustainable source of nutrients and can help reduce the pressure on traditional fish feed ingredients. Some of the potential alternative fish feed ingredients for sustainable aquaculture production in Africa are insect meal (black soldier fly larvae, housefly maggots, mealworms and crickets), animal by-products (leftover parts from the slaughter or processing of animals, such as poultry, cattle, pigs and fish), plant by-products (plant residues from the processing of crops, such as oilseeds, cereals, fruits and vegetables) and algae (photosynthetic microorganisms that can produce various bioactive compounds). Future and emerging trends outlooks in aquafeeds and alternative ingredients have shown that the integration of functional feed additives, such as probiotics and prebiotics, in aquafeeds offers potential health benefits and can enhance the performance and resilience of farmed species. Also, the adoption of circular economy principles in aquafeed production using agro-industrial by-products aims to minimize waste and maximize resource efficiency. Continued genetic advancements in aquaculture species, combined with customized feed formulations, can lead to enhanced growth rates, feed conversion efficiency, and disease resistance. Several alternative feed ingredients, including plant-derived materials, have been tested in aquaculture feeds for several fish species of economic importance. Meanwhile, research efforts have shown that other non-conventional protein sources such as agricultural wastes and byproducts hold enormous potential in future fish feed formulations (table 1).

Table 1: Research findings on selected alternatives fish feed ingredients

Fish species	Activities	References
African catfish	Poultry offals replaced 75% fish meal	Falaye A. E., Omoike A., Ajani E. K. and Kolawole O.T. (2011)
African catfish	20% Boiled Sunflower Seed Meal can partially replace soybean meal	Adesina, S. A., Falaye, A. E., Olusola, S. E. and Ajani, E. K. (2015)
Tilapia	Total replacement of fish meal with soybean meal	Ajani, E.K; Orisasona, O; Omitoyin, B.O. and Osho, E.F (2016)
African catfish	Groundnut Oil can successfully replace up to 50% of Fish Oil	Tijani, G. F., Ajani, E. K. And Agbede, S. A. (2015)
African catfish	Soyabean meal can be replaced with up to 50% of boiled lima bean meal	Orisasona O. ,.Falaye A. E, Ajani E. K.and Kareem O. K. (2016)
African catfish	Chicken offal meal replaced 75% of fish meal	Omitoyin, B.O and Faturoti (2000).
African Catfish	Feather meal replaced 25% of fish meal	Omitoyin B.O and Faturoti, E.O. (2001)
Nile tilapia	Cassia fistula replaced 25% of soybean meal	Nwanna, Fagbenro & Jegede (2004)
African catfish	Inclusion of water hyacinth at 15%	Nwanna & Ajani (2005)
Nile tilapia	Discarded cocoa bean meal replaced 75% of maize	Nwanna & Fashae (2008)
Nile tilapia	Soybean oil replaced 100% of fish oil	Nwanna & Bolarinwa (2000)
African catfish	80% maize + 20% Green plantain peels meal	Nwanna, Ogundowole & Nwanna (2014)
Nile tilapia	Cattle rumen waste replaced 50% of maize	Nwanna, & Oladipupo (2018)
Nile tilapia	Maggot meals replaced 100% fish meal	Ajani, Nwanna & Musa (2004)
Heterobranchus bidorsalis	Inclusion of 3g/kg velvet bean	Oladipupo, Nwanna, Ogunlana & Omoogun (2019)
African catfish	Cocoyam leaves replaced 50% of Soybean	Nwanna, Afolabi, Sanni, Nwanna, Boligons & Athayde (2016)

(Continued on next page)

The alternative feed ingredients offer greater opportunity for sustainable aquaculture production in Africa as these can improve the resilience and sustainability of aquafeed production, decreasing reliance on scarce resources. Also, it creates opportunities for the aquaculture industry to emphasize their commitment to environmentally friendly practices through the utilization of alternative raw ingredients. However, the alternative fish feed ingredients utilization in aquafeed are faced with the challenges of ensuring the cost-effectiveness and scalability of alternative raw ingredients. More research and innovations in ingredient production and processing can help in addressing these concerns and facilitate market adoption. Furthermore, the development of clear regulations and standardized criteria for alternative raw ingredients in aquafeeds is essential to ensure quality control, safety, and integrity in the production and marketing of aquaculture products.

More research and innovation are, however. needed to overcome these challenges and unlock the full potential of alternative feed ingredients as a sustainable and circular solution for aquaculture production. Further research is needed to optimize the processing methods, formulation strategies and feeding practices of these alternative feed ingredients for different fish species and culture systems. In conclusion, these alternative fish feed ingredients can reduce the dependence on imported feed ingredients, lower the cost of production, improve the nutritional quality of fish and enhance the environmental and social sustainability of aquaculture in Africa.

LAND BASED AQUACULTURE; A PROMISING PRACTICE IN JORDAN'S AQABA/RED SEA

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One of the areas that receive considerable attention in all countries of the Red Sea region is the development of additional resources for food security enhancement. These goals can be partly attained by improving farming technology, such as intensive aquaculture. Almost by definition, agriculture in this arid region has to be based on the use of as little freshwater as possible due to extreme sacristy in rainfall at these latitudes. Hence, marine aquaculture or mariculture, offers an excellent solution as it is based exclusively on the use of seawater. At the same time, countries in the region suffer from a deficit of seafood production and face poor fishing conditions. Jordan for example has been importing almost all of its seafood consumption (about 97%). Lately however, concern has been raised regarding the effect of the fish cages on the Gulf of Aqaba/Red Sea coral reef ecosystem. Thus, development of alternative solutions such as Land-based mariculture has the potential to provide an economic efficient and environmentally friendly resource using the technology of recirculating aquaculture systems (RAS).

The strategy of mariculture in Jordan now is based on culture of economically valuable and environmentally non-demanding species and at the same time applies strict management controls for these practices. In environmentally sensitive areas such the Gulf of Aqaba/Red Sea known for its oligotrophic nature in support to coral reefs ecosystem, we attempted practices in land based aquaculture apart from natural water bodies following national regulations. Using RAS in Jordan's aquaculture is specifically calibrated for endemic cultured fish species. This leads to the focus on high value low environmental burden aquaculture under RAS conditions. It allows implementing intensive culture fish species with minimal water consumption. Another approach is the culture of giant clams (*Tridacnidae*) which exploits effective recycling of material between two trophic levels embodied within one organism, animal host with its algal symbionts (zooxanthellae). This enables clams to tap different nutrient sources and achieve high growth rates in spite of low ambient concentrations. Recently attempts were undertaken to domesticate the local shovel Red Sea lobster (*Scyllarides tridacnophaga*) using also a specially designed RAS. These practices of aquaculture will hopefully paves the road for the use of RAS in supporting sustainable marine aquaculture in Jordan's Red Sea. At the same time, avoiding direct exploitation of the limited coast and expanding in intensive land based rearing systems.

ISOLATION, CHARACTERIZATION AND ANTIBIOGRAM PROFILE OF ENVIRONMENTAL BACTERIAL PATHOGENS FROM FARMED AFRICAN CATFISH IN NIGERIA

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Fish health is greatly influenced by the prevailing bacterial communities and the dramatic change in their structure in the aquatic environment. The prevalent environmental bacterial pathogens in aquaculture production in two southern states of Nigeria were characterized and evaluated for antibiotic sensitivity, antimicrobial resistance, and presence of virulence genes.

Liver, kidney, and spleen collected aseptically from apparently healthy African catfish (*Clarias gariepinus*) farmed in Delta and Ogun states, were subjected to bacterial culture, isolation, identification, and DNA extraction. Whole-genome sequencing of extracted DNAs was carried out at WorldFish, Malaysia while biochemical and antibiotic susceptibility tests were conducted at Mississippi State University, USA. Ribosomal RNA-containing contigs were identified and their corresponding 16S rRNA gene was extracted and used to BLAST against the NCBI microbial 16S database. Mass screening of contigs for antimicrobial resistance and virulence genes was performed.

The BlastN revealed *Providencia vermicola* (99.802%), *Providencia rettgeri* (99.666%), *Proteus mirabilis* (99.799%), *Proteus vulgaris* (99.527%), *Citrobacter freundi* (99.667%), *Morganella morganii* (99.728%), *Alcaligenes faecalis* (99.316%), and *Pseudomonas qingdaonensis* (100%) as the prevalent environmental organisms. Analyses of the isolates showed that only *Alcaligenes faecalis* had no antimicrobial-resistance (AMR) genes. *Providencia* spp. (*P. vermicola* and *P. rettgeri*) genome had seven AMR genes; *tet*(57) and *tet*(59) (tetracycline), *aadA1* and *ant*(3'')-Ia (Streptomycin), *sat2*_gen (Streptothricin), *catB2* (Chloramphenicol), and *dfrA1* (Trimethoprim). *Proteus* (*P. mirabilis* and *P. vulgaris*) possessed fourteen AMR genes: *hugA*, *blaTEM*-1, *blaTEM*-1B (Beta-lactam), *catA1, catA4,* and *cat* (Chloramphenicol), dfrA7 (Trimethoprim), *sul1, sul2*, (Sulfonamide), aph(3'')-Ib; aph(6)-Id (Streptomycin), tet(A), tet(J) (Tetracycline), and *blaTEM*-1B (Amoxicillin, Ampicillin, Cephalothin, Piperacillin, Ticarcillin). *Citrobacter freundi* possessed four AMR genes; *qnrB12* (Quinolone and Ciprofloxacin), *blaCMY*-159, *blaMOR*-2, and *blaCMY*-98_1 (Cephalosporin). *Morganella morganii* had two AMR genes; *catA2* (Chloramphenicol) and *blaDHA*-17 (Cephalosporin, Amoxicillin; Amoxicillin+Clavulanic acid; Ampicillin; Ampicillin+Clavulanic acid; Cefotaxime; Cefoxitin; Ceftazidime; Piperacillin; Piperacillin+Tazobactam; Ticarcillin; Ticarcillin+Clavulanic acid). *Pseudomonas qingdaonensis* possessed seven AMR genes; *cmlB1* (Chloramphenicol), *dfrA1* (Trimethoprim), *sat2*_gen (Streptothricin), *sul3* (Sulfonamide), aac(3)-IIe (Gentamicin), *aac*(3)-IIa (Tobramycin), *aadA1* and *ant*(3'')-Ia_1 (Streptomycin).

Out of the eight isolates, only *Citrobacter freundi* and *Pseudomonas qingdaonensis* had virulence factors; 11 (*csgB, csgD, csgE, csgF, csgG, ompA, entA, entB, entE, fepG*, and *fepC*) and 2 (pilH and algR), respectively.

Opportunistic pathogens are becoming an emerging threat to aquaculture systems because diseases caused by them have been generally overlooked. The possession of AMR genes and virulence factors by opportunistic environmental pathogens in farmed fish suggests pollution of aquatic environments with adverse effects on the environment, animals, and public health.

PREVALENCE, ANTIBIOGRAM, AND ANTIBIOTIC RESISTANT GENES (ARGS) OF *Vibrio parahaemolyticus* ISOLATED FROM CULTURED *Clarias gariepinus*, BURCHELL 1822, FROM SOUTHERN STATES IN NIGERIA

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The incidence of diseases in aquaculture production has been described as one of the greatest setbacks, characterized by financial losses with attendant environmental and public health implications. The prevalence, antibiogram, and antibiotic-resistant genes of *Vibrio parahaemolyticus* isolated from apparently healthy farmed *Clarias gariepinus* were assessed. A total of 285 adult fish and 39 fingerlings were analysed. Tissue samples were cultured using Thiosuifate Citrate-Bilesalts Sucrose (TCBS) media (Millipore®, Germany) and incubated at 30°C for 24 hours after which biochemical characterisation was carried out for detailed identification. Nineteen (19) representative isolates were selected for Antibiotic Sensitivity Test (AST), and Antibiotic Resistant Genes (ARGs) determination through whole-genome sequencing.

A total of two hundred and seven (207) *Vibrio parahaemolyticus* organisms were isolated, which translated to 39.8% and 47.7% prevalence in Delta and Ogun states, respectively. All the *Vibrio parahaemolyticus* isolates showed 100% sensitivity to tetracycline and florfenicol, 81.8%/87.5% to chloramphenicol and streptomycin, 72.7%/62.2% to ampicillin, and 63.6%/87.5% to Trimethoprim/Sulfamethoxazole in both states, respectively. The isolates had 72.2% sensitivity to kanamycin in Delta State. 100% resistant to Novobiocin, 90.9%/50% to terramycin, 81.8%/87.5% to Nalidixic acid and Nitrofurantoin, 81.8%/75% to Colistin sulphate respectively, and also resistant to kanamycin (62.5%) in Ogun State. The multiple antibiotic resistance index (MARI) ranges between 0.16 and 0.67. The whole-genome sequencing revealed the presence of twenty-five antibiotic resistance genes covering aminoglycosides, beta-lactamases, chloramphenicol, trimethoprim, florphenicol, fosfomycin, quinolones, fluoroquinolones, streptothricin, sulphonamides, and tetracycline.

The prevalence, multi-drug resistance status, and acquisition of a large number of antibiotic resistance genes in aquaculture environment has public and environmental health implications for the AMU/AMR menace. The results from this study suggest a significant abuse of antibiotics, aquatic environmental pollution from hospitals and manufacturing industries. This also renders the treatment of fish diseases difficult and makes both fish and fish products unwholesome. Best management practices, treatment of effluent discharges and adequate oversight by competent authorities is hereby recommended.

TRANSFORMATION OF THE FEED SUPPLY SEGMENT OF THE AQUACULTURE VALUE CHAIN IN BANGLADESH

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The rapid growth of aquaculture in Bangladesh over the past 3 decades has been facilitated by increasing supplementary feed use and increasing numbers of feed suppliers, but little is known about the organization and behavior of the feed supply segment of aquaculture value chain. We conducted a comprehensive survey with 79 feed suppliers of two types: 'dealers' linked to feed companies (n=34) and independent retailers (n=45), in the seven main aquaculture producing districts of southern Bangladesh in 2021 to address this knowledge gap. We find the following. (1) Over the past 10 years, the number of traders increased 70% and the volume of feed traded almost doubled. (2) Feed supply is shifting from traditional agricultural byproducts to formulated feeds (47% of total feed) (Table 1), and floating feeds as a subset of those (54% of formulated feed), contributing to increasing farm productivity. (3) The formulated fish feed market in Bangladesh is diverse, but quite concentrated. Feed suppliers sold formulated feed produced by 35 companies, with eight companies accounting for 74% of sales. (4) Feed handling practices are efficient. Traders sell feeds quickly (average turnover time 10 days) and storage practices are adequate to maintain quality. (5) No traders reported experiencing any waste or loss of feed during their most recent completed transaction, and only 5% of traders reported a losing a small portion of feed (1.7%) during transport. (6) The average profit margin earned by feed suppliers is a modest 6.2%. (7) Feed trading creates substantial employment: 43,937 full time equivalent (FTE) jobs in the seven surveyed districts. In sum, these findings suggest the feed supply segment of the aquaculture value chain in Southern Bangladesh is dynamic, well-developed, and relatively competitive and efficient. This finding is contrary to the conventional wisdom, which often portrays the sector as inefficient and beset by problems.

Table 1: Characteristics of aquaculture feed traders

Variables	Wholesaler	Auctioneer	Total
N	34	45	79
Mean volume of feed traded (t/year)	305	130	182
Mean value of feed traded (USD/year)	154,443	53,589	83,331
Formulated feed share in total volume (%)	76	18	47
Mean labor days per ton feed sold	9.2	15	13
Total FTE jobs created	21,495	22,442	43,937
Working capital (USD/year)	42,120	10,593	28,141
Mean operating cost (USD/year)	5,799	2,302	4,248
Mean gross margin (USD/year)	5,349	2,041	3,882
Marketing margin (%)	6.0	6.5	6.2

ECTOPARASITES OF FARMED NILE TILAPIA IN LAKE VOLTA

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Cage culture of Nile tilapia (*O. niloticus*) in Lake Volta accounts for about 80% of the total annual aquaculture production in Ghana. In the past decade, however, cage farms in Lake Volta have experienced numerous disease outbreaks resulting in high mortalities and economic losses. Unfortunately, most efforts on fish disease in Ghana have focused on bacterial and viral infections, while far less attention has been given to parasitic infestations. However, fish parasites, especially ectoparasites, have the potential to cause mortalities by increasing the risk of secondary bacterial and viral infections. This study, therefore, sought to identify the ectoparasites present in Nile tilapia cage farms in Ghana, estimate their prevalence, mean intensity, and density.

A structured questionnaire with both closed and open-ended questions were administered to 30 Nile tilapia cage farms to obtain information on the peak period of occurrence of ectoparasites in these farms. Fish were sampled from selected farms for ectoparasites identification over a period of 6 months (Feb. – July 2023). The selected farms were located at the up-, mid- and down streams of Stratum II of the Volta Lake – the hub of aquaculture in Ghana. A total of 900 fish were randomly collected from five farms and transported live to the laboratory for examination. Ectoparasitic identification was done using a combination of taxonomic keys and identification guides. The ectoparasites were counted and their prevalence, intensity and abundance of infestation estimated. Ectoparasites belonging to the genera *Trichodina*, *Ichthyophthirius, Dactylogyrus, Gyrodactylus*, *Cichlidogyrus, Diplostomum*, Myxosporean and *Argulus* were encountered. Two were species unidentified. *Trichodina*, *Dactylogyrus, Gyrodactylus* and *Cichlidogyrus* were present in all farms except Myxosporean, *Argulus, Diplostomum, Ichthyophthirius* and the two unidentified species which occurred in some of the farms. *Trichodina* sp. were the most prevalent parasites in all farms, while *Ichthyophthirius* was least prevalent.

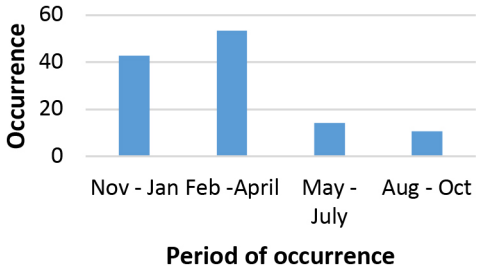

Fig 1: Period of occurrence of ectoparasites infestation

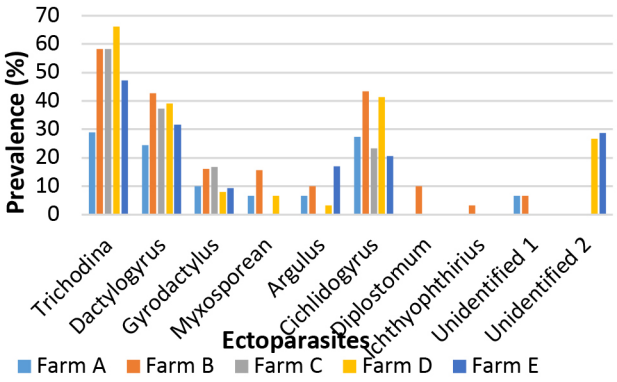

Fig 2: Prevalence of ectoparasites in cage cultured Nile tilapia from five farms on the Volta Lake, Ghana.

Moringa oleifera AND *Amaranthus caudatus* AS A NUTRIENT SUPPLEMENT FOR AQUAPONICS LETTUCE, MINT, *Coptodon rendalli* AND *Clarias gariepinus* PRODUCTION IN AN AQUAPONICS PILOT PROJECT

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Angola is strongly engaged in the development of aquaculture to improve per capita fish consumption to reach desired levels worldwide.

The Aquaponics pilot project combined cultivation of fish and plants, in a symbiotic environment using conventional methodology in fish farming of the Thai or Redbreast Tilapia (*Coptodon rendalli*) in an aquaponics system. This approach was implemented at the ECOCENTER PEIXES, Lda, Research Pilot Center, in order to obtain greater yield with the use of this technology.

Aquaponics is an excellent plant production system that uses wastewater from fish farming to fertilize the plants and thereby, avoids the emission of ammonia and nitrogenous compounds into the environment. It also allows better extraction and use of the remaining nutrients from the feed, concentrated at the bottom of the fish farming tanks.

In this pilot project, 12 breeders of *Coptodon rendalli* were used, weighing 250 to 300 g on average, in a $3m^3$ circular tank, with a 1000 L biofilter, 0.5 CV electric pump and 200 L decanter.

To feed the fish, a compound with local raw materials was used as an alternative feed ingredient, based on cornflour, cassava corn meal, rice bran, mucua, soy beans, coconut oil, leaves of *Amaranthus caudatus*, sweet potato and *Moringa oliefera*, and, as animal protein, fish meal of *Sardinella aurita*, insect larvae of *Catato angolensis*, which provided a food conversion rate of 1.5 kg of feed to 1.0 kg of fish biomass during 8 months of closed and recycled cultivation.

The results showed rapid growth of vegetables, Lettuce and Mint, in 45 and 60 days without the use of soil or pesticides, and a high average yield of the species under cultivation.

Excellent yields were also achieved in terms of vegetable growth, with the replacement of Redbreast Tilapia by the Catfish *Clarias gariepinus*, finally concluding that the combination of aquaculture with agriculture is a perfect symbiosis for the environment and a strong and sustainable blue economy.

Angolan demography is growing, and encouraging aquaculturists to cultivate organic fish and plants in combination, as they are alternative foods with high sources of animal and vegetable protein, to provide sustainable food for the Angolan population is the main challenge of this work.

CONTRIBUTION OF RICE-FISH FARMING TO FOOD SECURITY AND INCOMES IMPROVEMENT OF SMALLHOLDERS IN THE MALAGASY HIGHLANDS

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Madagascar is one of the countries most affected by malnutrition. 40 per cent of children under 5 years old suffer from chronic malnutrition (Demographic and Health Survey, 2021). Causes of malnutrition are related to inadequate food practices and limited availability and accessibility of animal proteins. Indeed, the average fish consumption is only 4 kg/inhabitant/year, which is well below the African average (10 kg) and the global average (20 kg).

The NGO *APDRA Pisciculture Paysanne* works to improve the availability and accessibility of fish to the most vulnerable by supporting small-scale aquaculture production. Best practices for integrated carp (*Cyprinus carpio*) farming in rice fields are fine tune to fit the local context and disseminated, through local advisors. This approach reaches more than 10,000 smallholders in the Malagasy Highlands. In addition, a network of more than 1,000 fingerlings producers ensures the fingerlings supply to rice-fish farmers in remote areas. As such, the integration of fresh water fish farming in rice plots not only allows to the production and access to animal proteins, but also to increase rice yield on the same plot by at least 10 per cent, using the same amount of water. It helps to diversify and increase the incomes of vulnerable smallholders. Hence, the surveys conducted in 2020 of 41 fish producers have shown that fingerlings producers earn an average monthly income between 35 and 66 USD (80 to 150 per cent of the minimum income in Madagascar), while rice-fish farmers, earn between 9 and 15 USD per month from their fish sales (20 to 33 per cent of the minimum income in Madagascar). On average, rice-fish farms produce 33 kg of fish each year.

Madagascar has about 150,000 ha of rice fields suitable for rice-fish farming. This area could support to the production of one third of the fish requirement of the country by 2040. However, in the context of climate change, new adaptations need to be design and scaled (water management, cycle schedule, collective management, etc.) to ensure the rice-fish farming resilience and performance. Promoting technical and organizational innovations co-constructed with farmers will ensure that rice-fish farming in Malagasy Highlands remains resilient and can adapt to current and future conditions.

EFFECTS OF COMMERCIAL DIETARY PROBIOTICS ON GROWTH PERFORMANCE AND CONTROL OF *Streptococcus agalactiae* INFECTION IN NILE TILAPIA FINGERLINGS IN GHANA

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The aquaculture industry in Ghana is predominantly hinged on Nile tilapia farming. Nile tilapia production constitutes more than 70% of total annual aquaculture production in the country. Attempt at increasing Nile tilapia production has been met with the challenge of disease outbreaks, most of which are of bacterial origin. One of the dominant bacterial pathogens is *Streptococcus agalactiae*, which has two serotypes (1a and 1b) documented as present and causing high mortalities in most farms. Farmers have resorted to the use of antibiotics to treat these diseases. However, globally, this practice is frown upon due to environmental and consumer health concerns. An eco-friendly alternative is the use of probiotics which are live microorganisms that when fed to fish confer growth and health benefits to them, with no known negative implications on the consumer's health.

The objective of this study was to evaluate the effects of three dietary probiotic products (PB1, PB2 and PB3) on growth performance and control of *Streptococcus agalactiae* infection in juvenile Nile tilapia. The probiotic diets were prepared using a basal diet containing 40% protein for juvenile tilapia. They were added to the basal diet based on the manufacturers' dosage as follows: PB1: 12.5 ml/kg; PB2: 0.1g/kg and PB3: 5g/kg whiles the control group was fed the basal diet. Fifteen fish of mean weight 10 g were placed in 40L aquaria tanks (3 replicates/diet) in a flow through system and fed the diets for 12 weeks before the challenge with *S. agalactiae*. Water quality parameters were recorded over the 12 weeks and fish weights determined fortnightly. Serum bactericidal activity was analysed pre and post challenge. Fish were challenged through IP injection with *S. agalactiae* at 1.5 x10^8CFU/ml. Results showed no significant difference in growth parameters of the control and probiotic diets (P=0.047). However, there was significant difference in percent mortalities of fish fed the control and probiotics diets after the pathogen challenged (P=0.000000000299).

Table 1. Effect of control and probiotic diets on the growth of juvenile Nile tilapia. Values are means ± s.d of 3 replicates.

Parameter	Control	PB1	PB2	PB3
Initial weight (g)	10.01±0.04	9.99±0.02	9.99±0.02	10.0±0.03
Final weight (g)	67.1±8.87	59.04±4.01	60.1±11.69	65.7±5.88
FCR	1.78±0.22	2.64±0.47	2.33±0.46	2.05±0.31
SGR (%/day)	28.93±0.89	27.42±1.27	28.14±1.18	28.17±0.09

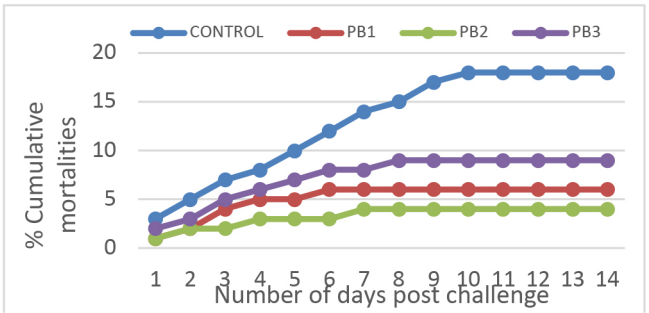

Fig.1. Percent cumulative mortality of Nile tilapia fed control and probiotic diets and challenged with *S. agalactiae*.

EVALUATION OF THE EFFECT OF THE INCLUSION OF COMMON EGGPLANT (*Solanum melongena*) ON THE GROWTH OF WHITE SHRIMP *Penaeus vannamei* CULTURED IN INTENSIVE SYSTEM IN LOW SALINITY

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Eggplant is considered one of the vegetables with the greatest antioxidant power (Cao et al., 1996), with phenolic compounds being the main secondary metabolites. These are substances with high antioxidant capacity, have their origin in the plant world and have beneficial effects. For health within them we can mention chlorogenic acid (CGA) as the main phenolic compound found in the pulp (Nuez et al., 2007). ACG, an ester of caffeic and quinic acids, is one of the most abundant in nature and constitutes the main soluble phenolic compound in eggplant, resulting in the greatest contributor to the high antioxidant activity of this fruit.

Phenolic compounds have been reported to accumulate in response to various types of stress, including low temperature (Clé et al., 2008; Massolo et al., 2011). The best growth was observed in the treatment with 5% eggplant flour, although there was no significant difference between the treatments, a slightly better survival rate was observed in treatment number 4.

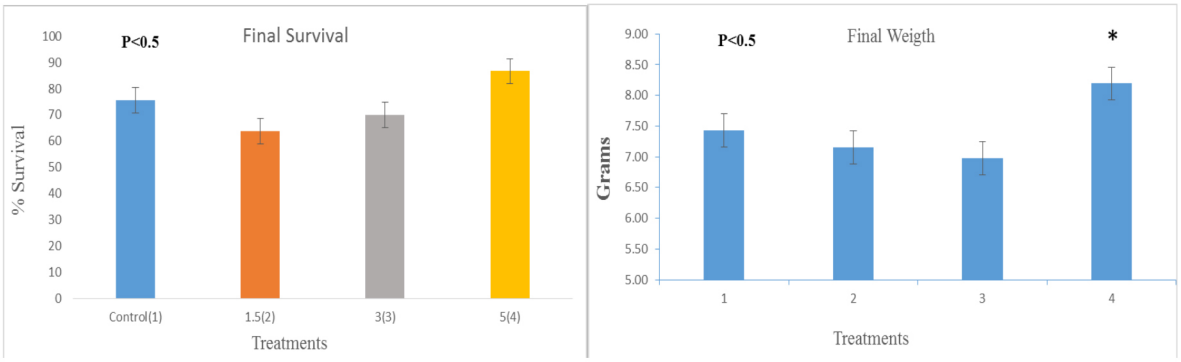

Figure 1. Survival of P. vannamei and growth during 8 weeks of culture, differ-ence p <0.05 (*) indicate a significant differences

IMPACT EVALUATION OF FISH FARMERS'S TRAINING ON AQUACULTURE FISH WELFARE IN NIGERIA

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Aquaculture fish welfare recognizes the scientifically established sentience of fish, and impact on fish health, productivity, and quality among others. Farmed fish are in a state of good welfare when: their living environment meets their natural and behavioral needs, they are in optimal health, they are free of negative experiences (such as pain, fear, hunger, thirst, distress), and they have access to positive experiences (such as social companionship, co-existence, and environmental compatibility). One Health and Development Initiative (OHDI) implemented train-the-trainer workshops in Nigeria to educate and build the capacity of fish farmers on fish welfare practices and its integration on their fish production systems. The training topics introduced them to the concept of fish welfare and practices, with welfare considerations in several aspects of fish production such as growing systems, stocking density, feeding, water quality, handling, transportation, environmental enrichment, and fish health.

To evaluate the change in knowledge of fish farmers on fish welfare, questionnaires were applied for pre-and post-training surveys on 87 fish farmers who were selected and trained over 3 pilot training sessions in Ibadan and Abeokuta, Nigeria. A preliminary survey of fish farmers showed that most have little knowledge of fish welfare, its impacts, and benefits. Results showed an overall 30% increase in knowledge of farmers on fish welfare practices, especially in feeding, handling, transportation, and slaughtering of fish. At least 64% self-reported excellent understanding of all topics with highest satisfaction of welfare practices in feeding (81%), benefits of fish welfare practices (80%), water quality (80%), handling (78%), and growing systems (76%). The reviews on the workshops' delivery, showed 60% reported excellent satisfaction, with the highest received in facilitators engagement (100%), group works (82%), and conducive learning environment (82%). Furthermore the farmers indicated that handling, feeding, water quality and slaughtering were the most important fish welfare practices that they committed to implementing on their fish farms.

These results demonstrate significant impacts and benefits of the fish welfare training on fish farmers with considerable increase in their knowledge, capacity, and commitment to implementing fish welfare practices on their farms. It was recommended that the training should be scaled up and there should be follow-up research to evaluate farmers' on-site implementation of fish welfare practices and impacts on their fish farms.

IMPLICATIONS OF INBREEDING IN *Clarias gariepinus* FISH FARMING: FARMERS' PERSPECTIVES IN NIGERIA

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There has been a nationwide unexplainable huge loss of fish at the fry/fingerling juvenile stage since 2013 by catfish breeders or fish farmers in Nigeria. This has prompted search for the probable causes for the huge losses during these stages. The systematic elimination of the probable causes of the massive mortality of fish fry/fingerlings, by the practicing farmers and the concerned supervising authorities, has been narrowed down to inbreeding of catfish. This has come with different narrations of woes ranging from a great reduction in hatching of catfish, to table size production. Inbreeding in fish is said to be the mating of closely related individuals leading to loss of hybrid vigor. It has made hatching unpredictable because most brood stocks in the country have lost hybrid vigor. The genuine concern for the loss to hatchery operators led to a concerted effort of a group of fish farmers from different geo-political zones of the country, other professional career civil servants, coming together to exchange notes on practical experiences and findings on their farms. This has continued to date. The general observation from empirical experience of hatching *Clarias gariepinus* was that on hatching, there will be growth but indiscernibly slow, active, and showing promises of potential fingerlings/juveniles. However, between 3rd and 4th week the fry will suddenly die in large numbers and within six weeks, the mortality is complete. This was termed by one of the farmers as the asymptomatic third week syndrome of *Clarias gariepinus* fry.

The other consequences of inbreeding can be summarized as follows: the slow growth of the fish, taking longer days to reach market size of an average of 700g to 1kg; slow conversion ratio of feeds; percentage runts are high; low immunity to infections; low returns on investment if not total capital loss; high flux of fish farmers. The difficulties in importation of fresh catfish brood stocks as juveniles from other countries especially Holland, South Africa, and Indonesia to improve the hybrid vigor led to inbreeding. Old stocks are being re-circulated. The degree of inbreeding depends on the filial generation of the male and female brood stock crossed which is not known by most breeders. The filial generation of the catfish brood stock being sold and transferred between farms and geopolitical zones of the country became unknown. The F generations of the brood stock in the country is undetermined and remain indeterminate. The challenge has persisted with farmers looking for alternative ways to resolve the issue of inbreeding. Time is fast approaching that none can hatch. The co-author of this paper wrote a petition to the then Chairman Senate Committee on Agriculture and had discussions at different levels on this issue. This paper provides possible solutions to resolving problems associated with inbreeding in catfish farming in Nigeria. These are the short-term solution which is the immediate importation of fresh brood stock and on the long run, the establishment of a national brood stock bank.

MANAGING FISH DISEASES OF *Clarias gariepinus* IN AQUACULTURE IN NIGERIA

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Fish diseases are as old as the beginning of *Clarias gariepinus* aquaculture in Nigeria. It did not pose so much threat at that time. The proliferation of fish farms by private investors, after the NEPAD Fish for all Summit in 2005, the intensive culture of fish, and increase in the production of Clarias spp. brought its diseases to the fore. The lack of proper farm management practice which included slack of strict observance to Hazard Analysis of Critical Control Points (HACCP), led to an upsurge in disease occurrences. Investors were quick to seek solutions to safeguard their investments, hence the use of antibiotics and chemicals such as malachite green, potassium permanganate copper sulphates, etc. The uncontrolled use of antibiotics was so much that research identified residual antibiotics in fish products that could cause drug resistance in human beings. Again some of the chemicals were found to be cancer inducive. The identification, treatment, and documents of fish diseases by veterinary doctors working with fisheries officers commenced, and awareness was created amongst fish farmers especially through their associations and cooperatives. This led to the gradual establishment of a disease reporting system. It was found that the disease occurrence was more because of poor farm management especially water management, unconscious use of adulterated feeds, poor genetic fish strains which made the fish easily susceptible to infections. Other sources of contamination identified included the bulk packaging of starter feeds which many breeders could not exhaust in one or two hatching thereby resulting to storage.

FAO had recommended the use of salt in *Clarias gariepinus* fish farming and identified the chief cause of fish diseases as *Aeromonas hydrophila*. A severe attack by *Aeromonas hydrophila* thrives in heavily polluted water. The bacterium has been identified as the single most causative factor of mortality in aquaculture, which dies at 1.5% saline solution. The preventive and curative use of saline solution for the control of fish diseases depend on the percentage saline solution from 0.5%-2%; exposure time of some seconds to 30 minutes; the size of the fish from fry to adult fish; and the degree of infection. This takes care of bacteria, fungal and parasitic diseases in Clarias fish.

The saline solution kills the bacteria by osmosis immediately unlike drugs that take time to act. It was found that salt is the most potent substance as against the use of chemicals and antibiotics. The salt equally improves the immunity of the fish.

MARKET ACCESS OF MOZAMBICAN AQUACULTURE PRODUCTS. THE GMAP INTERVENTION IN MOZAMBIQUE

Ariscado, José.*; Correia, Margarida

United Nations Industrial Development Organisation (UNIDO)
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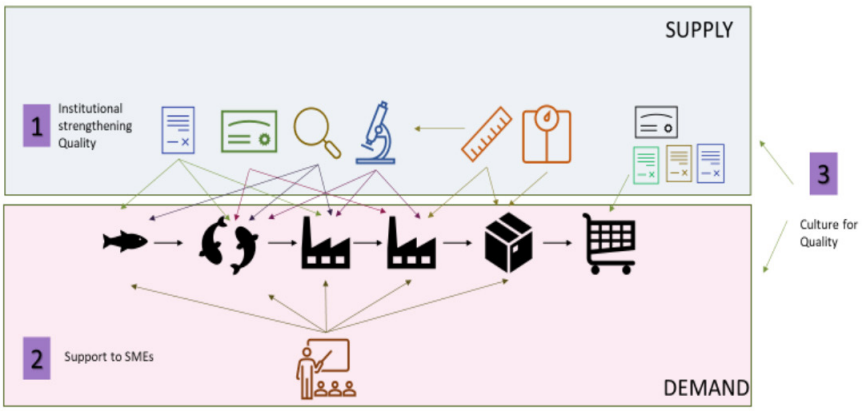
Part of a global programme called Global Market Access Programme (GMAP) developed through a joint programmatic approach between UNIDO and the Norwegian Agency for Development Cooperation (NORAD) the GMAP intervention in Mozambique, Market access of Mozambican Aquaculture Products (MAMAP) initiated in 2022 and aims to achieve technical competence and sustainability of the institutions related to quality infrastructure and enhance market access. Mozambique remains as one of the best endowed countries in Africa in terms of natural capital being drained by several important rivers, vast land resources and coastline. The fisheries sector contributes to 2.3% to the GDP with aquaculture contributing with less than 1%. Fishery production amounts to more than 447.5 thousand tons per year and an average of USD 67.231 Millions of exports per year (equivalent to 10.567 exported tonnes). The country is estimated to have potential production areas of approximately 258,000 ha for freshwater aquaculture and 120,000 ha for marine aquaculture.

The overall objective is to make Mozambican aquaculture SMEs more competitive at market level, through strengthening their quality standards and compliance capacity. With the country still recovering from numerous economic challenges and the backdrop of the Covid-19 pandemic, the implementation approach adopted by UNIDO is regarded as strategic and focused on some of the domains of the Blue Economy with various public sector interventions, support for private sector development and improved competitiveness for reaping economies of scale whilst raising awareness and building a culture of Quality.



INFLUENCE OF DIETARY SIAM WEED (*Chromolaena odorata*) LEAF EXTRACT ON GROWTH, BODY COMPOSITION AND THERMAL STRESS RESISTANCE IN NILE TILAPIA (*Oreochromis niloticus*)

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The objective of the current study was to evaluate the effect of dietary siam weed (*Chromolaena odorata*) leaf extract on growth, feed utilization, proximate composition and stress resistance in Nile tilapia (*Oreochromis niloticus*).

Fingerlings (~3.5 g initial weight) were fed 4 experimental diets with different levels of siam weed extract; 0 g/kg (SW0, control), 1 g/kg (SW1), 2 g/kg (SW2) and 3 g/kg (SW3) in triplicates for 8 weeks. After 8 weeks feeding trial, 14 fish from each tank were subjected to thermal stress, 7 for high temperature and 7 for low temperature. Water temperature was gradually increased from 28ºC to 34±1ºC and/or decreased from 28ºC to 18±1ºC, respectively over a 1-week period. Fish were fed for another 2 weeks at high (34ºC) or low (18ºC) temperatures.

At the end of the 8-week feeding trial, fish increased their initial body weigh 4 – 4.4 fold depending on the experimental groups. Final weight, %weight gain, specific growth rate (SGR) and feed conversion ratio were not significantly influenced by the dietary treatments averaging 14.6 g, 311.6%, 2.5 and 1.3. However, growth performance dramatically decreased at high (2.2 fold lower SGR) and low (4.5 fold lower SGR) temperatures compared to those raised at optimal temperature. High temperature exposure caused a higher MDA level when fish fed control and SW1 diets in comparison to those fed SW2 and SW3 diets. In fish fed SW2 diet when exposed to high temperature MDA level was similar with those on control diet but significantly higher in comparison to those exposed to low temperature. Fish on the highest level of dietary siam weed extract (SW3 diet) had similar MDA levels for all temperatures. Serum cortisol level was significantly influenced by temperature, temperature × siam weed extract interaction (P<0.05), but not by the dietary siam weed level. Cortisol level tended to increase with both high and low temperatures compared to the optimal temperature (Fig. 1). However, fish fed the diet with the highest siam weed extract (SW3; 3 g/kg) at 34 °C had similar serum cortisol level with those fed at optimal temperature (28 °C).

Dietary siam weed extract did not influence growth; however, lowered oxidative stress at high temperature when provided at 2 – 3 mg/kg level, and physiological stress when provided at 3 g/kg level. Further dose-dependent studies need to disclose the impact of dietary siam weed extract on growth and welfare in Nile tilapia.

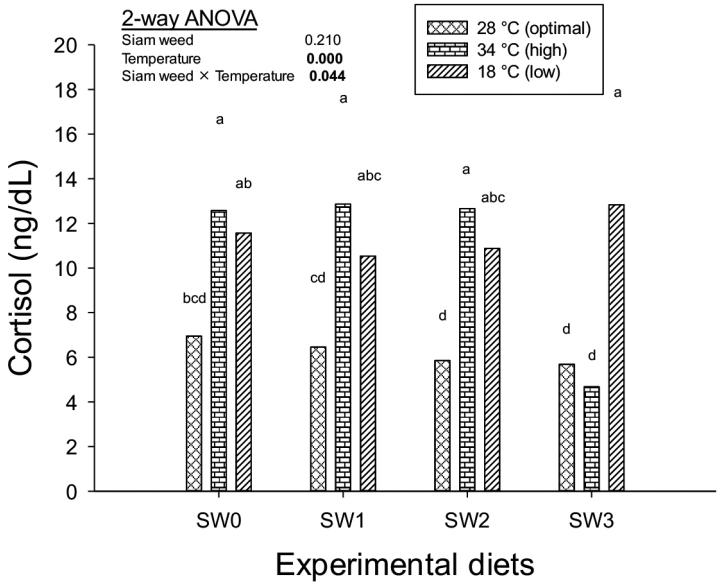

Fig. 1. Serum cortisol level in Nile tilapia fed diets with different levels of siam weed extract for 8 weeks then exposed to high (34 °C) and low (18 °C) temperatures for another 2 weeks.

TRUEFISH PROJECT GENETIC SCREENING RESEARCH IMPLEMENTED BY WORLDFISH: EXPLORING TILAPIA GENOTYPE DISTRIBUTION IN THE LAKE VICTORIA BASIN THROUGH SNP GENOTYPING

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Tilapia aquaculture systems in the East Africa Community (EAC) region are based on a handful of species, notably *O. niloticus*. However, there are other wild tilapia species and strains that could be potential candidate species for fish farming with or without genetic improvement. The additional tilapia species may contain genes contributing to disease resistance, accelerated growth, or tolerance to adverse environmental factors such as temperature or salinity. However, the uncontrolled movement and introduction of genetic materials between populations of these groups of species could result in a loss of biodiversity. At the same time, aquaculture operations can potentially benefit from selective breeding campaigns where this does not negative impact sustainability. While aquaculture production has increased remarkably in the EAC region, it is likely that the increase might have occurred at the expense of aquatic biodiversity. In EAC, there is currently paucity of information on the status of the wild tilapia strains, the level of distribution and stocking of alien strains, and their potential impact on biodiversity in the Lake Victoria basin.

We sequenced 389 tilapia samples from the Lake Victoria basin (Uganda, Kenya and United Republic of Tanzania) using an Illumina HiSeq 4000 to identify informative 32,125,84 Single nucleotide polymorphisms (SNPs). Our results show that 33 individuals were classified as hybrids, all involving *O. niloticus*. 19 of these are crosses with *O. esculentus* (from seven sites), 11 with *O. variabilis* (from six sites) and 3 with *O. leucostictus* (from one site). No site had more than one type of hybrid. Result revealed that, *Orieochromis niloticus* from Lake Albert had one ancestry group, while those from Lakes Kakyera and Kijanibarola were from another, fish from Lake Victoria had a mix of the two groups. It was evident that there is weak population structure within *O. niloticus,* with a small amount of differentiation segregating, which can be described as ongoing. These results will facilitate making informed decisions on how best management could preserve the diversity of these resources with a view of using them sustainably for selective breeding programs and consequently promoting their use in improving commercial aquaculture in EAC.

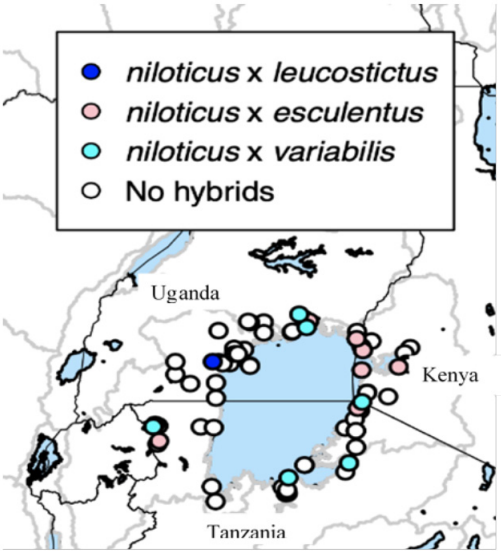

Figure 1. Map of the Lake Victoria basin, showing all sampling sites and coloured according to where species combinations of hybrids are located there.

EMBRYO CHARACTERISTICS AND HATCHABILITY OF EGGS OF *Clarias gariepinus* INCUBATED IN HARD WATER

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Temperature, dissolved oxygen and pH are the more frequently investigated exogenous factors affecting the hatching success of fish eggs. Members of the family Claridae have a high fecundity. The insufficient supply and relatively high cost of *Clarias gariepinus* (Burchell 1822) fingerlings resulting from the low output of breeding attempts indicate the need to widen the scope of factors affecting the low production. Limitations arise when the choice of water is limited to groundwater. In most cases, this water source produces hard water, creating problems for eggs, larvae, and fry.

We monitored *C. gariepinus* embryos incubated in hard water with four different treatments of Mg:Ca hardness ratios: 0Mg:0Ca, 10Mg:0Ca, 0Mg:10Ca and 10Ca:10Mg hardness equivalent to 0 (T1), 10 (T2), 10 (T3) and 20mg/l (T4) hardness as $CaCO_3$. The hatching rate was determined using the volumetric method. The effect of hard water on embryonic development and survival was determined using a mobile phone-attached microscope (60X) and digital camera. The hatching rates differed significantly across the treatments ($p<0.05$), with T1 having the highest hatching rate (43.14%) while T4 had the least hatching rate with 0% hatching success. There was no significant correlation between any water quality parameter and the hatching success of *C. gariepinus* larvae from eggs incubated in hard water. All correlations were not significant ($p>0.05$). Embryos in T1 showed progressive development with less mortality. Embryos in T2 and T3 also developed progressively but with mortalities. There was particularly significant mortality (100%) in T4 (10Mg:10Ca). This study highlights the importance of watching out for calcium and magnesium hardness in the hatchery water supply to avoid total fry mortality, as experienced by some farmers. Levels of 10Mg or 10Ca hardness alone affect the hatchability of *C. gariepinus* eggs, and the full complement of 20mg/l combination of 10Mg:10Ca hardness causes total mortality of embryos. The current results should guide farmers in designing water treatment facilities if the water supply is affected by Ca^{2+} or Mg^{2+} hardness.

Table 1: Hatching rate of *C. gariepinus* eggs in hard water

Trt	TH	mg Ca/L	mg Mg/L	Hatch (%)
T1	0	0	0	43.14 ± 8.34^{b}
T2	10	0	2.4	39.01 ± 7.52^{b}
T3	10	4	0	30.12 ± 5.81^{b}
T4	20	4	2.4	0.00 ± 0.00^{a}
p-value				0.002

Trt = Treatment; TH = Total Hardness

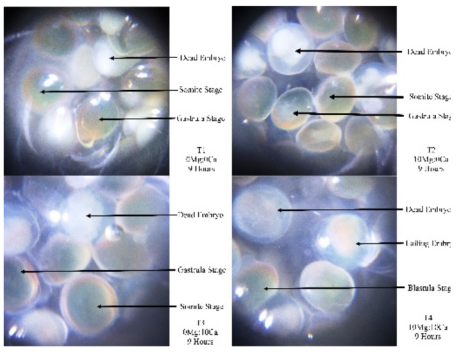

Figure 1: Condition of Embryos under each treatment at 9 hours post fertilization

LAKE VICTORIA MARINE SPATIAL PLAN IN RELATION TO AQUACULTURE SUITABILITY

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The Lake Victoria Marine Spatial Plan in relation to Aquaculture Suitability under the Sustainable Activities in Water Areas (SAWA) project is a state of the art and world class decision-making tool-oriented research and management project focused on the Kenyan portion of Lake Victoria. SAWA project intends to build, in partnership with Kenyan governance stakeholders, an evolving aquaculture governance framework that improves decision-making and addresses challenges of multiple lakes uses such as areas with resource competition. The plan delineates the lake into inshore and offshore aquaculture. The inshore cage suitable areas that mainly range at a depth of about 6 – 10 m for cage culture alongside constraints like navigation routes, water hyacinth hot spots and breeding areas. The area recommended for inshore aquaculture in the lake is 291 km^2 representing 8% of the lake. The "not suitable" and "less suitable" areas are recommended for accessing the lake for transport, navigation, capture fisheries, tourism, sports and other lake uses. The recommended inshore aquaculture zones are potential areas for small scale farmers with low capital requirements. The offshore suitable areas that mainly ranges at an optimum depth of about 10 – 40 m for cage culture are alongside constraints like navigation routes, water hyacinth hot spots, and breeding areas. Such installations require firm anchorage to withstand strong currents and could be mainly for capital intensive farms. These sites will be suitable for commercial aquaculture and large-scale farms/firms. The area available in the lake with high suitability potential for large scale firms is only 11% of the lake surface area, representing about 408 km^2. It is suggested that the 11% "highly suitable" potential portion of the lake is utilized for cage culture depending on requests from investors after which more room can be sought for "suitable areas" that account for 21% (783 km^2) of the lake depending on the existing production carrying capacity. Just like inshore cage farming suitability, the other "not suitable" and "less suitable" areas are recommended for accessing the lake during transport, navigation, capture fisheries, tourism and sports.

HARNESSING AFRICAN BLUE ECONOMY THROUGH FISHERIES AND AQUACULTURE: A STRATEGIC MANAGEMENT APPROACH

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The conversations around Blue Economy (BE) in the last decade, particularly in Africa has taken an interesting dimension which demands continuous engagement by stakeholders, academia, and governments across the continent. This paper seeks to advance the discourse, using strategic management approach to beam more lights on the dynamics of wealth creating opportunities around Africa's marine and aquatic life; the challenges, opportunities, setbacks, solutions and resolutions, while setting strategic agenda for harnessing the potentials for Africa's economic growth and posterity.

The blue economy is often characterized by three conjoined elements of economic, social, and environmental pivots. It is expected that this will generate an equipoise in Africa's economic advancement, social balance (as may be experienced in gainful workforce engagement and appreciable drop in poverty index), and ecological conservation. It is therefore imperative that this paper gives form to the agitation for a wholistic distillation of the strategic management approach to ensuring that fisheries and aquaculture enterprise in the continent is clearly defined with its trajectories and potentialities for a more prosperous continental economy.

This paper seeks to show how deep-pocket capital investment, the accessibility of electric storage, a better level of trade openness, exports, and sustainable ocean management policies will favourably influence aquaculture activities, while the challenges of overfishing, climate change, marine pollution, illegal, unreported, and unregulated (IUU) fishing vessels; and ineffective ocean management threaten the marine ecosystems.

The appreciation of blue economy through marine fish stocks and the fisheries they support, play a dynamic role in meeting the food and dietary security of millions of African people, hence the intentionality that must be deployed in building sustainable wealth and nutritional values in this regard.

Understanding and appropriating the key drivers of the blue economy is a critical path to unlocking the vaults of marine wealth, particularly as it relates to fisheries and aquaculture. The onus is therefore on the paper to offer practical and strategic direction to the resolution of the issues raised in the contemplations.

MOLECULAR INVESTIGATION OF MAJOR VIRAL PATHOGENS OF THE GIANT TIGER SHRIMP *Penaeus monodon* (Fabricius, 1798) ALONG THE COAST OF GHANA

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Shrimps are decapod crustaceans of high economic value. Most wild-caught shrimps and all farm-raised shrimps belong to the Penaeidae family. In Ghana's infantile shrimp farming industry, the only cultured shrimp species is *P. monodon*. The gravid females are obtained from the wild, spawn in the hatchery and the post-larvae used for their grow-out operations. Globally, *P. monodon* is documented as highly susceptible to viral pathogens such as White spot syndrome virus (WSSV), Monodon baculovirus (MBV), Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV), Infectious myonecrosis virus (IMNV) among others and the need to screen the wild-caught brooders for these pathogens cannot be overemphasized.

The study sampled the giant tiger shrimps from three coastal regions along the 570 km Coast of Ghana and screened for the presence of four globally important penaeid shrimp viruses; White Spot Syndrome Virus (WSSV), Monodon Baculo Virus (MBV), Infectious Hypodermal and Haematopoietic Necrosis Virus (IHHNV) and Infectious Myonecrosis Virus (IMNV) using molecular methods.

Fifty (50) samples were collected from each of the following regions in Ghana: Greater Accra (GR), Volta Region (VR) and Central Region (CR). DNA and RNA extractions were performed on the gills, muscles, midgut and hepatopancreas using Qiagen extraction kits. Conventional PCR and real-time qPCR were used to screen for the presence of these viruses.

The initial PCR screening of some few collected hetopancreas and muscles samples indicate non detection of the viruses. However, DNA and RNA extractions and PCR analysis of the rest of the samples continues in order to confirm presence and otherwise of the four WOAH-listed viruses in Ghanaian shrimps.

Table 1: Quality of extracted DNA and Viral detection by PCR

Sample	DNA Conc (ng/µL)	Detected Virus
Hetopancreas	117.7	Negative
Hetopancreas	62.0	Negative
Muscles	90.4	Negative
Muscle	32.3	Negative
Muscle	54.6	Negative
Muscles	67.9	Negative
Hetopancreas	34.6	Negative
Hetopancreas	49.8	Negative
Hetopancreas	69.0	Negative
Hetopancreas	93.9	Negative

POTENTIAL FOR INCREASED PPRODUCTION OF FARMED RAINBOW TROUT *Onchorynchus mykiss* (Walbaum, 1792) IN AFRICA THROUGH GENETIC IMPROVEMENT

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As a salmonid, the genome of the Rainbow trout *Onchorynchus mykiss* (Walbaum, 1792) is complex, with tetraploidy following whole genome duplication (Ss4R) 88 to 103 million years ago. This gives the species enormous evolutionary potential, and possibly drives the ability of the species to survive in many areas outside its native range, under higher temperatures. With total annual production of 848,051 tonnes in 2018, global lead producers of farmed *O. mykiss* are Iran, Turkey, Norway, Peru, Denmark, China, Chile, Italy, France, USA, Colombia, Sweden and the UK, with some countries producing up to 190,000 tonnes annually. Only seven countries in Africa farm *O. mykiss*, with Lesotho producing 2599 tonnes, South Africa (1583), Kenya (598), Morocco (250), Zimbabwe (90), Malawi (84) and Ethiopia (11) tonnes. This low production in Africa is due to the use of un-improved strains whose production is whittled down by environmental shocks, especially global warming and diseases. Norway and Chile are examples of countries that embraced the use of genetically improved strains of *O. mykiss*, with increased annual production. As a model species in scientific and evolutionary research, genomic resources have been developed over the last decades to support genetic improvement of trout. Just like for the Atlantic salmon, an integrated map of the trout genome now exists, enabling fine mapping of quantitative trait loci (QTL), and the selection of positional candidate genes to support selective breeding. Similarly, QTLs have been identified for disease resistance, parasite resistance, immunity, growth rate, stress tolerance, upper thermal tolerance, embryonic development, spawning time and early maturation. We argue that African countries could substantially increase production, despite environment shocks, by using these genomic resources to increase accuracy of selection for more resilient genotypes that increase annual production.

EFFECTS OF HYPERTHERMIA TREATMENT ON INFECTIOUS SPLEEN AND KIDNEY NECROSIS VIRUS (ISKNV) INFECTION IN FRY OF CULTURED TILAPIA IN GHANA

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The first case of Infectious Spleen and Kidney Necrosis Virus (ISKNV) disease in Africa was reported in Ghana in cage culture systems of Nile tilapia in Volta Lake in 2018. Since then, it has caused high mortalities during the early life stages of the production cycle and poses a serious threat to the Nile tilapia industry in Ghana. Unfortunately, as a viral disease, chemotherapeutic treatment is challenging except in cases where treatment for secondary bacterial infection may be required. Although, available vaccines can only be applied at a size of 3 grams, ISKNV infection can set in when the fry is less than 1 gram. Therefore, there is the need to try out an alternative approach to halt the spread of the virus in the fry whiles reducing mortalities.

This study investigated the efficacy of hyperthermia as alternative treatment measure. It compared the effectiveness of different water temperatures: 38°C, 40°C and 42°C. The control group were kept under room temperature between 25–26.4°C, ISKNV infected fry were kept in separate tanks containing freshwater and gradually heated to the set temperatures and maintained for 30 minutes in a controlled environment for six consecutive days. The heat-treated fry were later raised in hapas for 60 days to monitor growth and survival. At the end of the study, significant ($p<0.0001$) differences in the percentage survival at the different temperatures, 38°C, 40°C and 42°C were recorded among all the treatments. Water temperature at 42°C was lethal and killed all the fry. The result showed that subjecting Nile tilapia fry to hyperthermia at 40°C water temperature was effective in reducing mortality due to ISKNV infection in Nile tilapia.

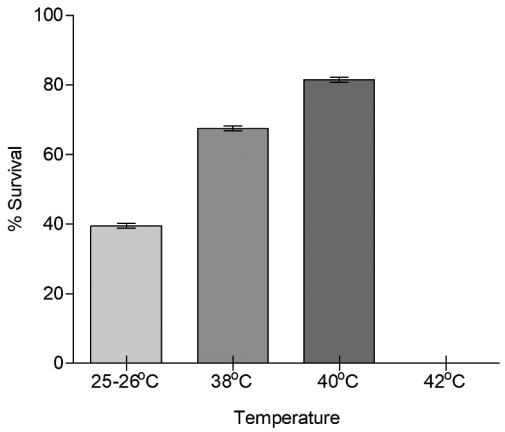

Figure 1. Percent cumulative survival of Nile tilapia fry during hyperthermia treatment at different temperature levels.

Table 2. Percent cumulative survival of Nile tilapia fry at the end of the 60 days growth period of hyperthermia treatment at different temperature levels.

Temperature	Total number	Mortality	% survival
38°C	201	44	78
40°C	242	9	96
42°C	0	300	0
Control	116	52	55

IMPACT OF CLIMATE CHANGE ON FISHERIES AND AQUACULTURE IN DEVELOPING WORLD AND OPPORTUNITIES FOR ADAPTATION

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This review paper reviews the importance of fisheries and aquaculture, with particular reference to poor people in the developing world, and the likely impact of climate change on these activities and on food security. It highlights some practical measures that can be taken to adapt to the expected effects of climate change. These focus in particular on building the capacity of communities to adapt to climate change in ways that allow them to moderate potential damage, to take advantage of new opportunities and to cope with the consequences of climate change, and on enhancing the resilience of communities and the ecosystems on which they depend. The review paper recommends basing interventions as much as possible on local practices and traditions.

KELP MARICULTURE'S POTENTIAL TO REDUCE NEGATIVE EFFECTS OF FINFISH AQUACULTURE ON WATER QUALITY

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Finfish aquaculture often poses harm to the marine ecosystem through the associated output of nitrogen waste primarily in the form of ammonium (1 p.3). Managing this nitrogen output must therefore be an important consideration of aquaculture farmers and inform the way they set up and manage their farms. Growing kelp alongside finfish farms represents a potential solution to nitrogen pollution as well as providing other co-benefits, and the Southern Ocean Carbon Company is participating in practical research through the Blue Economy Co-operative Research Council in part to realise this potential. The deployment of *Macrocystis pyrifera* (Giant Kelp) at sites adjacent to finfish aquaculture farms may provide a solution due to the nitrogen harvesting of giant kelp (1 p. 1). Modelling has shown that growing kelp next to farms can drastically improve the water quality of the system and provide economic co-benefits to practitioners (1, p.1).

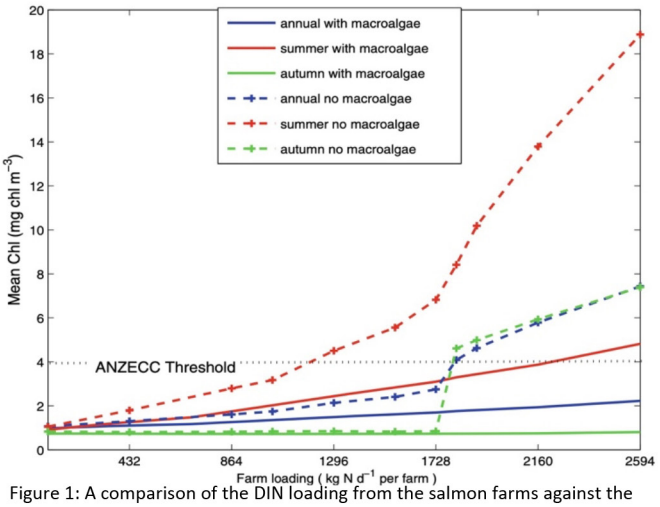

Figure 1: A comparison of the DIN loading from the salmon farms against the mean annual and mean summer concentrations of chlorophyll for the estuary. Key features are the strong nonlinear response of Chl to farm loadings above 1730 kg N day−1 per farm, and the strongly mitigating effect of IMTA macroalgae. Source: Hadley et. al 2015

Not only do these systems have the potential to benefit finfish aquaculture farms through improving water quality through processing their nitrogen waste, but in processing this waste there is an associated benefit of significantly improved seaweed growth as a result of the increased levels of nitrogen (Figure 2). This suggests that close proximity to nitrogen sources is the ideal place to install giant kelp aquaculture in order to maximize production. This giant kelp biomass provides further value through a number of co-benefits. These include applications as a soil additive for terrestrial farming, as food, as an emerging alternative to conventional plastics, and also as a carbon sequestering agent to address climate change. Similar co-location strategies may assist those looking to increase protein production in an environmentally sensitive manner.

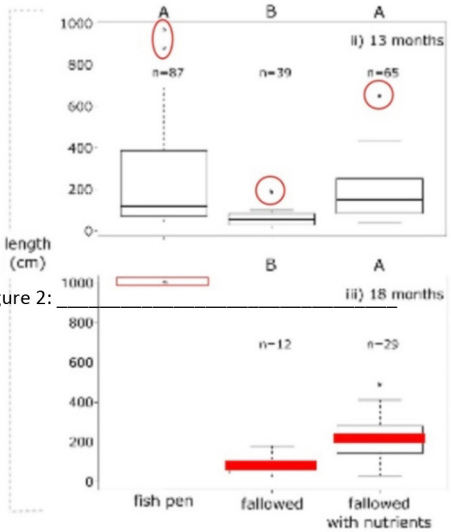

Figure 2: (Unpublished data via Cayne Layton)

SHORE BASED IMTA OF ABALONE, SEAWEED AND SEA CUCUMBER IN SOUTH AFRICA

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Improved integrated multitrophic aquaculture technology for co-culturing abalone (*Haliotis midae*), seaweed (*Ulva lacunilata*) and an indigenous sea cucumber (*Neostichopus grammatus*) was developed on the Wild Coast Abalone farm in South Africa. The research formed part of the European Union H2020 'Aquavitae' programme to develop technology for the culture of low trophic species in the Atlantic Ocean region. A baseline assessment of energy and nutrient utilization efficiency was undertaken on the existing abalone – effluent *Ulva* culture system which provided fresh seaweed feed for the abalone. A series of trials to improve the IMTA system were undertaken to 1) introduce a high value sea cucumber species to remove solid abalone tank waste, 2) improve the nutrient *uptake* efficiency of the culture *Ulva* and 3) evaluate the performance of the IMTA *Ulva* in a formulated abalone pellet. The culture of seaweed in abalone effluent significantly reduced the demand for mineral fertilisers at Wild Coast Abalone as the dissolved nutrients in abalone wastewater provided (34-38%) of the nutrients required by IMTA seaweed. The *Ulva* growth rate, yield and nutrient utilization efficiency was substantially improved by substituting 50% of the applied inorganic fertilizer with a live microbial fertiliser. Wild-collected sea cucumbers adapted well to captive conditions, readily consuming solid abalone waste and coming into spawning condition in early summer. The sea cucumbers performed best when provided with a sandy substrate. Overall the results demonstrated that the IMTA technology can improve economic performance and reduce environmental impacts in respect of effluent nutrient discharge and carbon footprint.

POPULATION GENETICS OF *Gyrodactylus Sp.* (*Monogenea: Gyrodactylidae)*, THEIR PREVALENCE AND EPIDEMIOLOGICAL IMPACT IN TILAPIA AQUACULTURE IN SOUTH AFRICA

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Africa has vast potential for aquaculture growth, however, the translocation of African cichlid fishes for aquaculture has resulted in the co-introduction of some of their parasites. *Gyrodactylids* attachment to fish causes epidermal damage and fin erosion resulting in reduced swimming capacity and increased mortality. High parasite burdens cause physiological and histological disturbances that can induce osmoregulatory failure. The objectives of this study are; to conduct first-level taxonomy of the parasite *Gyrodactylus* based on morphological and molecular characterization; to observe the population structure in parasites between different farming systems, bio-geographical regions, or drainage areas representing different populations, and to measure the impact of the disease caused by these parasites on productivity, survival (or mortality) and sustainability of tilapia aquaculture in South Africa at different levels of production. Specimens of Gyrodactylus will be collected from cultured and natural populations of *O. Mossambicus*, *O. Niloticus,* and *C. Rendalii* from different bio-geographical regions representing different populations. Each sample of fish will be fixed and stored in 95% ethanol until examination. Type material deposited in national collections will also be included in the study. Parasitic indices such as the mean intensity, prevalence, and abundance will be determined and calculated. Findings from this study will provide information on the major clusters of *Gyrodactylids* parasitizing the tilapia population. The extent of morphological and molecular variation between parasite specimens and population will be observed. The prevalence, intensity, and epidemiological impact of the *Gyrodactylids* in Tilapia Aquaculture will be determined and potential control measures identified.

GLOBAL SEAWEED NEW AND EMERGING MARKETS TO 2030

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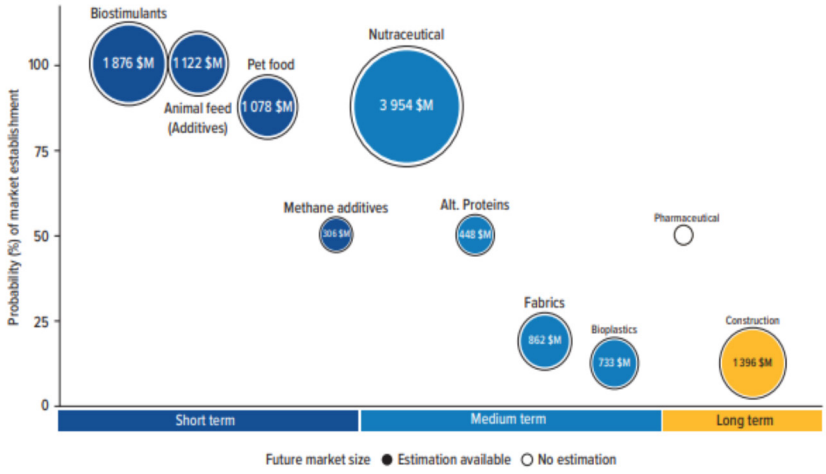
Seaweed has traditionally been used as a nutritious food source for humans, animals, and soil remediation for decades. In the recent years, seaweed cultivation has been associated with provision of ecosystem services such as biodiversity conservation, and climate change mitigation and adaptation while uplifting rural communities mainly women. Fueled by aquaculture, global seaweed production has been increasing at a rate of 6.2% per year since 2000 reaching an estimated 31.8 million tons (Mt) by 2018 with a market value of more than US$11.3 billion. Currently, 97% of seaweed is farmed.

A major challenge for a sustainable expansion of the seaweed farming sector, is the lack of reliable data on production, potential markets, and investment opportunities. The World Bank Group Aquabusiness Investment Advisory (AquaInvest) Platform, funded by PROBLUE Multidonor Trust Fund, released a comprehensive study, the "Global Seaweed New and Emerging Markets Report 2023" addressing this challenge. The report has identified ten global new and emerging seaweed markets with the potential to grow by an additional USD 11.8 billion by 2030 (Figure A).

Figure A. Predicted seaweed market size by 2030 ($ million) with chance of market establishment indicated on a high-level market horizon timeline.

The most promising short-term markets for seaweed are biostimulants, animal feed, pet foods, and methane-reducing additives. Methane-reducing additives used as functional ingredients for livestock are expected to be one of the most promising new applications that will combat climate change through emission reduction. Nutritional seaweed-based supplements, known as nutraceuticals, alternative proteins, bioplastics, and fabrics can offer medium-term opportunities.

Unlocking the potential for these various markets and opportunities requires public and private sector investment in research and seaweed farming to increase production, formulation of sector specific national policies and strategies and enabling regulations.



MANAGING LAND AND SEASCAPE CARBON FOOTPRINTS THROUGH INTEGRATED AQUACULTURE

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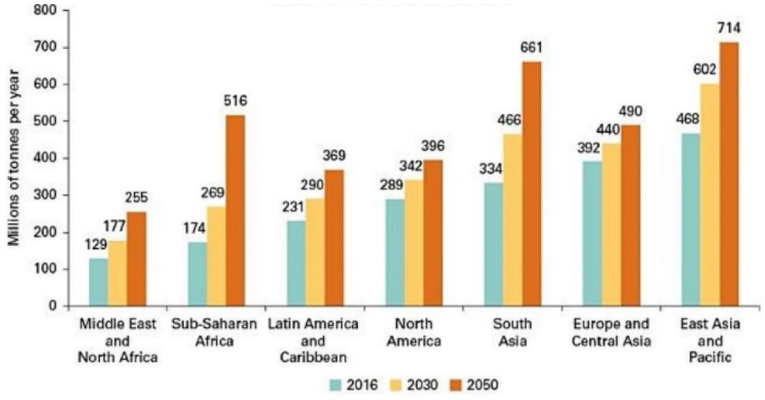
Current and future food systems must be capable of adapting, mitigating and attenuating climate change while promoting efficient use of scarce natural resources. Aquaculture is a key sector for the economy, development and human well-being contributing 57% of all blue food globally in 2020 and generating over 20 million jobs in rural and peri-urban areas, and is a source of livelihood for billions. Resilience of agricultural landscapes and livelihoods of resource poor farmers, including women and youth, are threatened by land and water access limitations, loss of biodiversity, and increased waste (see Figure 1), due to limited efficiency in the utilization of available natural resources. Integrated and restorative aquaculture systems can play a crucial role towards increased resilience of agricultural landscapes and livelihoods. These systems are framed towards increased production and profitability, efficient management of natural resources, and provision of ecosystem services, including biodiversity conservation and climate change action.

Numerous studies have demonstrated that integrated and restorative aquaculture with circular economy approaches can reduce dependence on external inputs e.g., aquafeed and fertilizer requirements and improve resource-use efficiency, while enhancing essential ecosystem services. However, despite decades of promotion, their global expansion is limited by economic viability data and lack of financial valorisation of these ecosystem services.

In efforts to catalyse investments in integrated restorative aquaculture, the World Bank is implementing an analytical project on "Integrating Aquaculture into Land and Seascape Programs", aimed at compiling reliable data on integrated and restorative aquaculture production systems from an economic perspective. Robust engagement and partnerships on integrated and restorative aquaculture, are needed to gather economics data, formulate right policies and regulations, and enhance public and private investment towards economically viable integrated solutions.

Figure 1. Projected waste generation per region to 2050 (World Bank, 2018)



THE WORLD BANK FINANCING SUSTAINABLE AQUACULTURE DEVELOPMENT IN AFRICA

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The demand for fish is growing significantly in much of the African continent, as is the production derived from the aquaculture sector. But capture fishing is either stagnant or decreasing in production in most of the continent, which means that domestic fish production cannot cover current and future demand. Africa will have to increase it's efforts and investment in aquaculture and reform the aquatic food systems if it will not continue as a net importer of fish and fish products.

The World Bank is actively engaged in promotion of sustainable aquaculture and fisheries sectors across the continent in order to transform them into vibrant economic activities able to cover the domestic demand for aquatic blue foods and target export opportunities. Given that aquaculture currently contributes over 57% of fish production globally, the World Bank has recently increased its focus on aquaculture development. The World Bank's investment are aimed at addressing the main structural problems of aquaculture in Africa, such as the poor access to quality feed and improved seed, limited technical skills and capacities, limited access to information and innovative technologies, weak aquaculture and policy implementation as well as poor access to credit.

The Aquabusiness Investment Advisory (AquaInvest) Platform funded by the PROBLUE Multi-Donor Trust Fund and administered by the World Bank is an advisory service and analytics (ASA) formed to systematically address these challenges. The AquaInvest Platform is a collaborative initiative between the WB, International Finance Corporation (IFC), Food and Agricultural Organization (FAO), Global Environment Facility (GEF), World Wildlife Fund (WWF), United States Agency for International Development (USAID) and other partners to distill and improve best practices in aquabusiness development for economic, social, and environmental sustainability and support countries with the needed analytics and advisory. The platform acts as a hub for guidance notes, tools, and knowledge products and is preparing global guidelines in sustainable aquaculture investment. In this paper, we discuss how the work of the World Bank and partners will continue to unlock the potential for resilient aquaculture within the public sector with special emphasis on small and medium scale aquaculture investments across the aquaculture value chain.

INTEGRATED AQUACULTURE REDUCES LAND AND SEASCAPE CARBON FOOTPRINTS

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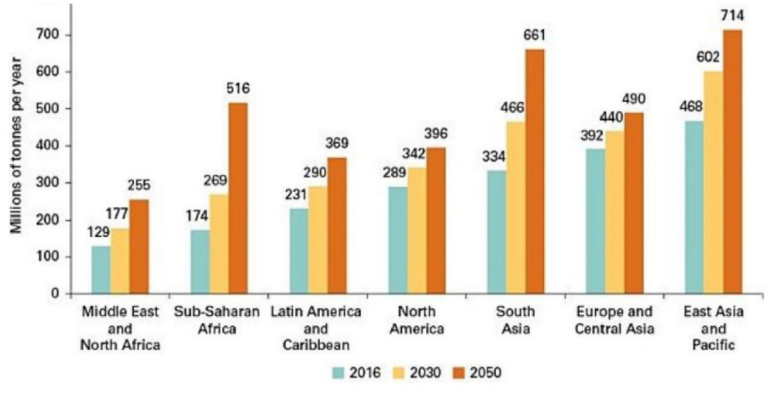
Current and future food systems must be capable of adapting, mitigating and attenuating climate change while promoting efficient use of scarce natural resources. Aquaculture is a key sector for the economy, development and human well-being contributing 57% of all blue food globally in 2020 and generating over 20 million jobs in rural and peri-urban areas, and is a source of livelihood for billions. Resilience of agricultural landscapes and livelihoods of resource poor farmers, including women and youth, are threatened by land and water access limitations, loss of biodiversity, increased waste (see Figure 1), and limited efficiency in the utilization of available natural resources. Integrated and restorative aquaculture systems can play a crucial role towards increased resilience of agricultural landscapes and livelihoods. These systems including integrated crop fish, livestock fish, shellfish, and integrated multitrophic aquaculture (IMTA) including seaweeds are more environmentally friendly, enhance production, foster efficient management of natural resources, and enhance provision of ecosystem services, including biodiversity conservation and climate change adaptation.

Numerous studies have demonstrated that integrated and restorative aquaculture with circular economy approaches can reduce dependence on external inputs e.g., aquafeed and fertilizer requirements and improve resource-use efficiency, while enhancing essential ecosystem services and reduction of carbon footprints. However, despite decades of promotion, their global expansion is limited by dearth of economic viability data and lack of financial valorisation of these ecosystem services.

In effort to catalyse investments in integrated restorative aquaculture, the World Bank has been undertaking studies to quantify economics of different integrated systems including overall farm level carbon footprint reduction capacity. This data will enable valuation of integrated and restorative ecosystems allowing formulation of appropriate policies and regulations and enhancing public and private investment in aquaculture.

Figure 1. Projected waste generation per region to 2050 (World Bank, 2018)



FINANCING SUSTAINABLE AQUACULTURE INVESTMENTS IN AFRICA

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The demand for aquatic blue food is growing significantly across the African continent, amid climate change impacts and stagnating capture fisheries. Apart from a few African countries, domestic fish production cannot meet current and future demand. Africa will have to increase her efforts and investment in aquaculture and reform the aquatic food systems if it will not continue as a net importer of fish and fish products.

The World Bank is actively promoting sustainable aquaculture and fisheries sectors across the continent to transform them into vibrant economic activities able to satisfy the domestic demand for aquatic blue foods and to target export opportunities. Given that aquaculture currently contributes over 57% of aquatic production globally, the World Bank has recently increased its focus on aquaculture development. The World Bank's aquatic investment are aimed at addressing the main structural problems of aquaculture in Africa, such as the poor access to quality feed and improved seed, limited technical skills and capacities, limited access to information and innovative technologies, weak aquaculture and policy implementation as well as poor access to credit.

The Aquabusiness Investment Advisory (AquaInvest) Platform funded by the PROBLUE Multi-Donor Trust Fund and administered by the World Bank is an Advisory Service and Analytics (ASA) formed to systematically address these challenges. The AquaInvest Platform is a collaborative initiative between the WB, International Finance Corporation (IFC), Food and Agricultural Organization (FAO), Global Environment Facility (GEF), World Wildlife Fund (WWF), United States Agency for International Development (USAID) and other partners to distill and improve best practices in aquabusiness development for economic, social, and environmental sustainability and support countries with the needed analytics and advisory. As a hub for guidance, tools, and knowledge products, the AquaInvest Platform is preparing global guidelines in sustainable aquaculture investment. In addition, the World Bank's Blue Economy for Resilient Africa Program, announced at COP27, provides multisectoral analytical, financial, and policy support to help fish farming communities to adopt climate resilient aquaculture.

In this paper, we discuss how the World Bank and partners will continue to unlock the potential for resilient aquaculture within the public sector with special emphasis on small and medium scale aquaculture investments across the aquaculture value chain.

GLOBAL SEAWEED NEW AND EMERGING MARKETS REPORTS: WHAT NEXT?

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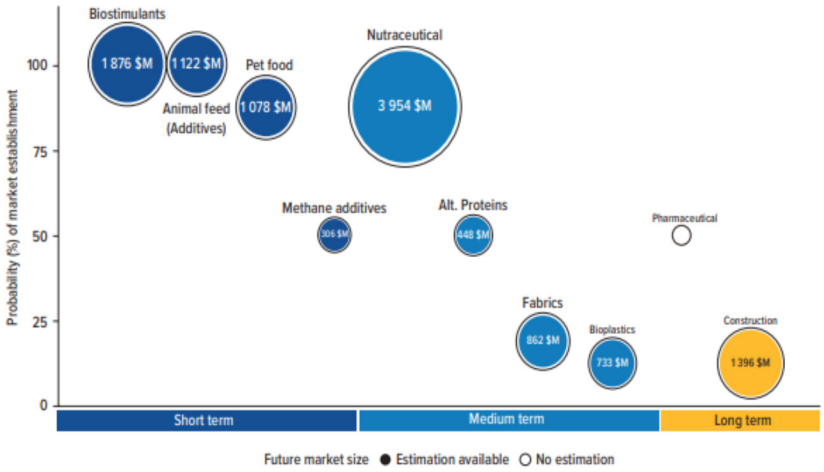
Fueled by aquaculture, global seaweed production has been increasing at a rate of 6.2% per year since 2000 reaching an estimated 31.8 million tons (Mt) by 2018 with a market value of more than US$11.3 billion. Currently, 97% of seaweed is farmed. Most of the seaweed has traditionally been used as a food source for humans, animals, and soil remediation. In the recent years, seaweed cultivation has been associated with provision of ecosystem services such as biodiversity conservation, and climate change mitigation and adaptation while uplifting rural communities mainly women.

A major challenge for a sustainable expansion of the seaweed farming sector, is the lack of reliable data on production, potential markets, and investment opportunities. The World Bank Group Aquabusiness Investment Advisory (AquaInvest) Platform, funded by PROBLUE MultiDonor Trust Fund, recently released a comprehensive study, the "Global Seaweed New and Emerging Markets Report 2023" addressing this challenge. The report identifies ten global new and emerging seaweed markets with the potential to grow by an additional USD 11.8 billion by 2030 (Figure A). It indicates most promising short-term non-conventional markets for seaweed to include biostimulants, animal feed, pet foods, and methane-reducing additives. Methane emission reducing additives in livestock feed are together with ability to sequester carbon and excess nutrients are expected to enhance provision of ecosystem services and combat climate change. Nutritional seaweed-based supplements, known as nutraceuticals, alternative proteins, bioplastics, and fabrics can offer medium-term opportunities.

The greatest challenge to realization of this potential is the slowing down of seaweed production in many countries. Unlocking the potential for these various markets and opportunities requires public and private sector investment in research of genetics and breeding, conservation of wild population biodiversity, disease prevention, and expansion of seaweed farming into new frontiers to increase production, and formulation of sector specific regional and national policies and strategies and enacting enabling regulations.

Figure A. Predicted seaweed market size by 2030 ($ million) with chance of market establishment indicated on a high-level market horizon timeline.



PRIVATE FINANCING IN AFRICA

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Rising incomes, changing diets, and increasing global population have made the livestock and aquaculture sectors one of the fastest-growing agricultural subsectors in middle- and low-income countries.

The increase in meat, fish and dairy consumption is leading to significant sustainability challenges–including a rise in greenhouse gas emissions, an increase in land conversion, more risks of deforestation and loss of biodiversity. There are also concerns related to the production of fish, meat and dairy, such as biosecurity, animal welfare, and antimicrobial use.

In response to the growing demand for proteins and these sustainability challenges, it is imperative that both the public sector and industry follow a sustainable growth path.

IFC's approach to investing in aquaculture companies is based on identifying and supporting sustainability in companies' activities, and we recognize that the best way is through specific practices that enhance animal health and welfare, protect the environment, promote food safety, and respect relevant regulations and laws.

IFC is the first major financial institution globally to come to the market with a clear position on what constitutes a sustainable investment in animal protein production--a sector where financial intermediaries are facilitating an estimated $USD100bn of investment each year.

Through its investments, IFC has proven that sustainability can be a driver for better financial performance and is keen to share its set of practices in investing in aquaculture operations both with policy makers and with peer financial institutions.

FISHERY-INDEPENDENT SURVEYS AS TOOL TO INFORM MANAGEMENT DECISIONS FOR SMALL IMPOUNDMENTS IN EASTERN PROVINCE, ZAMBIA

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Any successful fisheries management intervention needs to begin with a thorough biological-, limnological- and socio-economic baseline. The Fish for Food Security in Zambia Project implements participatory fisheries management of small water bodies in the Eastern Province of Zambia. The project is working with dam management committees (DMCs) selected by their community which oversees a dam fishery. To inform management decisions and develop monitoring systems that ensure that catches are legal, reported and regulated, we did four fishery independent surveys (two wet seasons, two dry season) from November 2020 to date. These included sampling of the fish population with a variety of gears (multi-panel experimental gillnet fleets, large- and small-mesh seine nets, cast nets and traps), as well as descriptions of the physical environment and habitats of the dams.

Ten dams were surveyed (ranging in size from 1.9 hectares to 31.8 hectares). In total, 20 species were captured from six families, with Cichlidae (11 species) and Cyprinidae (5 species) the most specios. Large cichlids (*Oreochromis* species and *Coptodon rendalli*) and catfish (*Clarias gariepinus*) are the most important species caught in experimental gillnets and large-mesh seine net. Gillnet catches were seasonally variable within each of the dams and were highest in Lumamba Dam in the wet season (3.206 kg.100m-1) and highest in Mukungwa (1.667 kg.100m-1) in the dry season. Large mesh seine net catches were highest at Malipa Dam with a relative biomass of 4.337 kg.haul-1 and 24.137 kg.haul-1 in the wet season and dry season respectively. Five dams (Rukuzye, Lumamba, Tigone, Bikoko and Malipa) exhibited signs of poor juvenile recruitment due to low adult fish densities. No large cichlid species (i.e., no juveniles or adult fish) were sampled at Nthambo since the survey began in 2020, indicating that they no longer occur in the dam.

Management recommendations were made to help DMCs inform their management planning for each dam, and to complement ongoing catch-assessment surveys being conducted at each dam. In the presentation we present some of the results in detail, the fishery-independent survey approach as a management planning tool and highlight what indicators should be considered for viable fisheries management in small impoundments.

CHALLENGES OBSERVED IN THE ADMINISTRATION OF AN AUTOGENOUS VACCINE OF COMMONLY ASSOCIATED BACTERIAL PATHOGENS ON SMALL SCALE AQUACULTURE ESTABLISHMENTS ON LAKE KARIBA

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The increase in Aquaculture production in the country has brought about fish diseases which are of bacterial origin. It is suspected that to promote growth, prevent and treat disease, some farmers have resorted to using antimicrobials that have concerns relating to the environment and public health. It is therefore important to devise other ways of disease prevention such as vaccine usage. In Zambia, the initiative to disease management in the sector, has been to develop an autogenous vaccine for *Lactococcus garvieae* and *Aeromonas hydrophilia*. The vaccine has been developed for use through the intraperitoneal route. However, during our field trials on Lake Kariba, we made significant observations such as the need for farmers to be explained to as regards the effect of anesthesia. The cage design made it difficult to administer the vaccine. Furthermore, the intraperitoneal route is not practical in smaller fish and may not be economically feasible to administer several times in the fish production cycle. Therefore, an alternative method for vaccinating fish on Lake Kariba would be to use an oral or immersion route. We have started developing the oral vaccine of *Lactococcus garvieae* and *Aeromonas hydrophilia* which will be administered via the feed. This study confirmed the efficacy of the *Lactococcus garvieae* intraperitoneal route administered vaccine in fish.

A DIFFERENT TAKE ON TANNINS – APPLICATION IN DIETS OF AFRICAN CATFISH *Clarias gariepinus*

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This study done by Stellenbosch University explores the potential use of hydrolysable tannins in the diets of African catfish (*Clarias gariepinus*). Hydrolysed tannins extracted from sweet chestnut wood (*Castanea sativa*) are known for their antioxidant, antimicrobial, and astringent properties, and are effectively incorporated in livestock feeds to reduce the impact of production and environmental stress and to reduce antibiotic use. A commercially available tannin extract (Farmatan Aqua, Tanin Sevnica Slovenia) was included in an extruded catfish grower diet at seven increasing levels (0, 0.5, 1, 1.5, 2, 2.5 and 3 g/kg) and fed for the duration of a 90-day growth trial to establish influence on production performance, meat quality, haematology and intestinal morphology. Each treatment was replicated seven times. After the growth trial, one fish from each treatment was transferred to separate static tanks where water quality parameters were monitored over a 24-hour period at one-hour intervals after one feeding.

Results from this study showed that the inclusion of 1g/kg tannin extract significantly improved feed conversion efficiency from 1.27 (0 g/kg) to 1.22:1 while survival was significantly improved from 79 to 87% at 1.5g/kg inclusion. Haematocrit measurements increased linearly with tannin inclusion ($y = 1.5235x + 24.546$; $R^2 = 0.9048$). Fillet Drip-loss were significantly reduced with 1.5% at 1.5g/kg inclusion and cooking loss with 10 and 15% at 2 and 2.5g/kg inclusion. Ammonia accumulation over a 24-hour period was significantly reduced ($y = 4.3401x^2 - 25.735x - 5.8066$, $R^2 = 0.883$) with up to 45% at 3g/kg tannin inclusion.

The results from this research offer an opportunity to improve production performance and meat quality while supporting water quality management of catfish production whilst reducing its environmental impact.

PROBIOTIC BACTERIA ISOLATED AND TESTED IN NILE TILAPIA *Orechromis niloticus***

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1 Scholarship CNPq 102075/2022-0

The microorganisms use as probiotic, can be a viable alternative to prevent stress, pathogenic agents, and also improvement on growth zootechnical performance indexes. This work aimed to evaluate the pre-selected intestinal bacteria of Nile tilapia from commercial fish-farms in Brazil, utilization on feeding and it is effect as a possible probiotic, evaluating zootechnical growth performance. The experiment was conducted at Fishery Institute – Brazil, for a total of 81 days. The experimental design was entirely randomized, with seven treatments and three repetitions: T0 – control; T1 – *Bacillus velenzis* (10^{11}); T2 – *Bacillus pumilus* ($3x10^{9}$), T3 – *Bacillus subtilis* ($1,5\ x10^{12}$), T4 – *Enterococcus hirae* ($3x10^{12}$), T5 – *Enterococcus faecium* ($7x10^{12}$) e T6 – mixture treatment. Probiotic were added in 2% soy oil and sprayed in the feed at a dosage of 1g/kg. The result observed was that treatments T2 and T6 promoted an increase in final fish biomass, when compared to control group ($p<0,05$). We conclude that isolated and pre-selected bacteria from Nile tilapia intestine of group T2 (*B. pumilus*) and T6 (mix – *B. velezensis, B. pumilus, B. subtilis, E. hirae* e *E. faecium*), improve growth performance, and can be used as a probiotic for tilapia.

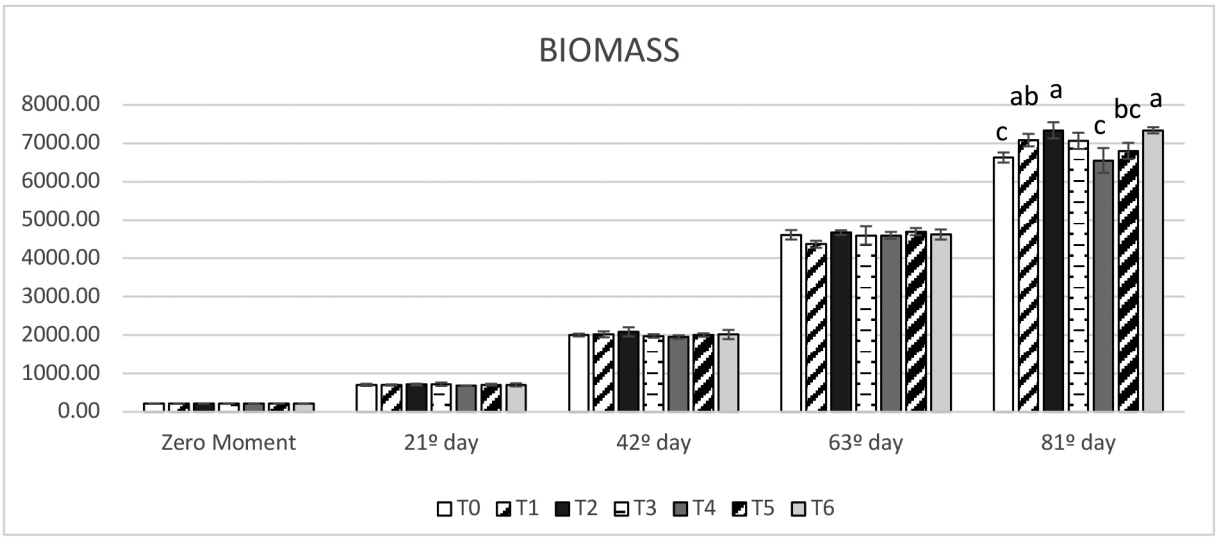

Figure 1. Averages and standard deviation of Nile tilapia. *O. niloticus* total biomass (g) fed with different probiotic bacteria. [ab] Different letters indicate statistically significant results by Duncan´s Test ($P<0,005$)

SURVEY OF CULTIVABLE MICROALGAE FROM THE NIGERIAN COASTAL WATERS FOR BIOTECHNOLOGICAL APPLICATIONS

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Microalgal biotechnology has received research attention in recent years owing to increased knowledge that some microalgae species contain important bioactive compounds (e.g. polyunsaturated fatty acids, astaxanthin, polyphenols, carotenoids, amino acids etc.) with potential application in the animal and human nutrition, cosmetics, pharmaceuticals, and even in fuel industries. However, only few of these species have been successfully cultivated for the commercial production of their high valued products. As Nigeria is striving to tap into numerous opportunities in blue economy, the need to explore various commercial benefits inherent in microalgae appears to be more urgent now than ever.

The first and critical step in bio-prospecting of microalgae is the selection of microalgal species, which involves series of steps, including sample collection, isolation, purification, identification, maintenance and characterization of potential products. Cultivation protocols must then be developed for the screened isolates of notable benefits in order to optimize their production for commercial propagations.

The present study identified cultivable microalgae occurring naturally at the Araromi Beach (Lat 6° 22' 43"N Long 4°49'59"E) area of Ondo State, Nigeria. Samples were collected in the beach (Araromi) at about 1 km from the shoreline, at entry point of a river flowing into the beach (Ese Odo), and at the upper part of the river at a distance of about 1 km from the entry point (Owawa). Phytoplankton samples were obtained by scooping to a depth of 0.5 m below water surface with a plankton net (mesh size 25μm) mounted on a moving boat. Similarly, water quality parameters (temperature, salinity and pH) of sampling locations were measured *in-situ*. The collected phytoplankton samples were transported immediately to the laboratory and cultured in Beneck's broth and Algal culture broth for a period of ten days. 1 ml of each broth was re-suspended twice in the fresh broth and cultured following standard procedures. Algal growth in the broth was examined morphologically under a light microscope (40X and 100X magnifications) and identified using appropriate texts. A total of eight species of microalgae were identified from the sampling locations (Table 1).

Table 1. Cultivable microalgae recovered from Araromi Beach Area of Ondo State, Nigeria

Sampling Location	Water quality parameters			Cultivable microalgae form different culture media	
	Temperature (°C)	Salinity (mg/L)	pH	Algal culture broth	Beneck's broth
Araromi beach	27 – 28	32	8.7	*Spirulina sp, Chlorogonium elongatum,*	*Spirulina sp, Navicula spp, Oscillatoria limnetica,*
Ese-Odo	27 – 28	20	7.6	*Chlorogonium elogatum, Spirulina sp, Chlamydomonas globosa, Scenedesmus incrassatulus, Euglena spp, Phaeodactylum tricornutum*	*Chlorella vulgaris, Spirulina sp, Oscillatoria limnetica, Scenedesmus incrassatulus,*
Owawa	27 – 28	12.5	7.9	*Chlorella vulgaris, Chlorogonium elongatum,*	*Chlorella vulgaris, Oscillatoria limnetica, Euglena spp*

IMPROVING TILAPIA PRODUCTIVY IN COTE D'IVOIRE THROUGH THE USE OF PILOT FARMS

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Fisheries Division (NFI)
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Côte d'Ivoire is heavily dependent on imports of fishery products (more than 80% of consumption estimated at 600,000 tonnes/year). The country in its 2030 strategy aims to make aquaculture development a key instrument for economic growth, poverty reduction, food security and job creation. In this context, the aquaculture of tilapia, the main fish species farmed in Côte d'Ivoire (7,700 tonnes/year) is an opportunity to reverse the trend.

Within the framework of the programme FISH4ACP, FAO is supporting the upgrading of the farmed tilapia value chain in Côte d'Ivoire. Ten (10) farms were selected nationwide as part of the implementation of the FISH4ACP strategy in Côte d'Ivoire. These extensive or semi-intensive pilot farms are representative of the different types of farming used across the country. FISH4ACP is providing them with technical and financial support to turn them into demonstration sites of improved business models and best farm management techniques.

The presentation will highlight first results of the approach of as well as discuss the challenges linked with the use of pilot farm to mainstream improve practices and business models.

DIVING INTO SUSTAINABILITY: UNLEASHING AQUACULTURE'S POTENTIAL THROUGH MULTI-STAKEHOLDER PARTNERSHIPS

Foungnigue Traore Djire, Abubakar Usman, Paul Mwera

Fisheries Division (NFI)
Food and Agriculture Organization of the United Nations

FISH4ACP programme is supporting sustainable aquaculture development of three aquaculture value chains (VC) in Africa: the farmed tilapia VCs in Cote d'Ivoire and Zimbabwe and the catfish VC in Nigeria. The programme's approach is centered on a participatory process with strong stakeholder involvement. The complexity of interactions among value chain operations warrants the need to engage with different stakeholders in identifying the issues to be assessed and in setting priorities for upgrading the value chains. To ensure sustainability and long-term impact, VC stakeholders need to be involved and gradually lead the process if real change is to be achieved. This is the logic behind the concept of the Multi Stakeholder Partnership (MSP).

FISH4ACP therefore supports the establishment of a MSP for each recipient aquaculture VC of the programme. This partnership brings together key public and private actors across the VC with the aim of identifying and removing the bottlenecks preventing the sector's development and fostering innovation. It helps to ensure stakeholder coordination, address divergent viewpoints, mobilise resources and manage power differences and conflicts. This process aims to create of a self-sustaining value chain dynamic, embodied by a functional, self-financing MSP (Figure 1). MSPs now constitute a catalysing force that is contributing to unleashing aquaculture's potential in Côte d'Ivoire, Zimbabwe and Nigeria.

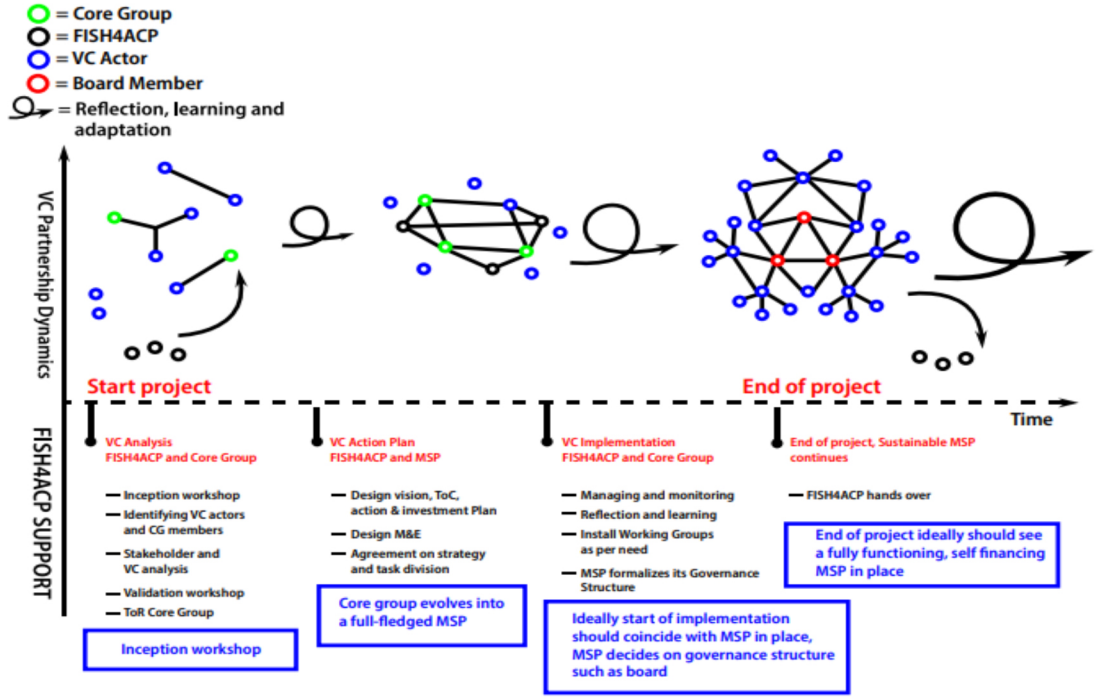

Figure 1: Visualization how over time a rather weak value chain partnership can transition into a strong network, facilitated by the FISH4ACP programme

CREATING FARMER BUSINESSPERSONS IS FUNDAMENTAL TO BUILDING AND EXPANDING A PROFITABLE AQUACULTURE SECTOR ACROSS AFRICA

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Ghana and Nigeria have been consistently among the top 4 aquaculture-producing countries in Africa. Nigeria is predominantly (above 90%) a catfish-producing country, with annual production nearing 1,300,000 MT. Ghana is predominantly (80%) a Nile tilapia (*Oreochromis niloticus)-producing* country with an estimated 89,000 MT annually. Smallholder farmers contribute 80 to 85% of the total production in Nigeria and about 50% in Ghana.

Although smallholder farmers play an important role in production across Africa, they often face the challenge of raising capital and attracting investment to grow their businesses. Among the underlying reasons is the principal problem of a lack of financial records. Small-holder farmers do not prioritize the need to record financial data (bookkeeping) for lack of knowledge and skill to do so and/or inadequate beneficial motive to do so.

While the science of aquaculture is continuously researched, documented, and taught, the business and entrepreneurial aspects of it are inadequately documented and farmers are left by themselves to learn very costly lessons repeatedly. This paper documents and reports the suitability of a farmer-designed financial and bookkeeping training module that was rolled out to fish farmers in Ghana and Nigeria in June 2023 and the trainees' feedback. The modules taught farmers to prepare and interpret income statements, calculate margins and markups, and create business model canvases, among others.

Surveys were administered before and after training, along with focus group discussions, to a total of 38 respondents. Results indicated that 80% found the teaching material extremely effective. About 97% of participants found the bookkeeping methods implementable by themselves in their businesses. In all, 100% of participants had their training expectations exceeded, with 96% recommending other farmers attend the training.

EFFECT OF ADMINISTERING SERIALLY DILLUTED SUPRECUR AND MOTILIUM (DOPAMINE BLOCKER) ON THE BREEDING PERFORMANCE OF *Clarias gariepinus*

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This study was designed to determine the effect of using serially diluted Buserelin acetate (Suprecur®), which is a luteinizing hormone-releasing hormone analogue (LHRHa) with dopamine antagonist (Motilium®) on the latency period, fecundity, percentage fertilization and percentage hatching of *Clarias gariepinus*. Treatments administered include 50ug/l, 40ug/l, 20ug/l and 10ug/l of Suprecur® in tandem with 5mg/kg of Motilium®. Metrics obtained include egg numbers, latency period, fertilization rate, hatching rates, and survival to first feeding. The results obtained demonstrated that the use of Suprecur® (LHRHa) together with dopamine antagonist (Motilium®) successfully induced ovulation in the experimental *Clarias gariepinus* broodfish. The highest fecundity was from the treatment T40 There was no significant difference in egg weights stripped from each treated group. The application of 50 μg/kg of Suprecur® with 5mg/kg of Motilium® resulted in earlier synchronization of ovulation (Latency period; 12 hours). Results of the fertilization percentage indicated that an increase in the dose of LHRHa did not significantly affect the fertilization rate in treated groups of broodfish. Overall superiority of 50 μg/kg of Suprecur® plus 5mg/kg of Motilium® in spawning induction was proved by significantly high hatchability, 83.56%. Broodstock used for the 40μg/kg dose had the highest fecundity. There was no significant correlation ($p>0.05$) between the water quality parameters and the breeding parameters. In conclusion, the result obtained clearly indicates an overall superiority of using 50 μg/kg of Suprecur® together with 5mg/kg of Motilium® to induce spawning with regard to the recorded high hatchability percentage.

US PEACE CORPS AND FARMER-TO-FARMER EFFORTS IN INDIGENOUS AQUACULTURE IN AFRICA

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From 2000 to 2019, Africa's aquaculture sector grew by 11% annually (Ragasa et al., 2022). Important growth has taken place in large scale investments, creating major fish domestic producers in countries such as Zambia and Ghana. However, subsistence and small-scale aquaculture continue to be important for food security and nutrition, and by providing strategic income diversification from crop and livestock agriculture (AFD, EU and GIZ, 2017). Small-scale fish farmers raise Nile tilapia or native tilapia species. Catfish is a popular cultured fish, but more resources, including pelleted feed and fingerling production, are required. Segmentation of catfish culture allows modest income farmers to purchase feed and fingerlings from those who specialize. Farmers can raise fingerlings to market size quickly in limited space and water because African catfish can breath atmospheric air. Introduced non-native common and other carp have escaped culture, becoming established in some areas and farmed by medium farmers.

The United States Peace Corps and the USAID-funded Farmer-to-Farmer (F2F) expert volunteer program have been promoting indigenous aquaculture to improve food security and nutrition, and to develop fish culture as a business. Sullivan was initially involved in Zambia (1999-2001) through the Peace Corps' Rural Aquaculture Promotion Program and thereafter implemented dozens of F2F assignments in over ten African countries. In Peace Corps, volunteers teach fish farmers to raise tilapia in hand-dug ponds with little or no monetary input because the average farmer's income was only a few hundred dollars a year from crop farming.

There is high demand for market fish, small-scale commercial fish farming is growing, and fish farmers are creating cooperatives and associations. The F2F program recruits expert volunteers for two-to-four week assignments to teach medium and small-scale commercial farmers skills needed for financial success, including pond construction and management, fish feeding and feed production using local materials, and fingerling production. Topics also include spawning catfish using hormones when available or locally obtained pituitaries from wild fish when not. Assignments also cover business and financial management, marketing, and association building. Finally, value addition can provide greater incomes. As refrigeration and freezing are often difficult due to problems with electricity, smoking and canning can stabilize products for sale when the prices are competitive. The recent foreign investment in African aquaculture creates resources that can also assist smaller fish farms, but in the continued absence of these resources in many countries, affordable indigenous solutions can still be promoted to address problems of suitable culture environments, spawning and maintaining of unwilling broodstock, creating appropriate feeds for all life stages from fry to market to spawners, genetic selection, and creating value added, self-stable products.

INTEGRATED MULTI-TROPHIC AQUACULTURE AS A MEANS OF IMPROVING COSTAL LIVELIHOODS RESILIENCE THROUGH DIVERSIFICATION OF INCOME: ITS PROSPECTS AND CHALLENGES FOR FOOD SECURITY IN AFRICA

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According to the FAO, the growth of aquaculture in 2020 propelled the total production of fisheries and aquaculture to a record high of 214 million tonnes in 2020. Aquaculture now, contributes more than 57 % of global fish production and is experiencing rapid growth, with an annual increase of 8.8 percent. The latest data indicates that approximately 600 million people are estimated to depend on fisheries and aquaculture in some way for their livelihoods. In Africa, aquaculture production has surpassed 2 million tonnes, valued at nearly 3 billion USD, and it employs over 1.2 million people. The expected growth of aquaculture requires the development of responsible and sustainable approaches, technologies, culture systems, and practices. Integrated Multi-Trophic Aquaculture Systems (IMTAS) is a sustainable approach to aquaculture that aims to enhance productivity while minimizing environmental impact. IMTAS integrates different species within the same system, creating a symbiotic relationship where the waste from one species becomes a resource for another. By combining several species from various trophic levels, IMTAS maximizes resource utilization, reduces nutrient pollution, and improves ecosystem health. Furthermore, by integrating species with different growth rates and market values, IMTA systems can enhance overall productivity and profitability. This diversification can provide a more stable income, as they are not solely dependent on a single species.

Nigeria and Morocco, with their extensive coastline and favourable climatic conditions, have the potential to become among the leading Marine aquaculture producers in Africa. According to the Morocco's National Agency for Aquaculture Development, the country's aquaculture potential could be as high as 380,000 tonnes per year. The present study has been undertaken with the objective to explore the status of aquaculture in Nigeria and Morocco, to present an alternative form of sustainable seafood production using IMTAS and discuss its prospects and challenges for food security in Africa.

ASSESSING THE AQUEOUS EXPOSURE TO SILVER NANOPARTICLES WITH ACTIVE CHARCOAL AS SUPPLEMENTARY FEED ON GROWTH, ANTIOXIDANT INDICES, AND HISTOPATHOLOGICAL EXAMINATIONS OF NILE TILAPIA, *Oreochromis niloticuS*, CHALLENGED WITH HEAVY METALS

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The present study offers some important information into the interaction between the aqueous exposures to silver nanoparticles (NPs-Ag) with dietary active charcoal on the performance and physiological functions of Nile Tilapia, *Oreochromis niloticus*, challenged with heavy metals. A 50-day rearing attempt included 7 groups were performed as follows: CG: fish did not aqueous expose to NPs-Ag and fed a basal diet without active charcoal. G1 (NPs-Ag10), and G2 (NPs-Ag20): fish were aqueous exposed to 10 and 20 µl/l of NPs-Ag. G3 and G4: fish were exposed to the NPs-Ag10 by adding 30g and 15 g/kg of dietary charcoal to the basal diet respectively. G5 and G6 fish were exposed to the NPs-Ag 20 by adding 30g and 15 g/kg of dietary charcoal respectively. A 315 juvenile with an initial average weight of 3.55 g were randomly distributed into 21 plastic tanks with a capacity of 30 litters. A basal diet of 30% crude protein was used and fish fed at 4% of their biomass. The water exchange rate was 20% every 3 days with adjusting the doses of NPs-Ag in each tank. The results revealed that the growth performance and antioxidant indices of fish exposed to the lower NPs-Ag levels and 15 g/kg of dietary charcoal improved significantly compared to other treatments. Wherein, G4 the rate had the highest growth, the best level of antioxidant indicators, and the highest survival after the challenge with copper sulfate.

EXOGENOUS B-MANNANASE AND DL-METHIONINE AS FEED ADDITIVES TO IMPROVE GROWTH, FEED EFFICIENCY AND HEMATOLOGICAL INDICES OF NILE TILAPIA *Oreochromis nilotucs* FED DIETARY PLANT PROTEIN

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The present study was done to determine the effects of exogenous β-mannanase (Hemicel® enzyme) and methionine on growth performance and blood parameters of Nile tilapia *Oreochromis niloticus* fed plant protein diet. Two basal diets were formulated to contain 27% CP one of them contained fishmeal (A) and other was plan protein (B). This study included six treatments were as the following: T1: (negative control) fish fed with diet A, T2: (positive control) fish fed on diet B, T3 and T4: fish fed on diet B with adding 0.025 and 0.05 % of Hemicel®, respectively, and T5: fish fed the diet B with 0.025% of Hemicel® and 5% methionine and T6: Diet B with adding 0.05 % Hemicel and 5% methionine. 120 juveniles were randomly divided into 12 plastic tanks (water size: 35 liters) with density of 10 fish/tank. Fish reared in saline of 3ppt, and fed two times daily for six days weekly with rate of 4% of body weight. Results confirmed that feed additives of Hemicel and Dl-methionine significantly improved nutritional utilization of plant protein diets. One way ANOVA analysis did not show significant differences in growth performance between fish fed with a soy-based diet containing 0.025% Hemicel® and Dl-methionine 0.5% (T5) and those fed with the diet containing fish meal (T1). Fish in T5 and T4 had highest body content of protein and the best blood indicator. Generally it can be totally replaced fish meal by soy bean with adding Hemicel® and Dlmethionine at levels of 0.025% and 0.5% respectively.

AQUA-SPARK AFRICA: AFFIRMING OUR COMMITMENT TO SUSTAINABLE AQUACULTURE IN SUB-SAHARAN AFRICA

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Aqua-Spark is the world's leading sustainable aquaculture investment fund with over EUR 500 million of assets under management and 28 investments across the globe. Our impact focus combined with our patient capital structure has allowed us to play a significant role in stewarding the development of the blue economy and in catalyzing much needed investment.

Africa has always been a core component of our investment focus, and to date we have successfully completed three investments in farming operations across the continent and are currently in the final stage of closing a fourth landmark transaction in the aqua-tech space. These investments will now serve as the corner stone for our soon to be launched Aqua-Spark Africa – the world's first Africa-specific sustainable aquaculture fund.

The specific challenges that we collectively face on the continent are well known. At the forefront of our minds is the growing population, which will double from 1.3Bn in 2020 to 2.5Bn by 2050 according to the IMF and double again to 4.3Bn by the end of the century according to the AFDB. Equally critical, is the fact that many will be entering prime employment age and will be seeking honorable livelihoods.

This comes hand in hand with chronic undernourishment, which affects one out of every four Africans. This is a function of two factors.First is low incomes per capita, which means that households must spend around forty percent of income on sustenance which is a grossly outsized portion. The second is the low access to quality proteins, with African's consuming on average c. 13 grams of non-plant proteins per day, which is 40% of the global average, and 20% of developed regions such as the EU.

At Aqua-Spark we believe that the flipside of these vast challenges are equally rewarding opportunities that can be unlocked by the blue revolution and investments that are tailored to deliver impact and to create showcase and beacon investments that will catalyze much needed capital and interest in this vital sector.

In recognition of these unique challenges, and to enable us to tap into significant public funds that are dedicated for the continent we are in advanced stages of launching Aqua-Spark Africa which will be fully dedicated to delivering impact in Sub Saharan Africa. By the end of the decade, we aim to have grown our portfolio to around thirty-five companies and to have deployed close to three hundred million dollars in investments and follow-ons.

In addition to leveraging Aqua-Spark's deep experience in this sector, we will be complementing our investment fund with grant-based support provided by the Aqua-Spark Foundation. The foundation has already established, with the support of the Rockefeller Foundation, a technical assistance facility aimed at empowering our portfolio companies to generate broader industry impacts, such as the development of outgrower programs and the piloting of innovative technologies.

We look forward to discussing our vision with esteemed AFRAQ members in Lusaka.

TACKLING SUB-SAHARAN AFRICA AQUACULTURE CHALLENGES THROUGH A VALUE CHAIN APPROACH & THE NOVEL FINANCIAL TOOL SAMAKI PEPEA

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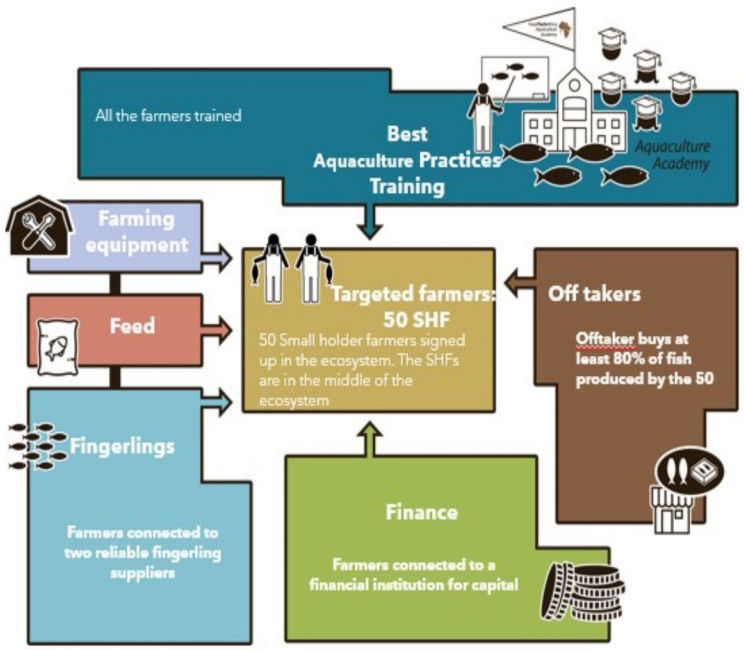
With an annual growth rate of 11%, Sub-Saharan Africa aquaculture is growing fast. The sector has moved beyond the infancy stage, yet the regional sector is still far from unlocking its potential. Widely recognized challenges remain the availability and price of quality inputs such as feed and seed, low practical skills, access to finance, and market linkages. To sustainably tackle these challenges, there is a need for well-informed interventions built on objective collaboration among sector players.

Putting this theory into practice, a pilot is being run in Kenya, where representatives of the various parts of the aquaculture value chain have been organized in an ecosystem with one goal: to increase the productivity and profitability of smallholder fish farmers. Leveraging the experience of the Aquaculture Academy in Kenya, the farmers have been practically trained in aquaculture skills in combination with a major focus on business acumen. Beyond, the farmers have been linked to input suppliers and the market, opening their business to offtake security.

A first-of-a-kind financial product has been developed specifically for fish farmers to increase access to finance. The product, dubbed Samaki Pepea (Samaki Pepea is Swahili for "soaring fish"), will enable farmers to buy high-quality inputs, a prerequisite to expanding their aquaculture ventures.

To practically implement, 50 farmers trained have, in turn, trained 243 other smallholder farmers. The 50 have produced an extra 100 MT of fish based on these interventions. There has been over 80% adoption rate of the best aquaculture practices (BAPs) taught to the farmers. BAPs at the farm level imply higher chances of business success and low negative environmental impact.

The value chain approach aims to break the silos in the region's promising aquaculture sector. It is based on responsible business practices where every stakeholder understands their role in the value chain and appreciates the need for valuable collaboration. The promising results of this initiative have shown practical applicability and provide a fitting model to help unlock the challenges along the sub-Saharan aquaculture value chain.



AQUACULTURE SEAFOOD SUPPLY CHAIN A RESILIENT INDUSTRY IN THE COVID-19 TIME

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The Monterey Bay Aquarium Seafood Watch Program® and partners: Resonance, The University of Arizona, Johnson & Wales University, the University of Massachusetts Boston, and the Qingdao Marine Conservation Society conducted a survey to understand the impacts of the pandemic COVID-19 on members of the aquaculture supply chain. Taken into consideration that fresh seafood products are highly perishable and must be sold, processed, or stored quickly, are at particular risk, this study explored the effects of restrictions and quarantine measures on aquaculture from the perspectives of government, industry, eco-certifications, importers, and retail/food service sectors. Our goal was to learn what areas of the aquaculture operations and supply chains are being impacted by the pandemic, identify what mitigation and/or preventative measures have been taken, and the degree to which these measures have been successful.

The research team distributed an anonymous survey in July 2020 to the different actors involved in the aquaculture supply chain. The assessment was organized into three main areas 1) Producers, which includes Salmon, Shrimp, and Tilapia producers; 2) Regulators, which include certifying bodies and standard owners; and 3) the industry, which considers importers, food service, retail companies, and Eco-certification.

Different difficulties were identified in different areas. Overall, complications found were: 1) there have been more difficulties across the supply chain procuring shrimp when compared to salmon or Tilapia, 2) Seafood buyers were able to quickly switch procurement countries to meet demand, 3) Food Service was the most impacted seafood buying sector due to the closure of restaurants, 4) Reliance on passenger air travel for salmon distribution was problematic, 5) Frozen and shelf-stable products are in greater demand as consumers are more interested in convenience options (heat and eat) on retail, 6) Shorter supply chains make adapting to the COVID-19 crisis easier.

In general, aquaculture products are more available than wild capture, offering greater resilience in times of stress. Seafood supply is more resilient to COVID-type impacts than other proteins, with chicken taking the place of seafood in some instances. Eco-certification programs adapted through the use of remote auditing, which worked well for auditing environmental variables, but not well for social audits. It is not feasible to conduct thorough social audits remotely.

The findings from this survey will help inform a more prepared and sustainable aquaculture industry that is resilient in the face of disturbances, contributing to secure food systems and livelihoods in the future.

PRODUCTIVITY INCREASED BY MONO SEX TILAPIA FINGERLINGS AND FISH VALUE ADDITION IN ZAMBIA

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The Technologies for African Agricultural transformation (TAAT Phase I) program funded by African Development Bank through the Aquaculture Compact led by WorldFish deployed aquaculture technologies to increase productivity in 12 African countries: Benin, Burundi, Cameroon, Cote d'Ivoire, DR Congo, Ghana, Kenya, Malawi, Nigeria, Tanzania, Togo and Zambia. The program uses the monitoring and evaluation and learning (MEL) system to ensure continued progress towards set goal and develop a culture of learning and sharing within the program.

The TAAT program collaborated with the Aquaculture Compact to conduct an outcome level study to determine the effects of project interventions on performance of actors and improvement of livelihoods of the people who benefited directly and indirectly from TAAT investment. Outcomes case study used a triangulation of mixed methods including Interviews, Focus Group Discussions (FGD), and Observations through ground truthing field visit to collect data.

Results of the outcome case study show that Aquaculture Compact leveraged on Zambia Aquaculture Enterprise Development Project (ZAEDP), a project funded by both GRZ and AfDB to scale up aquaculture technologies deployed. These are mass production of mono sex tilapia fingerlings in hapa, production of hybrid Clarias species, fish feed and feeding management; and value addition (solar tent, smoking kiln technology and product development). The fish breeders and fish processors benefited from practical trainings in Abbassa, Egypt and Elmina, Ghana respectively. Fish hatcheries were supported with improved brood stock for mass production of tilapia mono sex fingerlings supplied to fish farmers. Several In-Country trainings were organized, stakeholders along the value chain were identified and sensitized.

In terms of outcome, many tilapia breeders have higher survival rate recorded for fingerlings produced. Growth rate of table-size tilapia has increased from 250g to 350g after 6 months culture period. Production of local feed has stimulated more jobs to be created along the value chain. Value addition of fish by solar tent dryer and smoking kilns have produced 11 new fish products, thereby increasing profit margins of fish farmers and processors. A total of 225 beneficiaries have been trained comprising of 101 women trained and 124 men. Income increased by 30% and 8,000 jobs have been created along the Aquaculture Value Chain. Number of people trained are 336 and final beneficiaries effectively using the technologies are 2,898. Total of aquaculture value chain actors as beneficiaries reached are 10,177. The fish breeders trained have produced 27,934,646 fingerlings under the TAAT programme in Zambia.

Despite the challenges encountered, beneficiaries reported several crucial lessons that can be carried forward to beneficiaries of future projects.

WATER QUALITY IN SUPER-INTENSIVE WHITELEG SHRIMP PONDS IN CA MAU PROVINCE, VIETNAM

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Introduction

Intensive brackish shrimp culture has been rapidly developed in the Mekong Delta (MD), Vietnam, especially in Ca Mau province with the area accounted for 7,900 ha in 2022. During farming operation, water quality plays a vital role in achieving high quality production and sustainable shrimp farming. Poor water quality in shrimp farming may subject shrimp to stress that negatively affects growth and survival of shrimp subsequently creating a favorable environment for diseases. Shrimp production relies on growth and survival rate proportional to water quality in the culture environment.

Objective

The aim of this study was to assess the status of water quality in super-intensive whiteleg shrimp ponds in Ca Mau province to provide fundamental information for better water quality management in shrimp farming towards sustainable development of brackish shrimp industry in the MD, Vietnam.

Methodology

Water samples were collected in six super-intensive shrimp ponds in Ca Mau province with different stocking densities: (*i*) Group 1: 150-200 ind. m^{-2} and (*ii*) Group 2: > 200 ind. m^{-2}, three ponds for each group. The samples were collected a day before stocking and every one week after stocking during nursery and grow-out stages till harvesting time. The culture duration was 3 months. Temperature, salinity, dissolved oxygen, and pH were directly measured at sampling site using a HANNA Multiparameter, while alkalinity, TAN, NO_3^-, TSS, TN, PO_4^{3-}, TP, Chlorophyll were analyzed at the Advanced Aquatic Environment Lab, Faculty of Aquatic Biology and Environmental Science, College of Aquaculture and Fisheries, Can Tho University. All analytical procedures were following APHA (2017).

Results

Table 1: Water quality in super-intensive whiteleg shrimp ponds in the study

Parameters	Group 1	Group 2
Temperature (ºC)	31.0±1.86	30.6±1.44
Salinity (ppt)	32±2.48	31.8±3.66
DO (mg/L)	3.20±0.48	3.3±0.59
pH	8.10±0.12	8.10±0.14
Alkalinity (mg/L)	160±17.4	164±41.9
TAN (mg/L)	0.311±0.247	0.494±0.439
TN (mg/L)	2.15±1.49	3.43±3.73
TP (mg/L)	0.945±0.425	2.03±3.20
NO_3^- (mg/L)	1.23±1.10	1.16±0.982
PO_4^{3-} (mg/L)	0.079±0.068	0.125±0.110
TSS (mg/L)	120±38.8	151±53.2
Chlorophyll-a (µg. L^{-1})	109±113	176±178

Values presented as Mean±STD (n=3)

Conclusions

Most of the water quality parameters in the ponds were in an ideal range for shrimp growth. However, DO concentrations were relatively low at some sampling times, whereas TSS concentrations were relatively high as compared to water quality criteria for marine shrimp. Water in ponds with higher density contained higher TSS and chlorophyll-a concentrations.

RECIRCULATING AQUACULTURE SYSTEMS FOR FOOD SECURITY IN AFRICA, A PRODUCERS PERSPECTIVE

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Climate change, population growth, youth bulge, widespread unemployment, extreme poverty and hunger are some issues that the African continent struggles with, leading to food insecurity.
The continent's reliance on imports continues to grow, with an estimated 85% of food imported. Building aquaculture capacity in the continent will help address food insecurity. But despite decades of international financial and technical support, SSA countries account for less than 1% of global aquaculture production. Impacts from disease, climate change and inadequate infrastructure have hindered aquaculture development on the continent.

Recirculating Aquaculture Systems offer an ideal solution for commercial scale aquaculture on the African Continent.
Recirculating Aquaculture Systems (RAS) are the logical evolution of open/outdoor fish farming, employing a technological approach to aquaculture where the entire process is brought into an indoor, highly controlled facility. Every aspect of the operation can be optimized to create an ideal and consistent growing system. Fish are raised in large culture tanks with filtration systems constantly cleaning and recycling the water(up to 95%), greatly reducing the amount of fresh water used. Waste products are filtered and collected, and can be recycled for other agriculture uses. These systems have a much higher degree of biosecurity, reducing the threats of disease and eliminating the need for antibiotics, vaccines and hormones. Other advantages include predictable production, no seasonality and more resilience to climate change. These facilities can be located close to urban areas and are inherently scalable. Unlike other types of agriculture, the jobs the systems create are not seasonal, but are long term, secure technical careers with upward mobility.

Blue Ridge Aquaculture is uniquely positioned to offer insights into RAS Opportunities and Challenges for the African Continent.
Blue Ridge Aquaculture has operated a RAS facility for over thirty years. Our company produces 2,500 tons of tilapia per year(WFE). We have grown to be a completely integrated company with our own broodstock program (23 generations), hatchery, nursery, feed mill and distribution. Our biosecurity protocols have prevented disease from our system for over twenty years, allowing us to produce with antibiotics, vaccines and hormones. We enjoy better KPI's than any other operation in the industry, with mortality of less than 3%, biologic FCR of 1.45 and fast growth with hatch to harvest in under 8 months. We have been through our challenges and have participated in and witnessed the evolution of the industry. This gives us unique insight into the opportunities and challenges of establishing RAS in Africa. We are confident that Recirculating Aquaculture Systems offer the best opportunity to develop sustainable aquaculture on the African Continent.

UTILISATION OF DIFFERENT GROWTH MEDIA IN A PYRAMID NUTRIENT FILM AQUAPONIC SYSTEM: EFFECT ON WATER QUALITY AND BIOTECHNICAL PERFORMANCE OF GIANT AFRICAN CATFISH (*Heterobranchus bidorsalis*) AND TOMATO (*Lycopersicum esculentum*)

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This study was carried out to assess the biotechnical and limnological effects of different growth media in a Pyramid Nutrient Film (PNF) Aquaponic System on Giant African catfish (*Heterobranchus bidorsalis*) and tomato (*Lycopersicum esculentum*) raised in the aquaponic system. The aquaponic system was designed with a Poly Vinyl Chloride circular base of 10cm diameter perforated to produce a 5cm diameter hole made for the plant to float. Disposable plastic cup of 5cm diameter were filled with four growth media namely Palm kernel shells (PKS), Gravel (GRA), Crushed Snail Shell (CSS) and conventionally used loamy soil which was used as control to support the plants. Fish were fed for 56 days during which the water was recycled to serve as a source of nutrient for the plant. Water quality parameters were monitored throughout the experimental period and at the end of the experiment, yield of *L. esculentum,* growth performance and nutrient utilisation of *H. bidorsalis* were recorded. Significantly better ($p<0.05$) biometric parameters in terms of plant yield and fish zootechnical performance were recorded in *H. bidorsalis* and *L. esculentum* raised on the control, loamy soil and Palm kernel shells (PKS) in treatment one. This study showed that PKS is a suitable media bed in aquaponic for the production of tomatoes and *H. bidorsalis*. Palm kernel shells also enhanced the symbiotic integration of aquaculture and hydroponics in utilising waste as raw material to keep the aquaponic system sustainable and revolving.

Aquaponics is a form of sustainable agriculture that combines fish and plant in a closed recirculating system (FAO, 2016). A typical aquaponic system consists of a fish rearing tank, a solid removal tank, a biofilter, a hydroponic unit, and optionally a sump tank (Rakocy and Hargreaves, 1995). In aquaponic unit, water from the fish tank cycles through filters, plant grow beds and then back to the fish (Rakocy and Hargreaves, 1995).

The design of the aquaponics system used in the current study was a Pyramid Nutrient Film (PNF) Aquaponic System with a combined culture of Giant African catfish (*Heterobranchus bidorsalis*) and tomato (*Lycopersicum esculentum*). The aquaponic system was designed with plastic cup of 5cm diameter were filled with four growth media namely Palm kernel shells (PKS), Gravel (GRA), Crushed Snail Shell (CSS) and conventionally used loamy soil which was used as control to support the plants.

The water quality parameters monitored in the aquaponic system during the experimental period is shown in Table 1.

Table 1: Water quality parameters in the aquaponic system during the experimental period

Treatments (Support media)	Temperature (^{O}C)	Conductivity (siemens)	Dissolved oxygen (ppm)	pH
Control	24.70 ±0.13^{b}	19.50 ±1.32^{a}	5.80± 1.13^{a}	7.05± 0.32^{a}
Treatment 1 (PKS)	24.75 ±0.02^{b}	19.72 ±1.12^{a}	5.83 ±1.32^{a}	7.10± 0.62^{a}
Treatment 2 (GRA)	24.80 ±0.32^{a}	20.17 ±1.36^{a}	5.90± 0.82^{a}	7.15± 0.35^{a}
Treatment 3 (CSS)	24.70 ±0.14^{a}	20.19± 1.34^{a}	5.85± .032^{a}	7.23± 0.32^{a}

Means followed by same superscript in the same column for each parameter are not

Discussion

The water quality parameters in the aquaponic system were within the recommended range for aquaculture (Ajani et al., 2011). The specific growth rates and feed conversion ratio observed in fish in the control were better than fish in other treatments. However, there was no significant difference in the SGR and FCR of fish in the control and PKS medium in treatment one. Although all the control treatments were significantly better in terms of plant and fish biotechnical performance than the other treatments, there was no significant difference between the control treatment and

(Continued on next page)

treatment one with the palm kernel growth media. This indicated that the protein contents of the experimental diets were effectively utilised to improve fish growth. This is in line with the findings of Oladimeji et al., (2020a) which stated that African catfish utilised protein in the aquaponic system better than conventional recirculatory and flow through systems.

Conclusion

This study demonstrated that non-conventional growth beds like palm kernel shell (PKS) is a suitable media bed in aquaponic production of tomatoes and giant African catfish.

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ASSESSING THE EFFECT OF GARLIC, ROSEMARY, AND TURMERIC DIETARY SUPPLEMENTATION ON THE GROWTH, SURVIVAL, AND FEED UTILIZATION OF *Oreochromis Macrochir* (BOULENGER, 2012)

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The experiment was conducted at the Misamfu Aquaculture Research Station in Kasama, Zambia. Fifteen (15) concrete tanks measuring 2 m^2 each were used. There were four (4) treatments: Diet + Rosemary (DR), Diet + Garlic (DG), Diet + Turmeric (DT), and Diet with no additives (control) were fed to tilapia, *Oreochromis machrochir*, and each treatment was replicated three times.

The final mean weight, weight gain, and SGR of juveniles of *O. machrochir* fed on different diets ranged from 24.25 0.10g to 27.88 0.2g, 16.95 0.22g to 20.44 0.4g, and 2.00 0.21% per day to 2.2 0.11% per day, respectively. Lower final mean weight, weight gain and SGR were recorded in treatment where *O. machrochir* was fed on a diet without any feed additives, which differed significantly from diets supplemented with rosemary, garlic, and turmeric, which did not differ from each other. There was no significant difference in the FCR of *O. machrochir* fed on Diet + Rosemary, Diet + Garlic, and Diet + Turmeric. The survival rate varied from 90% to 93%, with a significantly ($P<0.05$) higher rate in fish fed on rosemary and garlic supplements, followed by a diet supplemented with turmeric, which did not significantly differ ($P>0.05$) from each but from fish fed on a diet without additives. Water quality parameters revealed to have no significant different among the treatments

CLIMATE INFORMATION SYSTEMS (CIS) FOR AQUACULTURE: DEVELOPMENT OF A TEMPERATURE-BASED EARLY WARNING ALERT SYSTEM FOR FISH FARMERS IN ZAMBIA

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In Zambia, smallholder fish farmers need access to climate services for fish farming. Managing climate-driven environmental factors and stressors, such as temperature and water supply, is challenging with limited resources and technical skills and yet critical for smallholder productivity. This paper presents the results of an exploratory analysis of environmental data from smallholder fish farmers in Zambia to develop a predictive model for tilapia fish farmers. The model variables included time of day, air maximum temperature, air minimum temperature and pond temperature as the response variable.

Five models were compared, including linear regression, stochastic regression, deep learning, random forest, and Decision tree. The data was modelled for a pond designed according to best aquaculture practices, and therefore, pond size and pond depth are constants. A linear regression model for pond temperature is: $Y(t) = \alpha X1 + \beta X2 + C + \Upsilon$, where α and β are the gradients (coefficients) of the maximum and minimum air temperature features, respectively. Additionally, C denotes the intercept and Υ is the err coeff. Y(t) is the predicted pond temperature in degrees centigrade at time t. The R-squared value for the linear regression was 0.6, hence the linear regression was a good fit. The seasonal pattern of pond temperatures and predicted pond temperatures using the linear regression model displayed a close resemblance.

Three machine learning models (deep learning, decision tree, and random forest) were also compared. The decision tree model is most applicable and yielded good model fit results and a close resemblance of predicted pond temperature to actual pond temperature. It is one way to display an algorithm that only contains conditional control statements. The performance evaluation results of the decision-tree model displayed a R-squared value of 0.6 which is lesser than that of deep learning model (i.e. 0.85). The model did, however, display high performance metrics.

The decision tree model is a good foundation for farmers to understand and predict pond temperatures on their farms. This model is flexible and can be refined for specific operations so that farmers can update scenarios, actions and their predicted outcomes. The decision tree model will be refined over time as it currently incorporates discrete pond temperature measurements for the morning and evening. Additionally, modelling the return of temperature to optimal ranges through water replacement actions would be desirable. For this, pond temperature measurements need to be linked to the rate of water replacement (using flow meters) and the temperature of the source water. With continuous data of pond temperatures over 24 h-cycles, it may be possible to refine models to predict pond temperatures one day in advance.

OCCURRENCE OF MYCOTOXINS IN COMMON RAW INGREDIENTS USED IN AQUA FEED JAN-JUNE 2023

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Introduction

Mycotoxins are secondary fungal metabolites which are frequently found in various plant-based ingredients and can negatively affect health and performance of aquatic species. The increasing inclusion of plant protein in aqua feed, leads to the introduction of mycotoxins in aqua diets. Mycotoxin occurrence in raw ingredients as well as finished feed is monitored within the DSM Mycotoxin Survey, the longest running global mycotoxin survey available. Global results between January-June 2023 of prevalence and concentrations of the six well known mycotoxins aflatoxins (Afla), zearalenone (ZEN), deoxynivalenol (DON), T-2 toxin (T-2), fumonisins (FUM) and ochratoxin A (OTA), in commonly used ingredients are presented.

Material and methods

Samples were analyzed with ELISA, HPLC and LC-MS/MS (liquid chromatography coupled to tandem mass spectrometry) based methods. For Asia, mainly the multi-mycotoxin method Spectrum Top®50 developed by Romer Labs®, was used. This method allows the simultaneous detection of >50 different toxins and metabolites, including masked and "emerging" (unregulated) mycotoxins.

Results and discussion

Table 1 shows the number of samples analyzed, % of samples tested positive for each mycotoxin, average concentration of all positive samples (ppb), median concentration of all positive samples (ppb) as well as the maximum (ppb) detected.

Table 1: Global mycotoxin occurrence in soybean, wheat, corn, corn gluten meal and corn DDGS collected between Jan-June 2023. All concentrations in ppb.

		Soybean + meal	Wheat grain + bran	Corn	Corn gluten meal	Corn DDGS
	Number of samples	1461	705	2874	71	140
Afla	Contamination (%)	35%	13%	21%	41%	18%
	Average of positives	3	3	37	23	11
	Median of positives	2	3	4	18	5
	Maximum	14	8	9 846	163	156
ZEN	Contamination (%)	59%	42%	40%	97%	86%
	Average of positives	47	61	136	1 008	342
	Median of positives	41	38	55	259	211
	Maximum (	241	715	4 310	1 1693	5 357
DON	Contamination (%)	9%	54%	53%	89%	93%
	Average of positives	248	734	958	1 680	2 821
	Median of positives	133	386	569	849	2 199
	Maximum	1 700	10 556	20 440	21 092	16 884
T-2	Contamination (%)	27%	25%	16%	21%	16%
	Average of positives	36	24	54	64	46
	Median of positives	24	18	28	20	40
	Maximum	659	275	665	547	128
FUM	Contamination (%)	14%	28%	70%	97%	98%
	Average of positives	915	468	2 400	6 953	2 004
	Median of positives	536	290	1 060	2 443	1 152
	Maximum	4 672	6 009	142 773	43 136	37 949
OTA	Contamination (%)	4%	8%	9%	24%	11%
	Average of positives	15	13	14	5	8
	Median of positives	5	2	3	3	2
	Maximum	63	162	386	18	44

Afla occurs most frequently in soybean, but at moderate levels. Wheat/-bran shows high abundance of DON. Corn is frequently contaminated with *Fusarium* toxins (ZEN, DON, FUM), but shows also an extreme Afla maximum. Corn gluten meal and corn DDGS are risky ingredients due to high contamination. Poster will also provide details on rice bran, cottonseed - and sunflower cake, rapeseed meal as well as cassava.

Conclusion

Prevalence and concentrations of the six well known mycotoxins underline the importance of a proper mycotoxin risk management including regular testing of ingredients as well as testing of aqua finished feed and inclusion of a mycotoxin deactivator.

COPING MECHANISMS OF ADULT NILE TILAPIA *Oreochromis niloticus* EXPOSED TO HIGH ENVIRONMENTAL AMMONIA

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Fish exhibit different behavioural and physiological coping mechanisms to unionized ammonia (UIA). Some species detoxify ammonia to less toxic glutamine or urea, or they excrete it directly into the aqueous environment via the gills. The strategies adopted by Nile tilapia (*Oreochromis niloticus*) to UIA exposure, however remain vague. To investigate the coping mechanisms of *O. niloticus* to environmental ammonia, adult individuals were exposed to three levels of UIA, 0 (Control), 7 and 61 μM for 24,72 and168 h and assessing histological changes in the gills and alterations in haematological parameters.

Nile tilapia with an average mass of 281.1±34.0g were exposed to 2 different levels of UIA for up to 168h. One group was exposed to 7μM NH_3, and one was exposed to 61μM NH_3, and compared against a control group. Experimental fish were placed in individual PVC tubes in an experimental tank. For the control group, eight fish were used. For exposure to 7 and 61μM NH_3 groups of fish (n=8) were exposed for 24, 72 or 168h respectively. At the end of the exposure period, fish were euthanized and blood, gill, liver and white skeletal muscle was sampled from each fish.

Blood pH showed a significant ($p<0.05$) downregulation for each ammonia level exposure. Red blood cells on the other hand increased from the control fish group after exposing Nile tilapia to 61μM for 168h. Nile tilapia responded to ammonia toxicity by significantly increasing plasma Cl^- levels. Exposure to 61μM UIA resulted to a significant increase in plasma NH_3 and Na^+. Liver and muscle urea decreased significantly from the control fish group with a significant increase in excreted urea only after 24h of exposing fish to 61 μM-UIA. The groups exposed to 7μM showed a tendency towards a reduction in interlamellar cell mass (ILCM) for all exposure durations, although the reduction was not significant. In response to 61μM UIA, ILCM decreased significantly after 24 and 72h (Fig 1). At higher UIA levels, gill remodelling occurs in Nile tilapia in response to ammonia exposure. It is also known from this experiment that Nile tilapia detoxify ammonia to urea but are mostly excreted in the aqueous environment.

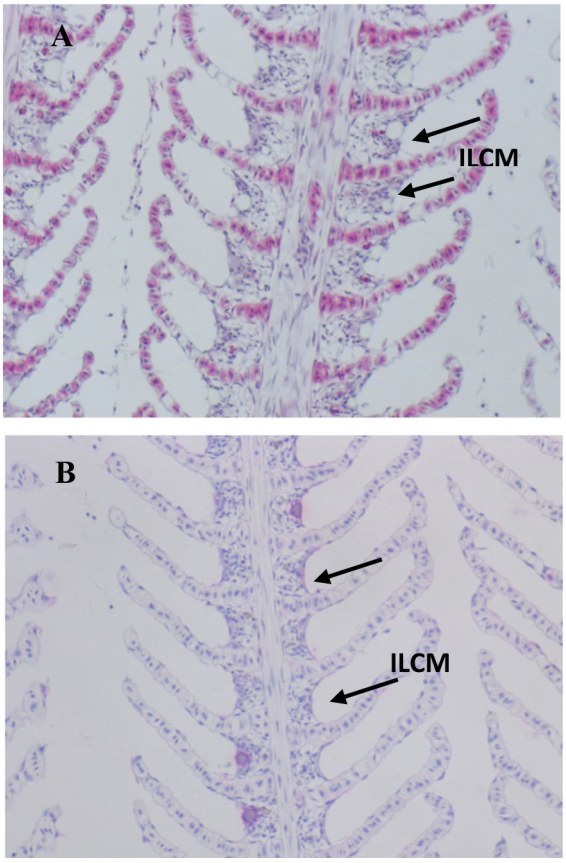

Fig 1. ILCM of (A) control and (B) NH_3 exposed Nile tilapia gills.

PERFORMANCE ASSESSMENT OF THE AQUACULTURE DEVELOPMENT PROJECT IN RELATION TO CEEC-FUNDING IN ZAMBIA: A CASE OF KITWE AND KALULUSHI DISTRICTS

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Zambia has significant potential for the development of a thriving aquaculture industry. In recent years, the Government of the Republic of Zambia has implemented policies and programmes aimed at promoting and developing the aquaculture sector, including the establishment of the Citizen Economic Empowerment Commission (CEEC) to provide financial and technical support. However, there were still concerns regarding the performance of aquaculture projects, particularly, in relation to the CEEC funding. Therefore, an assessment of the performance of aquaculture projects concerning CEEC funding was essential to better understand the effectiveness of these investments, identify areas for improvement, and provide evidence-based recommendations for future funding decisions. The lack of empirical evidence on the actual performance of CEEC-funded aquaculture projects, such as unmet projections and loan repayment challenges, necessitated the assessment of CEEC investments towards aquaculture.

Thus, the main objective was to assess the performance of the aquaculture development projects in relation to CEEC funding; in terms of actual production levels compared to their initial projections and plans, loan repayment rates, effectiveness of monitoring and evaluation (M and E) activities, and finally, identify areas for improvement in CEEC funding and project management. The study areas were Kitwe and Kalulushi districts. The research employed a mixed-methods approach, combining both quantitative and qualitative data collection and analysis methods. This included the use of surveys and interviews during data collection. The data was analysed using the Statistical Package for Social Sciences (SPSS).

The results showed that the performance of CEEC-funded aquaculture projects, in terms of actual fish production, had been relatively below average to their initial projections and plans. This shortfall can be attributed to several factors such as insufficient funds, late disbursement, and lack of skills. This study also revealed that loan repayment posed a substantial challenge, negatively impacting the profitability and sustainability of these aquaculture projects due to factors like high costs of inputs. Furthermore, this study pointed out that the effectiveness of the M and E activities carried out by the Department of Fisheries, in collaboration with CEEC officials and other relevant government agencies, was uncertain. This uncertainty suggested some aspects of inconsistencies in the M and E activities. Finally, this study recommended timely disbursement of funds, better project management skills, and autonomy in the use of funds as a means of improving performance.

THE GLOBAL SUSTAINABLE AQUACULTURE ADVANCEMENT PARTNERSHIP (GSAAP)

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The Global Sustainable Aquaculture Advancement Partnership (GSAAP) is a voluntary partnership mechanism of aquaculture stakeholders predominantly from academia. It was established by the Food and Agriculture Organization of the United Nations (FAO) and the Chinese Academy of Fishery Sciences (CAFS) to enhance the scientific basis of aquaculture, promote continuous innovation, and fully harness the potential of aquaculture for achieving the Sustainable Development Goals. The partnership functions as a collaborative platform to discuss key issues and challenges. It also facilitates transfer and implementation of aquaculture innovations and advancements in aquaculture science and technology.

Although GSAAP was founded only in 2022, FAO and its partners have already initiated substantive work where the areas of expertise of various partners intersect with the recognized needs of stakeholders striving to develop sustainable aquaculture. These needs, collected from various intergovernmental fora such as the COFI Sub-Committee on Aquaculture, multistakeholder events such as the Global Conference on Aquaculture Millennium +20 and through the academic work of partners through their own programmes, are expected to address constraints and blocking issues to aquaculture's development.

Currently, following the initial discussion and work plan, GSAAP has carried out some pilot projects such as policy dialogues on seaweed farming which have been convened with the participation of 44 countries from Africa, Asia and Latin America, bringing together major stakeholders in seaweed aquaculture to support international cooperation and capacity-building initiatives to address policy gaps and develop or strengthen national strategies. Pilot activities will be followed by in-country training and capacity development, and dissemination of results through the GSAAP network and the African Union Centres of Excellence in Fisheries and Aquaculture. In 2023, University of Ibadan has investigated the feasibility of black soldier fly larvae as an alternative feed for catfish in Nigeria. The University of South Bohemia (Czechia) has provided a technical backstopping mission to South Africa on aquaponics, and shared with national stakeholders the design and establishment of aquaponic research and pilot systems in Free State.

All interested stakeholders, including policymakers, academic institutions, and private sector are encouraged to join the partnership. For more information on how to join the partnership, please email the GSAAP Secretariat at GSAAP@fao.org.

GUIDELINES FOR SUSTAINABLE AQUACULTURE, BLUE TRANSFORMATION, AND FORTHCOMING IMPLEMENTATION: WHAT IT MEANS FOR AFRICA

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The Food and Agriculture Organization of the United Nations (FAO) has been requested by its Members to develop practical guidance to government authorities and policymakers in their efforts to promote the implementation of the Code of Conduct for Responsible Fisheries and enable aquaculture to effectively participate in the implementation of the 2030 Agenda for Sustainable Development. The Guidelines for Sustainable Aquaculture (GSA), prepared in a transparent, consultative and participatory process, provides this practical guidance on sustainable aquaculture development, integration of aquaculture into national, regional, and global development strategies and food policies, and ensuring that aquaculture production meets the growing demand for aquatic food and enhances inclusive livelihoods.

The GSA represent a cornerstone of FAO's Blue Transformation which provides a roadmap for the FAO's work on aquatic food systems for the period 2022-2030. GSA will contribute to guiding the achievement of objectives on sustainable aquaculture intensification and expansion worldwide, in supporting the global food system transformation, aiming to secure and maximize the contribution of aquatic food systems to food security, nutrition, and affordable healthy diets for all.

Aquaculture in Africa has great potential. According to FAO's State of the World Fisheries and Aquaculture Report, Nigeria produced nearly 12 percent of all cultured aquatic animals in Africa, and the rest of sub-Saharan Africa enjoyed double-digit growth of 14.5 percent reaching 396,700 tonnes in 2020 from 346,400 tonnes in 2019. Investing in African aquaculture is an imperative to achieve food security and nutrition in a continent that is disproportionally impacted by global challenges such as climate change and malnutrition.

The implementation of GSA provides a compass for sustainable aquaculture development, including the governance and planning, sustainable resource use, ecosystem and farm management, social responsibility, decent work and gender equality, value chain, market access and trade. All FAO Members are encouraged to review the gaps in aquaculture development, and FAO is ready to support Members in policy review, capacity building, innovations, and monitoring.

PRELIMINARY STUDY OF POTENTIALLY PATHOGENIC AND ZOONOTIC BACTERIA FROM WILD AND FARMED *Oreochromis Jipe* AND SOURCE WATER IN TAITA-TAVETA COUNTY, KENYA

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Bacterial infections can cause latent, low to high mortalities in farmed and wild fish populations, affecting aquaculture productivity and some of the bacteria can be zoonotic. This study isolated, characterized and determined potential pathogenic and zoonotic aerobic bacteria in farmed and wild *Oreochromis jipe, Oreochromis niloticus,* their hybrids and culture water source from Taita Taveta County. A total of 111 apparently healthy fish consisting of 67 *Orechromis jipe*, 34 *Orechromis niloticus* and 10 hybrids; and nine water samples (i.e. seven fish farms and two from Lake Jipe) were processed. Fish samples from each fish consisting of fish skin and kidney swabs; gills and intestinal tissues were aseptically collected. Conventional culture and biochemical tests were done to identify isolated bacteria. A total of 569 bacterial isolates of 17 genera*; Pseudomonas, Aeromonas, Bacillus, Staphylococcus, Streptococcus, Micrococcus, Flavobacterium, Proteus, Vibrio, Klebsiella, Escherichia Coli, Serratia, Enterobacterium, Citrobacter, Photobacterium, Edewardsiella and Listeria* (543 from the fish organs and 26 from water) were recovered. From these, skins had 33.4%; gills, 32.2%; intestines, 19.7%; kidney, 10.2%; and water 4.6% of the total bacterial genera isolated. Potential fish pathogens identified were *Aeromonas, Pseudomonas, Flavobacterium, Enterococcus, Micrococcus, Vibrio and Citrobacter* species. Possible zoonotic bacteria isolated found in this study were *Aeromonas* (19.3%), *Streptococcus* (6.67%), *Flavobacterium* (6.7%), *Vibrio* (4.3%), *E. coli* (3.7%), listeria and *Serratia* (1.7 %) species. Bacteria recovered from fish that were not found in the water were *Serratia, Proteus*, *Klebsiella*, *Listeria*, *Flavobacterium*, *E. coli,* and *Edwardsiella* species. In the sub-counties, the dominant/predominant bacteria were as follows; Mwatate had *Staphylococcus* (50%) and Bacillus (90%) species were most prevalent in *O. jipe* and *O. niloticus* respectively, while hybrid fish had *Bacillus* (60%) species. Voi sub-county had *Aeromonas* at (40%), Wundanyi had *Staphylococcus* (55%) and Taveta had both *Pseudomonas* (45%) and *Aeromonas* (100%) for *O.jipe and O. niloticus* respectively. This study shows that farmed and wild fish and source water sources harbor potentially pathogenic and zoonotic bacteria which may cause fish diseases and pose public health risks.

CHALLENGES AND OPPORTUNITIES FOR TILAPIA WELFARE IN EGYPT

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Egypt is the world's third largest tilapia producer providing affordable animal source protein for millions of low-income Egyptians. Aquaculture production in Egypt is mainly based in irrigated earthen ponds located to the North of the Nile delta. Over the last few years, aquaculture industry in Egypt was moving towards intensifications. However, farm management practices were the same and fish farmers still using conventional production methods. This was associated with high mortality rate of unknown reasons particularly in summer known as "summer mortality". The aim of this study was to understand handling and management of farmed tilapia from hatchery to the consumer. For which four participatory workshops with key stakeholders were conducted in three major tilapia production governorates. The total number of participants was 155 including farm owners, workers, aquatic feed factory owners, and local aquaculture researchers. For each workshop, the concept of participatory workshops and system thinking was explained. Then participants were seated around tables of 5 to 10 each. For each table, one of the research team was facilitator and another one was notetaker. The results indicated that, there is a lack of the concept of tilapia welfare and there is a need for raising awareness of tilapia farmers and workers towards the best management practices to improve health, productivity, and quality of farmed tilapia. To our knowledge, this is the first study for the assessment knowledge, attitude, and practices of tilapia farming stakeholders towards tilapia welfare.

THE GLOBAL ENVIRONMENT FACILITY AND IT'S APPROACH TO AQUACULTURE INVESTMENTS IN AFRICA AND BEYOND

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The Global Environment Facility (GEF) supports developing countries to address the world's most pressing environmental issues. GEF organizes its work around five focal areas – biodiversity loss, chemicals and waste, climate change, international waters, and land degradation – and takes an integrated approach to support e.g., more sustainable food systems, forest management, and cities. In recent years GEF has increased engagement on sustainable aquaculture with an expanding initial portfolio of projects.

GEFs investments are framed within overall trends which have seen capture fisheries tonnage largely stable since the 1990s at approx. 90 million tonnes, meaning aquaculture accounts for all growth and has grown faster than any other animal protein sector at an average growth rate of 6.7 percent per year over the past three decades. While the aquaculture sector occupies a critical space in the global food security equation - producing nutritional animal protein with a low environmental footprint comparable to terrestrial animal protein - the sector has long been criticized for causing environmental degradation.

In addition, each region comes with a distinct set of challenges. As an example, Asia produces more from aquaculture than from capture fisheries, and when the top producer is excluded in each region, Asia still has a high aquaculture share close to fifty percent. In contrast, if Egypt is excluded, Africa's contribution to world aquaculture production was below ten percent in 2020, the lowest among regional and subregional groups.

In this session the evolution of GEFs aquaculture investments will be presented. This includes investments across continents focused on sustainable practices, feeds, and livelihoods. It also includes anticipated African investments under the GEF Food Systems Impact Program. Considering regional and sub-regional differences, the program's inbuilt mechanisms to both crowd in and channel global actors and resources to support country projects, and to collate and communicate the models and knowledge generated into policy fora and the agendas of public and private actors, will benefit countries.

VACCINE DEVELOPMENT AGAINST COLUMNARIS-CAUSING BACTERIA FOR CATFISH AND TILAPIA

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Columnaris-causing bacteria (CCB; formally *Flavobacterium columnare*), are gram-negative, yellow-pigmented bacteria that are responsible for columnaris disease. As of 2022, CCB represent four distinct species: *F. columnare, F. covae, F. davisii*, and *F. oreochromis*, each having an association between species and virulence in different fish hosts. In the southeastern United States, columnaris disease causes significant losses in catfish aquaculture, and control methods rely heavily on antibiotics. The development and availability of an efficacious vaccine for the prevention and control of columnaris disease has been hampered, partially, due to a lack of understanding of the broad genetic diversity of CCB. Vaccine development has been re-initiated with the newfound knowledge of the genetic diversity of CCB. Multiple strains of *F. covae*, *F. davisii*, and *F. oreochromis* that are virulent in channel catfish (*Ictalurus punctatus*) or Nile tilapia (*Oreochromis niloticus*) are currently being evaluated as candidates for a live-attenuated CCB vaccine. Mutant strains will be characterized and investigated for protective immune responses in channel catfish and Nile tilapia. Safety testing and delivery optimization (immersion or oral administration routes) will be performed on the most promising candidate. To date, six strains of virulent CCB have been attenuated. Mutant isolates of *F. oreochromis* and *F. davisii* showed a total loss of virulence in Nile tilapia (0% cumulative percent mortality; CPM), while wild-type isolates had >60% and >80% CPM, respectively. In two separate trials, an *F. covae* mutant showed significantly less CPM (10% and 30%) compared to the highest dose of the parent wild-type strain, which was 100% CPM in both trials. Results of ongoing vaccination trials with other mutant *F. covae* isolates will be discussed. The long-term goal of this project is to produce a viable vaccine to protect catfish and other essential aquaculture species in the southern region of the U.S. against columnaris disease.

EXAMINING THE EFFECTS OF POULTRY MEAL AND PROTEASE SUPPLEMENTATION AS A MITIGATOR OF SOYBEAN MEAL IN RAINBOW TROUT DIETS

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Aquaculture is now one of the fastest-growing food-producing industries, and it is seen as a sustainable way of addressing our future food security and climate impact. The development of circular-based (restorative and regenerative/waste residues from other industries) derived aquafeed ingredients for farmed aquatic animals is at the heart of pursuing this long-term sustainable aquaculture-based food production model. Agricultural waste, such as processed animal proteins (PAPs) from the rendering industry has been overlooked as a critical contributor in attaining a circular seafood production model.

A feeding trial was conducted on rainbow trout (*Oncorhynchus mykiss*) in a 15 recirculating aquaculture system. Five diets were formulated, 1 Control and 4 experimental. The soybean meal fraction of the experimental diets was replaced with two levels of poultry by-product meal (12.5% & 25%). On top of this, these diets were duplicated and then spray coated with a protease enzyme (12.5%+P & 25%+P). Fish were fed for the test diets for a total of 14 weeks and weight gain was measured fortnightly. At the end of the trial full growth morphometrics was conducted as well as whole body proximate composition.

Results showed that diet 12.5%+P performed best across weight gain, FCR and SGR. With respect to proximate composition, diet 12.5%+P also yielded a higher lipid content than other diets. The authors believe that the replacement of soybean meal with poultry meal up to and beyond 12.5% of the total diet could increase on farm production rates. It is also clear that the supplementation of the diet with protease increases digestibility of the feed and creates a more efficient product for farmers.

Table 1. Growth performance, feed conversion ratio and somatic indices of rainbow trout fed test diets.

	Diets					
	CTRL	**12.5%**	**12.5%+Pr**	**25%**	**25%+Pr**	***P*-value**
Initial mean weight; g fish^{-1}	39.88±0.24	40.04±0.51	40.11±0.34	40.59±0.42	40.45±0.39	*0.233*
Final weight; g fish^{-1}	103.54±16.23	111.54±17.91	113.64±17.45	100.81±20.42	105.04±18.45	*0.000**
Mean weight gain; g fish^{-1}	63.71±6.26	70.76±3.33	73.53±1.95	60.40±5.51	65.69±8.70	*0.097*
FCR	1.28±0.08	1.20±0.06	1.17±0.03	1.36±0.11	1.29±0.12	*0.131*
SGR; % day^{-1}	1.13±0.07	1.20±0.04	1.24±0.03	1.08±0.06	1.14±0.08	*0.067*
HSI; % body weight	1.26±0.32	1.03±0.07	1.06±0.10	1.14±0.06	1.14±0.24	*0.131*
VSI; % body weight	12.60±2.88	12.31±1.81	11.09±1.24	14.37±1.70	13.14±1.74	*0.017**

FCR- Feed Conversion Ratio; SGR- Specific Growth Rate; HSI- Hepato Somatic Index; VSI- Viscera Somatic Index; ±-Standard Deviation.
*P<0.05.

EVALUATION OF GROWTH AND NUTRIENT INDICES OF *Clarias gariepinus* FINGERLINGS FED VARYING REPLACEMENT LEVELS OF TREATED *Moringa oleifera* SEED MEAL

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Introduction: Exploration of alternative plant protein sources for their prospect as potential replacements for fish meal has been intensified in recent times and *Moringa oleifera* (Lam) has been identified as one of such prospective candidates (Nsofor *et al*., 2012). However, removal of unwanted anti-nutritional compounds from plant protein sources is necessary to enhance their nutritional value and effective utilization of their full potential in fish feed production.

Methodology: The experiment was carried out at the Fisheries and Aquaculture Department, Usmanu Danfodiyo University, Sokoto, located on latitude 13^0 07' 47.6''N, longitude 05^0 12'11.3''E and altitude 275m above sea level (Google MAP, 2015). Five experimental diets were formulated, and fishmeal was replaced with the processed (B90min/S72hrs). *Moringa oleifera* seed meal at 0, 20, 40, 60 and 80% inclusion levels and fed to the fingerlings for twelve weeks. Fish growth, feed conversion and nutrient utilization indices were determined.

Results: Highest weight gain (12.77±1.14g) was recorded in the fish with diet T1 which is the control diet but, the difference was not significant from dietary treatment T2 with 20% MSM replacement level. Lowest FCR was recorded with fish fed diet T2 and there was no statistically significant difference in the PERs of all the treatments.

Discussion and Conclusion: Diet with 20% substitution level that contributed 8.33% by gross composition enhanced good growth, and the fingerlings were still healthy at 80% substitution level. The findings of the feeding experiment revealed a similar ($p>0.05$) survival rate across the treatments. However, the growth response decreased with increased inclusion level of the test ingredient MSM in the diets.

Table 1: Growth indices of *C. gariepinus* fingerlings fed diets with varied replacements of *M. oleifera* seed meal

	Treatments				
	T1 (0%)	T2 (20%)	T3 (40%)	T4 (60%)	T5 (80%)
Parameters					
No of fish stocked	20	20	20	20	20
Mean initial weight (g)	1.50±0.00	1.50±0.00	1.50±0.00	1.50±0.00	1.50±0.00
Mean initial length (cm)	6.17±0.06^a	6.17±0.06^a	6.13±0.06^a	6.17±0.06^a	6.17±0.06^a
Survival rate (%)	78.33±2.89^a	78.33±2.89^a	73.33±5.77^a	70.00±13.23^a	75.00±0.00^a
Mortality rate (%)	21.67±2.89^a	21.67±2.89^a	26.67±5.77^a	30.00±13.23^a	25.00±0.00^a
Mean final weight (g)	14.29±1.12^a	12.35±0.43^{ab}	11.08±0.13^b	8.48±2.27^c	8.21±0.36^c
Weight gain (g)	12.77±1.14^a	10.87±0.40^{ab}	9.57±0.12^b	6.97±2.25^c	6.70±0.35^c
Percentage weight gain (%)	849.13±72.06^a	720.39±27.85^{ab}	636.71±10.24^b	463.72±151.55^c	446.03±24.56^c
Specific growth rate (%/day)	2.26±0.08^a	2.12±0.03^{ab}	2.01±0.01^b	1.74±0.26^c	1.73±0.04^c
Mean final length (cm)	10.17±0.45^a	10.13±0.55^a	10.07±0.42^a	9.20±0.56^b	9.20±0.17^b
Condition factor (K)	1.36±0.11^a	1.20±0.15^{ab}	1.09±1.14^{ab}	1.14±0.49^{ab}	1.05±0.01^b

Mean values in row having different superscripts are significantly different ($p<0.05$)

NUTRITIONAL EVALUATION OF DIFFERENTLY PROCESSED *Moringa oleifera* SEED BEFORE AND AFTER OIL EXTRACTION FOR INCLUSION IN *Clarias gariepinus* BASED DIETS

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Introduction: The high cost, inconsistent availability, and varying quality of fishmeal has prompted research efforts towards the evaluation and utilization of non-conventional sources of plant protein sources such as *M. oleifera* seed. However, plant protein sources were reported to have some limiting factors such as crude fiber and anti-nutritional factors (Alegbeleye, 2005), and these are known to interfere with nutrients use, fish health, and other harmful effects (Akande and Fabiyi, 2010). Different processing methods result in the decrease of anti-nutritional factors ensuring improved growth performance in fish (Francis *et al.,* 2006).

Methodology: Four processing methods involving toasting at 10, 20 and 30mins, boiling at 30, 60 and 90mins, soaking at 8, 16 and 24 hours and combination of boiling (30, 60 and 90 minutes) and soaking for 72 hours were employed before and after oil extraction before and after oil extraction.. Four processing methods involving toasting at 10, 20 and 30mins, boiling at 30, 60 and 90mins, soaking at 8, 16 and 24 hours and combination of boiling (30, 60 and 90 minutes) and soaking for 72 hours were employed.

Results: The results for raw and processed seed meal before oil extraction showed that the three toasting treatments significantly increased the crude protein content while revealing a significant ($p<0.05$) increase in the crude protein (55.05±0.17) and ash (6.01±0.10) contents of the processed seed meal and significantly ($p<0.05$) lower fat (9.39±0.11), moisture (1.50±0.07) and crude fibre (3.93±0.05) contents after oil extraction. The anti-nutritional factors detected in the raw moringa seeds were (Oxalate, saponins, alkaloids, phytic acid, tannin, cyanide and phytate) with the following contents; 0.86±0.13, 1.50±0.06, 2.32±0.06, 269.84±1.62, 1.21±0.14, 0.56±0.04 and 69.82±0.86, respectively.

Discussion and Conclusion: Combination of boiling and soaking treatments (B30mins/S72hrs, B60mins/S72 hrs, B90mins/S72hrs) significantly ($p<0.05$) reduced the anti-nutritional factors to acceptable levels. However, displacement of oil after extraction greatly enhanced the crude protein level of the treated (B90mins/S72hrs) seed. It could be concluded that this processing method coupled with oil extraction could effectively improve on the crude protein content of the seed.

Table 1: Proximate composition of raw and processed (B90mins/S72hrs) *Moringa oleifera* seed after oil extraction

Composition	Treatments	
	Raw	Processed
Crude protein	37.63±0.17[b]	55.05±0.16[a]
Fat	18.78±0.11[a]	9.39±0.11[b]
Ash	4.22±0.10[b]	6.01±0.10[a]
Crude fibre	4.05±0.05[a]	3.93±0.07[b]
Moisture	2.65±0.67[a]	1.50±0.06[b]
NFE	32.68±0.25[a]	24.13±0.25[b]

Mean with same letter in row are not significantly different ($p>0.05$).

FROM FARMER TO ENTREPRENEUR: FUTURE-PROOFING YOUR BUSINESS!

Katherine Hawes

Principal Solicitor, Aquarius Lawyers
AISP President
Co-Founder of Aquaculture without Frontiers Australia

Aquaculture has become a focus for venture capitalists, other types of investors and businesses who service the aquaculture farms. These organisations are diving into the opportunity to collaborate with aquaculture farmers.
In aquaculture, both farmers and business alike have built their businesses on passion, hard work and a belief that our industry is both viable and valuable.

In this session we will explore how to manage your business to ensure that you are compliant with both the regulatory and governance framework required in today's marketplace. Doing this will ensure your business numbers grow so that you can explore further opportunities!

We will discuss the aquatech revolution and the use of technologies, such as, robotics, artificial technology and blockchain. However, the potential for disruption in aquaculture businesses that causes legal issues from intellectual property challenges through to contractual disputes, which put your business at risk. Learn how to protect your capital.

From her role as the President of the Association of International Seafood Professionals and co-founder of Aquaculture without Frontiers (Australia), Katherine is best placed to outline the legal frameworks that can optimise your commercial aquaculture business.

What will audience learn from your presentation?
Aquaculture businesses will understand:

- How to protect your assets
- Legal issues associated with adopting new technologies
- The types of business disruption that can occur in your supply chains
- What you need to do to legally protect your assets from disruption
- Importing and exporting
- What contracts you need
- If disruption occurs, and cannot be easily mediated, what you need to do to progress to a legal remedy.
- Investment agreements/funding opportunities.

Biography of presenting author
Katherine Hawes, referred to as the 'fish lawyer', completed a Bachelor of Communications prior to reading law. Katherine developed her Commercial Law experience in a large Sydney Law firm and then at government funded legal aid. During this time, she studied and registered as a Barrister then continued studying to gain a Post Graduate Diploma in Business Management, a Masters of Adult Education and a Master of Marine Law.

Establishing Aquarius Lawyers in 2013 she had over 20 years business law experience. Her passions are the 'blue economy' and digital technologies that enhance sustainable aquaculture manufacturing. She is an in-demand speaker and publisher around 'what is on your plate'!

WORLD BANK INVESTMENT GUIDELINES

Tom Hecht*, James McCafferty, Fred Formanek, Rachel Mullins, Brett Pringle, Christopher Brett, Harrison Charo Karisa, Ruth Garcia Gomez

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Recognising that global aquaculture production is projected to continue on its upward trajectory, the World Bank Group has established a Global Aquabusiness Investment Advisory Platform (AquaInvest Platform) that aims to "distil and improve best practices in aquabusiness development for economic, social and environmental sustainability". The Platform has been structured as a Global Advisory Services and Analytics (ASA) task, which is funded by PROBLUE and is a joint undertaking amongst World Bank teams, clients and partners. One of the key components of the AquaInvest Platform is the preparation of a set of Guidelines to promote aquaculture growth through sustainable investment in aquaculture, and aquaculture business development.

To this end, the World Bank, in collaboration with Advance Africa Management Services, is in the process of formulating the "Guidelines for Sustainable Aquabusiness Development". The Guidelines will be a publicly accessible "living document" that will present, in a user-friendly way, the necessary requirements, analytics and enabling factors for investments in aquaculture that are environmentally responsible, socially acceptable, and economically viable, in line with the FAO Ecosystem Approach to Aquaculture. The Guidelines will be global in their geographic scope, and will be adaptable across all major aquaculture species groups, production systems, production scales, and value chain activities. The Guidelines will not duplicate existing frameworks for sustainable and responsible aquaculture, but will build on these in a practical way, with a specific focus on investment and business development.

In this session, Advance Africa will present on the progress in developing the Guidelines to date, and introduce key discussion points to allow participants to provide their inputs to further inform the Guidelines.

THE GLOBAL GUIDELINES FOR SUSTAINABLE AQUACULTURE INVESTMENT AND AQUABUSINESS DEVELOPMENT

Tom Hecht*, James McCafferty, Fred Formanek, Rachel Mullins, Brett Pringle, Christopher Brett, Harrison Charo Karisa, Ruth Garcia Gomez

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In this presentation, I outline progress made in the formulation of the guidelines and highlight key learnings, challenges and success factors for sustainable aquabusiness development.

AQUACULTURE AND FISHERIES INTERFACE: MARINE INGREDIENTS FOR FEED FOR AQUACULTURE

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Introduction

World aquaculture production of animal species grew by 2.7 percent in 2020 compared with 2019, an all-time low rate of annual growth in over 40 years. However, the net increase of 2.3 million tonnes in the same period was comparable to some years in the last decade. Finfish farming remained steady with minimal fluctuation around 66 percent and accounting for the largest share of world aquaculture for decades.

At the regional level, African aquaculture (excluding algae) suffered from a slight contraction in its annual output (down 1.2 percent in 2020 compared with 2019), mainly the result of the drop in production in Egypt, Africa's major producer. In Nigeria, the largest producer in sub-Saharan Africa, the declining trend since 2016 worsened in 2020 with a sharp decrease of 9.6 percent. Aquaculture in the rest of Africa enjoyed a double-digit growth of 14.5 percent reaching 396 700 tonnes in 2020 from 346 400 tonnes in 2019.

We recognize a very close relationship and synergy with fisheries because it is a fact: The aquaculture industry will not exist without feed and marine ingredients mainly. Marine ingredients include essential proteins, fats, vitamins, and minerals that are important for farmed fish and are also passed on to humans when they eat farmed seafood. Growing global production from aquaculture, as envisioned by the United Nations' Food and Agriculture Organization in its recent "State of World Fisheries and Aquaculture 2020" report, will require additional feed and a greater demand for marine ingredients use of marine ingredients in aquafeed will not decline soon. Alternative ingredients with similar nutritional value profiles, and from marine origin should be a solution, and if it is possible to produce it in a sustainable manner

Methods and Materials

A key part of our methodology is to compile and review current aquaculture certification programs and schemes certifying marine ingredients and feed for aquaculture. How they are addressing the marine ingredients for feed in the supply value chain and the interdependency among aquaculture and fisheries certification programs. A full reference list will be shared during the presentation of this paper.

A case study of different alternative marine ingredients has been reviewed and evaluated. Therefore we have tried to examine these sequentially and have attempted to produce an assessment list for consideration at the moment of assessing a new feed marine ingredient and/or alternative – decision-making. Whilst we have provided an overview of the marine ingredients for feed in aquaculture and alternative sources, we have not examined this in detail as several global feed producers may have done in the private sector.

Results and Conclusions

A stairs process approach will be shared as well as reflections on the African feed marine ingredients; reflections on the important requirements are part of the conclusions.

Beyond certifications, the feed producers should start to develop an assurance model that includes KDEs for a continuous evaluation of the feed ingredient composition, origin, nutritional value, food safety, quality, sustainability, and labor conditions of workers in the supply chain.

TRUEFISH – ADVANCING AQUACULTURE BUSINESS IN EAST AFRICA

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The Lake Victoria Fisheries Organisation (LVFO) of the East African Community (EAC) is implementing the European Union-funded TRUEFISH Project towards advancing aquaculture in the Lake Victoria Basin. The project has three main components that deal with aquaculture business, skills and sustainability respectively. Landell Mills have been appointed to lead the aquaculture business development component, which is known as Component 1. Within this component there are three main focal areas, consisting of:

1. Establishing and hosting an East African Aquaculture Exhibition and Conference (EAAEC).
2. Facilitating an increased flow of investment into the sector.
3. Supporting regional aquaculture associations (B2B linkage and study tour programmes).

This paper consider the achievements to date in these areas. The East African Aquaculture Exhibition and Conference was hosted successfully in Kenya in March 2023, while it will move the Tanzania in 2024 and Uganda in 2025. Excitingly, TRUEFISH has been successful in securing the bid to host a World Aquaculture Conference in Uganda in June 2025.

To facilitate the flow of investment, TRUEFISH has developed a regional business plan, regional directory for aquaculture, supported the establishment of a the East African Regional Aquaculture Association, and developed a map of investors that can be engaged further.

B2B linkages are being established on an ongoing basis, while dedicated B2B training and contact sessions are being planned for Kenya, Tanzania and Uganda. Associations have also been supported by study tours to Egypt and are currently participating in a study tour to China, that will be followed by a study tour to Nigeria / Ghana in 2024.

The results of these interventions are starting to show. This paper considers the tasks that remain in Competent 1 of TRUEFISH, up to its termination in the middle of 2025. It considers the impact of high-level interventions and whether this has sector-wide benefits for aquaculture.

REGIONAL AQUACULTURE FRAMEWORKS IN THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

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The fisheries and aquaculture sector in the Southern African Development Community (SADC) region employs a total of about 3.5 million people, and accounts for an estimated 3.5% of the region's Gross Domestic Product (GDP). More than 95% of this production comes from a diversified capture fisheries sub-sector with about 3.7 million tonnes. The per capita fish consumption of 12 kg/annum in the region is well below global average of 20 kg/annum and below the WHO recommended value of 15kg/annum. The aquaculture sub-sector contributes about 207,831 tons (96,778 tons of food fish and 111,053 tons of aquatic plants), albeit still low, there are positive signs of growth of about 8.5% annually.

Many SADC Member States are endowed with abundant natural resources, including land and water, which are conducive to inland and marine aquaculture development. Nevertheless, it is generally recognised that the full potential of aquaculture in the region is still to be realised. Article 13 of the SADC Protocol on Fisheries (2001) stresses the need for Member States to develop enabling policy, legislation and/or regulatory frameworks, undertake research and extension activities, promote private sector participation, and undertake environmentally-responsible and sustainable aquaculture. This Article finds full expression in the SADC Regional Aquaculture Strategy and Action Plan (2016 – 2026) and the SADC Aquatic Animal Health Strategy (2016-2026). The extent to which Member States have implemented these provisions varies, with Zambia leading the way and providing important lessons for other Member States wishing to promote the growth of their aquaculture sectors in line with the Protocol.

To further catalyse its development, aquaculture was included in the SADC Industrialisation Strategy and Roadmap to 2063 as one of the priority regional value chains. To guide Member States, a framework titled the Aquaculture Value Chains in the SADC Region: Profiles, Prospects and a Roadmap for Development (2022) was developed, and currently being implemented at national and regional levels through various programmes and projects.

This presentation provides the status of aquaculture in the SADC region, and outlines how regional aquaculture frameworks are guiding SADC Member countries to increase the contribution by aquaculture to local, national and regional economic growth and trade.

DRIED BOMBAY DUCK *Harpodon nehereus* FROM NORTH-EASTERN BANGLADESH: BACTERIOLOGICAL QUALITY AND SAFETY ASSESSMENT

Md. Motaher Hossain,* Sharif Farliha Mahiyat, Md. Jakiul Islam and Mohammad Abu Jafor Bapary

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This research aimed to assess the microbial and sensory quality of dried Bombay duck (loitta) from various upazila markets in Sylhet district, ensuring its quality assurance. Carried out over six months from September 2022 to February 2023, the study collected 48 samples from two markets in each of the eight upazilas. Measurements included Aerobic Plate Count (APC), Total Coliform Count (TCC), presence of *Escherichia coli* & *Salmonella spp*., and sensory evaluation. Results indicated varying bacterial loads among upazilas, with Gowainghat showing the highest (log 5.69 ± 0.2) and Sylhet Sadar the lowest (log 3.453 ± 0.2) load. TCC ranged from 21 ± 1 to 80 ± 3 MPN/g, remaining within permissible limits. *Escherichia coli* prevalence was highest in Gowainghat (67%) and lowest in Sylhet Sadar and South Surma (17%). Similarly, *Salmonella spp*. prevalence was highest in Companiganj and Fenchuganj (67%) and lowest in Sylhet Sadar (17%). Samples from Gowainghat, Companiganj, and Fenchuganj were moderately good in quality based on origin. Sensory examination favored samples from South Surma. Presence of pathogenic bacteria suggests unsanitary processing conditions. Dried fish quality varied significantly among upazilas, emphasizing the need for improved hygiene and sanitation practices to ensure safe, high-quality dried loitta production.

DELIBERATE OR ACCIDENTAL? HIGH FISH DIVERSITY IN SUBSISTENCE AQUACULTURE PONDS IN LUAPULA PROVINCE, ZAMBIA

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The Luapula Province of northern Zambia falls within the Mweru-Luapula freshwater ecoregion and is characterised by a high diversity of fish species due to the influence of the Zambezian and Congolian fauna. Rainfall in the province can be as high as 1111 mm per annum, and the many wetlands and small streams create ideal agro-ecological conditions for dug-out and furrow-fed fishponds, which are often integrated into vegetable horticulture with basic irrigation. Ponds are small, ranging from 40-600 m^2, and usually shallow (40-120 cm deep).

During preliminary field work of the Fish for Food Security in Zambia Project, a sample of 20 established fish farms were visited in Kawambwa, Mwense and Mansa Districts, from early 2020 to late 2021. Ponds were sampled with a cast net and fish were placed into a bucket for identification and photographed.

A total of 17 species were recorded across the 20 farms, dominated by the family Cichlidae (11 species), followed by catfishes and cyprinids. Of the 17 species, only eight were recorded as having been purposely stocked, while the rest had colonised ponds from the wild. Despite the wide diversity of fish species identified across the sites, three-quarters (76%) of the diversity was infrequently encountered (only 1-2 sites). Only four species were frequently encountered: *Coptodon rendalli* (100%), *Tilapia sparrmanii* (90%), *Oreochromis niloticus* (65%) and *O. mweruensis/macrochir* (45%). This study also presents the first documented record of the poorly known but entirely Zambian-endemic Kawambwa tilapia (*Tilapia baloni*) from aquaculture ponds.

We also present how these results informed farmer trainings on fish identification and polyculture for optimising trophic use of the pond environment and maximising nutritional yields.

ISOLATION AND MOLECULAR DETECTION OF VIRULENCE AND ANTIMICROBIAL RESISTANCE GENES OF PATHOGENIC *Escherichia coli* ISOLATED FROM FARM RAISED CARPS OF FISH FARMS OF KASUR AND MUZAFFARGARH, PUNJAB, PAKISTAN

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Bacterial pathogens pose a significant challenge for fish production. *Escherichia coli* is a Gram-negative bacterium being among the leading contributors of economic loss to fish farmers worldwide. *E. coli* infects a variety of fish species making a concern for public health. In order to gain a better understanding of this issue, a study was conducted to isolate and identify *E. coli* present in *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, *Hypophthalmichthys molitrix*, and *Ctenopharyngodon idella* sampled from fish farms of Kasur and Muzaffargarh. *E. coli* was isolated from liver, intestine, stomach and kidney of fish samples using MacConkey and Eosin Methylene blue (EMB) agar media. DNA was extracted using Genomic DNA Purification Kit and *E. coli* was detected by amplification of virulence genes viz. stx2 and eaeA and antibiotic resistance genes viz. tetA and sul1 in *E. coli* by PCR using species-specific primers. *E. coli* was recovered from 103 (41.2% prevalence) fish samples of five species. Phenotypic and morphological characterization revealed pink, smooth, and circular colonies of E. coli on MacConkey agar while dark purple and circular colonies on EMB agar media. Biochemical tests proved *E. coli* positive in catalase, indole, urease, methyl red and motility tests while negative results in Gram-staining, oxidase, citrate, Voges-Proskauer, H_2S and indole production tests. *E. coli* isolates proved to be resistant against pencillin, sulfamethoxazole and tetracycline while sensitive against ampicillin, and erythromycin, and intermediate resistance against amoxicillin and cefotaxime. Maximum prevalence of stx2 gene of *E. coli* was recorded in intestine and liver of *L. rohita* and *C. mrigala*. Phylogenetic tree analysis of our isolated *E. coli* strains revealed 97% similarity with *E. coli* strains isolated in previously studies. The results concluded that shiga toxic gene was the most significant pathogenic gene of *E. coli*. High stocking density, low water quality parameters and unchecked application of antimicrobial agents causes emergence of pathogenic bacteria in fish farms.

ISOLATION AND MOLECULAR DETECTION OF VIRULENCE AND ANTIMICROBIAL RESISTANCE GENES OF PATHOGENIC *Escherichia Coli* ISOLATED FROM FARM RAISED CARPS OF FISH FARMS OF KASUR AND MUZAFFARGARH

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TRACKING METHODS FOR ANTIBIOTICS USE IN AQUACULTURE; A SALMON PRODUCTION CASE STUDY

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Intensive aquaculture production and adverse environmental conditions can lead to consuming a large amount of antibiotics to prevent and treat these diseases, which brings significant economic and environmental consequences. The Chilean aquaculture industry, the second worldwide salmon producer, has committed to reducing antibiotic use. Based on that effort, we explore in collaboration with the salmon industry the last 6 years of antibiotic consumption performance. Thus, our goal was the application of new indicators that would present and analyze data better and identify the main drives that trigger antibiotic use.

Salmon companies (n=17) provided antibiotics consumption data set from 2017 to 2022. The records include the production at closed cycle, from the three main production regions in Chile; Los Lagos, Aysén, and Magallanes, which is equivalent to more than 90% of national production (>95% of Atlantic salmon and coho salmon and 50% of rainbow trout). The data set analyzed represented 22,200 salmon cages, 1,330 close production cycles, and >5 million tons of harvested fish.

The data was curated to ensure accuracy, coded to safeguard confidentiality and to comply with antitrust regulations, also was validated by comparing different public and private sources of antibiotics consumption information (e.g., SERNAPESCA, global salmon initiative-GSI report, and sustainability reports informed by companies).

Proposed indicators for measuring antibiotic use were ICA (Antibiotic Consumption Index at closed cycle) and Frequency (number of times that farm received treatment at the closed cycle).

The indicators tested demonstrated efficacy at different levels (species, regional, and country levels) and easy implementation.

Antibiotic consumption data analyzed indicates (Fig.1) that the industry is capable of significantly reducing the use of antibiotics, achieving the reduction hinges on further reductions, individual company accountability, and investments in new and innovative solutions.

Reducing the use of antibiotics is a complex challenge that requires industry action and collaboration with government, academia, and nongovernmental organizations. It is crucial to find solutions to this challenge to ensure the viability of industry, livelihoods, and communities while safeguarding environmental health.

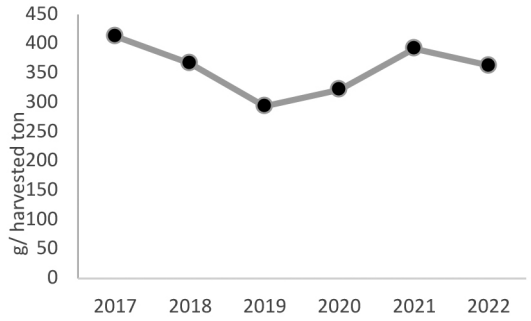

Figure 1. Total antibiotic consumption (grams/ harvested ton) at the industry level from 2017 to 2022. (Source: CSARP)

PINCOY PROJECT: A COLLABORATIVE MODEL TO REDUCE ANTIBIOTIC USE IN SALMON PRODUCTION IN CHILE

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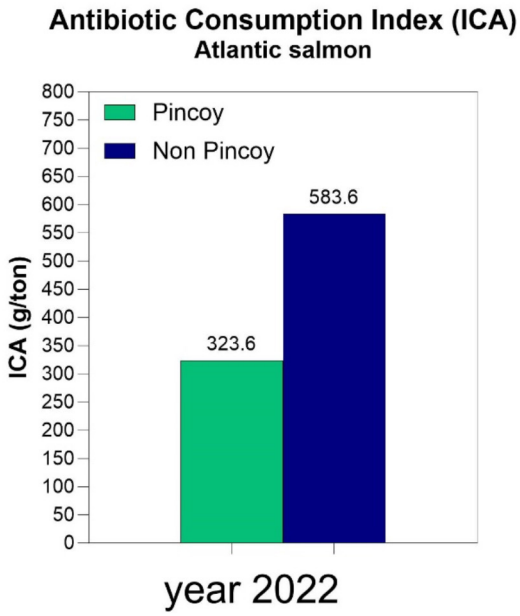
Chile is the second largest producer of famed Atlantic salmon (*Salmo salar*) and largest producer of Pacific salmon and sea farmed rainbow trout in the world. In 2022, Atlantic salmon production in Chile reached 758 thousand metric tons. As most intensive animal food productions, salmon farming is not exempt from the use of antibiotics to treat diseases. Although a decreasing trend in the use of antibiotics has been observed over the years, 389.8 grams of antimicrobial per harvested tonne were used in the Chilean salmon production last year. In addition, one endemic bacterial disease caused by *Piscirickettsia salmonis* is responsible for more than 90% of the use of antimicrobial treatment.

The Pincoy Project is a collaborative initiative towards strategies on a wide range of production practices, from genetic factors and functional and high-performing diets to smolt selection and vaccination with the aim to reduce antibiotic use in the Chilean salmon industry.

To evaluate the effectiveness of practices and strategies by statistical approaches large and quality data are required. The project has been collecting data at cage and farm site level from 2017 to date providing insight of variables that are related to a reduction of the use of antibiotics and mortality during production cycles. Several sanitary, productive, and environmental variables were used. Fish genetic background, vaccine and production strategies, site and environmental conditions are significant factor explaining the use of antibiotic and related mortality. Additionally, the antibiotic use and mortality data from the industry were compared with the results of the Pincoy project.

Appropriate strategies and practices encouraged by Pincoy Project can effectively reduce the use of antibiotics in Atlantic salmon production.



TRANSBOUNDARY FISHERIES MANAGEMENT IN KAVANGO–ZAMBEZI TRANSFRONTIER CONSERVATION AREA (KAZA-TFCA): PROSPECTS AND DILEMMAS

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Inland fisheries in the Kavango–Zambezi Transfrontier Conservation Area (KAZA-TFCA) offer food security to the riverine communities across the region. They also contribute towards the attainment of the United Nations' Sustainable Development Goals 1 and 15, which aim to alleviate poverty and maintain biodiversity conservation. Despite this significant role, the fisheries have suffered severe declines in the previous decades due to multiple factors, such as overfishing and poor legislation. Furthermore, climate change is exerting pressure by altering the ecology and productivity of the river systems. The unprecedented challenges of the COVID-19 pandemic have further constrained management efforts. Attempts to address these challenges have pointed towards transboundary fisheries management as a silver bullet in moving towards sustainable fisheries management. However, the implementation of this strategy in the region has encountered numerous roadblocks, thereby subjecting the river ecosystem to a wider environmental threat, with dire consequences on livelihoods. This paper reviews existing management and governance structures together with key informant interviews to elicit primary and secondary data essential for management at the regional level. The study identifies conflicting regulations, and inadequate policies and institutions across the region as major bottlenecks affecting the successful implementation of transboundary fisheries management. Finally, the paper offers some suggestions for the improvement of fisheries management in the region.

PARTICIPATORY GUARANTEE SYSTEM IN FRESH WATER FISH FARMING

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Participatory Guarantee System (PGS) is a low-cost quality assurance initiative which guarantees the quality of agricultural products and has the potential to regain consumers' trust. PGS has emerged as an alternative quality assurance mechanism to that of high cost third party certification system. The certification primarily focused on the domestic market and short supply chain. This system empowers the local producers to make their produce high valued by maintaining their quality. Concerns over the use of chemical fertilizers and pesticides have prompted interest in more sustainable approaches to agriculture, including natural fish farming within an agroecological framework. These approaches prioritize environmental health, biodiversity, and long-term sustainability while aiming to reduce the negative impacts of conventional practices on both human health and the ecosystem. Emphasizing principles of inclusivity, shared vision, transparency, and trust, the PGS India framework operationalizes through the establishment of local groups as pivotal decision-making entities. Adhering to predetermined eligibility criteria, individual farmers within these groups collectively commit to the PGS pledge and group agreement. The Participatory Guarantee System (PGS) in freshwater aquaculture has been initiated in support with DoF, Assam and ICCSPL and implemented in the natural fish farming practices in the Mayong development block of Morigaon district, Assam with support from German Development co-operation (GIZ) through Federal Ministry for Economic Co-operation and Development, Germany (BMZ).

In this study around 500 small-scale marginal fish farmers were selected based on their fish farming practices with the help of Farmer Co-operative. T of maintaining a balance between their farming activities and the health of the surrounding ecosystem as for example use of EM (Effective microorganism) for maintaining pond health and to reduce feed cost. Participation in the PGS empowered farmers to learn about the strategies and the functioning of the farmers' markets held by peers, recognizing the potential markets, risks involved and adopt mitigation measures accordingly with assurance of brand value through specific certification, labeling and value addition.

FARM PRACTICES, AND BIOSECURITY MEASURES ADOPTED BY FISH FARMERS IN THE EASTERN REGION OF GHANA

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In recent times, the growth of the aquaculture industry in Ghana has been threatened by the outbreak of fish diseases. Fish farms across the country, especially, some farms in the Eastern Region, which leads in fish production, have experienced unusual tilapia mortalities. Efforts to minimize disease impacts include improving farming practices, implementing simple biosecurity measures, attending outbreak investigation and disease diagnosis, vaccinating stock etc. This study was designed to better understand the root causes (or risk factors) that can lead to disease outbreaks by understanding farm management practices among farmers in the Eastern Region of Ghana and identifying the constraints in the adoption of biosecurity measures at the farm level.

A questionnaire-based cross-sectional study using the fish epidemiology and health economics online survey tool (EPI-Tool) was conducted to obtain information from farmers on their farming practices, biosecurity measures and losses due to diseases. A total of 137 farms in the Eastern Region were surveyed. Both parametric and non-parametric statistical techniques, such as the Chi-square tests, univariate and multivariate regression analysis were used in this study. The study found that factors such as district category and treatment of ponds were significantly associated with fish disease ($p<0.05$). Similarly, district category and feed type contributed to unusual fish mortality ($p < 0.05$) (Table. 1). Also, the majority of the farmers, 99 (72.3%) lack knowledge about aquaculture biosecurity in the study region. This was attributed to a lack of expertise, implementation difficulties, and lack of funds (Fig. 1). The study recommended training of fish farmers on biosecurity measures and farm practices. Follow-up studies on fish mortality causes and creating collaborative networks for disseminating best practices and disease control are needed.

Table 1: Summary of Significant Variables associated with Fish Disease and Unusual Mortality

Variables	Clinical signs of diseases	Unusual fish mortalities
	P-Value	P-Value
District	0.04	0.0001
Feed type		0.0001
Treatment of pond	0.0001	

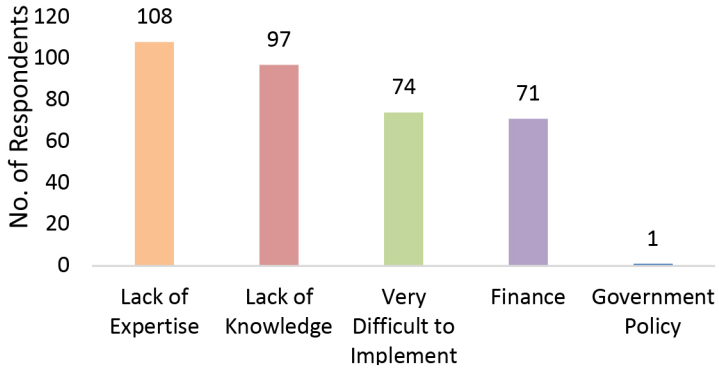

Fig 1: Constraints in adoption of biosecurity measures

SESSION ON AQUACULTURE GENETICS, SELECTIVE BREEDING AND AQUATIC BIODIVERSITY

Aquatic Genetic Resource Management for Sustainable Blue Food Systems

The potential for transforming Africa's emerging Aquaculture sector to constitute competitive sustainable yet blue food systems that contributes to the continent's food and nutrition security, socio-economic development, and climate-change resilience is immense. This opportunity stems from the continent's vast aquatic biodiversity, as well as the high genetic diversity within the culturable aquatic species on the continent. Indeed the majority of Africa's commercial aquaculture species are native to the regions where they are farmed and where they demonstrate strong resilience to the regional the endemic disease, parasites, and climatic challenges in these regions, thus showing great potential for exploiting these species beyond the current production boundaries with little genetic constraint.

The imperative for aquaculture producers is in the utility and attributed value of genetics towards growth, disease resistance, environmental adaptability and access to markets. Just like in the production of most of the indigenous terrestrial farmed animals, one of the challenges towards constraining the exploitation of these species to full production potential lies in the limited application of genetics and selective breeding tools in the aquaculture production of the different species. The application of genetic tools into selective breeding programs of the different cultured species can provide solutions to Africa's aquaculture industry by enabling the production of strains with increased feed efficiency or growth rate, increased disease resistance, and improved climate change resilience. Genetic tools are also of great importance in monitoring the genetic diversity of wild aquaculture populations and monitoring potential hybridizations between farmed and wild populations to prevent the compromising of the wild populations that can lead to biodiversity loss. Maintaining healthy wild populations is key to the food security of the region and also important for the aquaculture industry as these populations provide replenishing genetics to the farmed population to lower the build-up of inbreeding in the farmed populations.

Given that anchorage for the industry is the genetic integrity and health of the region's wild aquatic flora and fauna, the sustainability of Africa's aquaculture industry and its expansion into the Blue Economy cannot do without safeguarding aquatic ecosystem health and biodiversity. It has consequently become increasingly crucial, that the builds its capacity for quantitatively characterizing and assessing the genetic diversity of aquatic species and populations in the farmed and wild environments in consideration of the provisions of the Convention on Biological Diversity's alongside socioeconomic interests to develop aquaculture systems that foster equity and lend to Africa's Blue Transformation.

STRENGTHENING AQUATIC ANIMAL HEALTH, WELFARE AND ECOSYSTEM HEALTH IN AFRICA FOR SUSTAINABLE BLUE FOOD SYSTEM DEVELOPMENT AMIDST ENVIRONMENTAL AND CLIMATE CHANGE CHALLENGES

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As fish farming has expanded across the continent, aquatic animal and seaweed farmers across the continent have increasingly become concerned about the status of aquatic biosecurity, in the holistic sense. The status of aquatic animal welfare, impacts of pollution and erratic weather patterns on water quality especially for those farming in large aquatic ecosystems and access to quality feeds and other aquatic veterinary inputs vis-à-vis growing concerns over antimicrobial use and aquatic antimicrobial resistance are issues several producers are grappling with. The consequent impacts for food-safety affect certification and access to markets for large commercial producers. For example, practical indicators that would enable aquaculture producers assess the fish welfare under local conditions are generally not as accessible as they are for instance in the poultry sector. This makes it difficult to address system constraints early enough before major incidents happen. Seaweed producers on the other hand would wish to assure the sustainability of their enterprises and safety of their products. The re-emergence of transboundary aquatic animal diseases and debates on endemism are beginning to come forth. Maintaining the integrity aquatic ecosystems is evidently fundamental for aquatic life and aquaculture industries to thrive.

AFRAQ23 provides a continental forum for the sectors multiple stakeholders to share the wealth of experience from practitioners, industry, research and policy to enable the sector deliberate options to abate negative impacts of the above issues to foster sustainable aquaculture growth. AFRAQ23 provides a broad range of opportunities for sharing ideas, learning, establishing business-to-business linkages and networking through its plenary sessions, side events, exhibition and study tours. This thematic area will cover all these facets.

Presentations, side events and exhibition of products addressing the above are welcome. A deliberate study tour that involve practical demonstration for farmers and students that demonstrate options for farm-level aquatic biosecurity has been organized.

ACCOMPLISHMENTS OF THE WORLD AQUACULTURE SOCIETY, AFRICAN CHAPTER: A CASE STUDY OF EASTERN AFRICA REGIONAL CHAPTER

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The aquaculture sub-sector in Eastern Africa is one of the fastest-growing sectors in Africa. The sector is consequently evolving into a multi-disciplinary field involving a wide array of stakeholders that include women and youth. This transformation has paved the way for investments in large scale commercial aquaculture. To bring together aquaculture value-chain stakeholders in the region, continental chapters to integrate international diversity have been formed. For instance, in partnership with African Union, World Aquaculture Society-Africa Chapter was established in 2018 and so far, five sub-regional chapters have been established. Specifically, the Eastern Africa chapter has anchored into the continent's and region's aquaculture development policies. It has also collaborated with local and regional stakeholders and established partnerships. Through these approaches, the Eastern Africa chapter has organized two regional aquaculture conferences in partnership with the region's aquaculture stakeholders. It has also established tools and mechanisms for collating, managing and sharing information. As a result, there has been an increase in collaboration among regional and national aquaculture sector managers, universities and research centres. However, further support is needed to have dedicated farmer policy sessions. The outputs from these sessions will guide in generating policy briefs appropriate for aquaculture policy research and development within the region.

INSTITUTIONAL CAPACITY AND REGULATORY FRAMEWORK FOR AQUACULTURE DEVELOPMENT: THE SECOND FISHERIES GOVERNANCE PROJECT

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The African Union's interventions in the fisheries and aquaculture sector are guided by the priorities outlined in Africa's overarching development plan, the AU Agenda 2063 supported by strategic frameworks and the decisions of Africa's Heads of State and Government. In this regard, the Comprehensive Africa Agriculture Development Programme (CAADP), Malabo Declaration (2014) and the Policy Framework and Reform Strategy for fisheries and aquaculture in Africa (PFRS) serve as the pillars guiding sustainable aquaculture development in Africa. The African Fisheries Reform Mechanism is the pathway through which the continental policies and strategies within the sector are implemented coherence and harmonization approaches towards achieving one common goal by all African Union Member States (AU-MS). All AU Member States are accordingly committed to developing their fisheries and aquaculture sectors to achieve *(i)* productivity, *(ii)* profitability, *(iii)* sustainability, *(iv)* wealth generation, *(v)* social welfare, nutrition and food security, *(vi)* regional management of shared resources, *(vi)* strengthening south-south (bilateral and regional) cooperation and *(vii)* equity.

To establish the enabling environment for achieving the goals outlined in the PFRS, two Fisheries Governance Projects have been implemented. The first Fisheries Governance Project 2014-18 (FishGov 1) on '*Strengthening institutional capacity to enhance governance of the fisheries sector in Africa, commonly called Fisheries Governance Project (FishGov 1)*' initiated the development of synergies and coherence in fisheries management and aquaculture practices by aligning national and regional polices to the PFRS. It also enhanced the profile of the sector and strengthened coordination in the governance of the sector. As a follow-up FishGov 2 that is currently on-going aims to "Enhance sustainable fisheries management and aquaculture development in Africa: A programme for accelerated reform of the sector (FISHGOV2)' by furthering the lessons learnt and recommendations of FishGov 1 for implementation at regional and national level. Therefore, the specific objectives of FishGov 1 are *(i)* African Union decisions on sustainable fisheries and aquaculture policies are evidence-based; *(ii)* Fisheries and aquaculture policies in Africa are coherent with the PFRS and other AU priorities and coordinated at continental, regional and national levels and *(iii)* Africa is adequately represented and effectively participates in international fisheries and aquaculture fora and ably domesticates relevant global instruments.

SCOPING LOCAL INGREDIENTS FOR FISH FEED IN ZAMBIA, SUB-SAHARAN AFRICA

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The fish feed cost is a major constraint to fish farming in Sub-Saharan Africa. In Zambia, fish feed is a determinant factor in the aquaculture value chain and accounts for 60 -70% of the fish production cost. Part of the fish feed production costs are incurred owing to the import of ingredients. In an effort to better understand the Zambian raw material market, an ingredient and fish feed scoping study was conducted to focusing on the type, areas of production, seasonality of availability and price of local ingredients that can be used in fish feed production. Thus, 450 stakeholders were interviewed from 6 Zambian Provinces namely, Northern, Southern, Eastern, North-western, Luapula and Lusaka. A total of 27 assorted ingredients were identified of which 70.4% were categorised as plant, 22.2% as animal and 7.4% as other ingredient sources. Findings show that plant ingredient sources were mostly sunflower (*Helianthus annuus*) (21%), rice (*Oryza sativa*) (23%), maize (*Zea mays*) (26.7%), cassava (*Manihot esculenta*) (3.1%), velvet (*Mucuna pruriens*) (11%), cow peas (*Vigna unguiculata*) (9%), pumpkin leaves (*Cucurbita pepo*) (1%), chikanda (*Disa robusta*) (5.2%). The main animal ingredient sources were kakeya (assorted small fish) (17%), chisense (*Potamothrissa acutirostris*) (23%), kapenta (*Limnothrissa miodon*) (43%), caterpillar1(*Gonimbrasia belina*) (9%) and caterpillar2 (*Gonimbrasia belina*) (6%) and cray fish (*Cherax quadricarinatus*) (2%). While other ingredient sources were dried brewer's yeast waste (*Saccharomyces cerevisiae*) and local salt (*Sodium chloride*). The best available by-product ingredient sources were tea waste (*Camellia sinensis*), palm seed oil (*Elaeis guineensis*), sunflower cake, rice bran, soybean cake, chikanda powder, cassava chips, kayeya fish and caterpillar2. The ingredients were also divided into different nutrient categories. The most produced nutrients were carbohydrates (58%), followed by proteins (26%), whilst lipids, minerals, vitamins (9% combined) were the least. Sunflower cake had the lowest average price (ZMK2/kg), followed by maize bran (ZMK10/kg), sorghum (ZMK12/kg), velvet beans (ZMK13/kg), kayeya (ZMK14/kg), chisense waste (ZMK10/kg). The highest ingredient prices were for caterpillar1 (ZMK45/kg), cassava (ZMK35/kg), finger millet (ZMK36/kg) and cray fish (ZMK42/kg). This study overall revealed a diversity of local ingredients available in Zambia with potential to be used to formulate fish feeds. Therefore, proximate analysis and digestibility studies are required to understand their nutritional composition and potential use as local fish feed ingredients for the production of low cost, local fish feeds.

CONSUMER PREFERENCE FOR *Engraulicypris sardella* (USIPA) PRODUCTS IN LILONGWE URBAN, MALAWI

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Engraulicypris sardella (Usipa) is one of the most affordable and readily available source of animal protein in Malawi. Pelagic fish such as Usipa, have the potential to offer a solution to this deficit as they are readily found in local markets and affordable compared to large fish species. But little is known about consumer preference in urban areas for such fish species as most studies dwell their focus on large fish species. This is why this study focused on consumer preference for Usipa products in Lilongwe Urban. The study targeted 383 respondents in Lilongwe urban and the data was collected in May 2021. Fresh, sundried, smoked, paraboiled and fried Usipa were the products under scrutiny. In order to have a broad understanding of the consumers in the study area, socio economic variables were analyzed using descriptive statistics and inferential statistics was carried out to determine if there were significant differences in the socio-economic variables among the consumers. In addition to that, identification of Usipa products preferred by consumers was done, where respondents were asked to rank the products into most preferred, neutral and least preferred. The results indicated that fresh Usipa was most preferred in low and medium density areas while sundried Usipa was preferred in high density areas. Furthermore, a multinomial probit regression on the socio-economic factors that affect the preference for Usipa products revealed that gender, education and occupation of the household head affected the preference for the fresh, sundried and smoked Usipa. Lastly the study analyzed the consumption patterns of Usipa products and how preference affects their consumption in the study area. The results showed that fresh Usipa was the most consumed and its preference affected consumption. In conclusion, the results of the study will aid those in the Usipa value chain especially the processors and traders in delivering demand driven products on the market for the consumers.

ACMS AND GATSBY AFRICA: COMMERCIALIZING THE EAST AFRICAN TILAPIA SECTOR THROUGH RIGOROUS FOCUS ON HUMAN CAPITAL DEVELOPMENT

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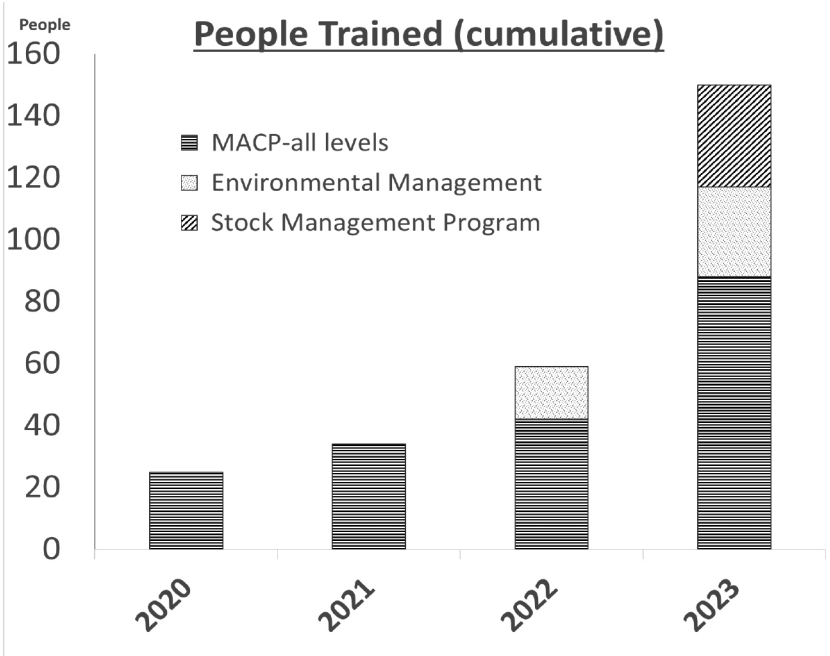
ACMS has been an implementing partner with the Gatsby Africa organization for over five years and have developed an intensive mentorship program to commercialize the mid-tier sector of the East African tilapia farming sector.

We currently have variations of involvement in 26 farms with a combined expected harvest output of over 6 500 MT for 2023. Economic FCR is our key performance metric and we have been able to measure an improvement from 1.9 to 1.5 across all harvested cages between 2020 and 2023.

Key to this is the training and capacity focus across various disciplines on each farm. We are proud to report on a total of over 150 key staff being trained through various programs. The focus areas are management controls and systems (MACP), environmental management and fish stock management.

This paper will provide a synopsis of some of our learnings, successes, and challenges that we have experienced to date, as well as offering a forward look on how it could develop into the future.



GROWING SMALLER FISH FOR INCLUSIVE MARKETS? INCREASING STOCKING DENSITY AND SHORTENING THE PRODUCTION CYCLE OF NILE TILAPIA IN CAGES IN LAKE VICTORIA

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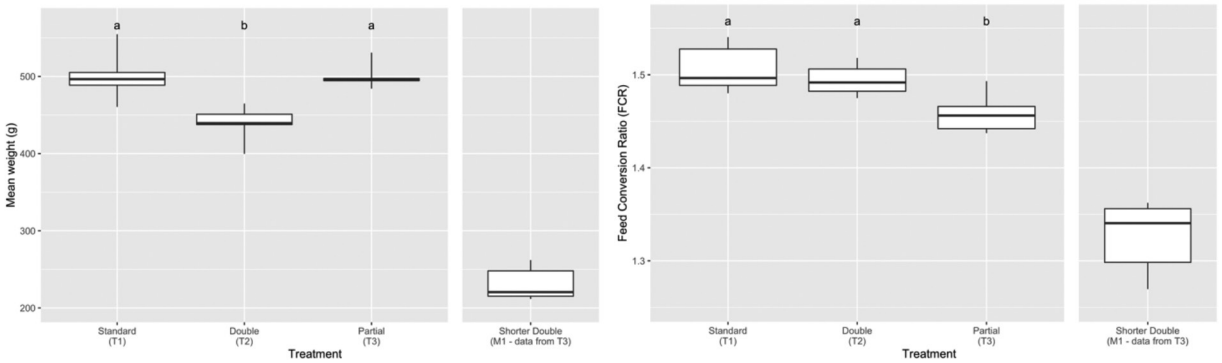
Fish farmers aim to maximise fish weight relative to feed inputs needed to turn a profit. Yet, many farmers in Africa lack the cash flow to grow large fish and many consumers prefer, or are limited to purchasing, small fish. This study aimed to intentionally produce small tilapia in cages by assessing the effects of higher stocking densities and shorter growth cycles on production and financial efficiency. An experiment with 3 treatments and 6 replicates took place on Lake Victoria. The first treatment (T1) used a stocking density of 2.9 ± 0.3 kg per m^{-3} and aimed to produce fish to an average body weight (ABW) of 400g (final ABW = 500.33 ± 31.01 g after 138 days). Treatment two (T2) did the same but with double the stocking density (5.9 ± 0.3 kg per m^{-3}), resulting in a final ABW of 439.22 ± 22.22 g over 138 days. The third treatment (T3) partially harvested 50% of the cage (after 76 days) once reaching an ABW of 230.92 ± 22.55 g. The remaining fish in T3 were allowed to grow on to an ABW of 400g (final ABW = 499.86 ± 15.95 g). A fourth production scenario (M1) based on data from T3, modelled a 100% harvest after 76 days of culture. There were no significant differences in mortality between treatments. There were no statistical differences in the feed conversion ratio (FCR) between T1 (1.51 ± 0.03) and T2 (1.49 ± 0.02), though T3 was statistically lower (1.46 ± 0.02; p = 0.03). Cages in T1 had a higher proportion of fish between 400-599 g while fish in T2 were mostly between 300-499 g. T3 had bimodal distribution with most fish either in 200-299 g or 400-499 g. There was little effect on average price per kg for T1 (3.0 ± 0.01 USD) and T2 (2.98 ± 0.01 USD), though T3 (2.89 ± 0.04 USD) was significantly lower (p = 0.001). Overall, T2 had significantly higher gross margins (17% ± 2.08) than T1 (13% ± 2.3, p = 0.021) and T3 (7.2% ± 2.43, p = 0.001), while M1 had the lowest gross margins (-11.8% ± 5.5). The results suggest that farmers can increase stocking densities. Some farmers can use partial harvesting strategies or shorter cycles to produce small tilapia and faster cash flows, though the economic margins are lower. Such approaches can provide opportunities for poor farmers and consumers.



AQUACULTURE CAN DIVERSIFY LIVELIHOODS AND DIETS, THUS IMPROVING FOOD SECURITY STATUS: EVIDENCE FROM NORTHERN ZAMBIA

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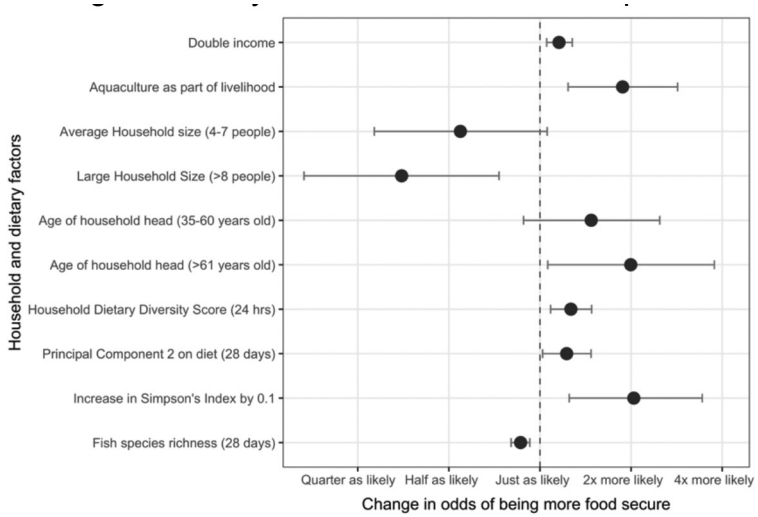
Much has been made of the potential for aquaculture to improve rural livelihoods and food and nutrition security in Africa, though little evidence exists to back such claims. This study, conducted in northern Zambia, assessed the benefits of adopting aquaculture by comparing a sample of households with (n=177) and without fishponds (n=174).

On-farm food production was assessed by summing all crop and livestock activities and calculating a production diversity score (PDS) of key food groups. Aquaculture households had greater crop diversification and were more associated with key nutritious foods grown on the farm, possibly due to additional water irrigation capabilities. A greater diversity of cultivated crops led to better household dietary diversity scores (HDDS). We further assessed the frequency of consumption of 53 food items (including 30 fish species) over a period of four weeks via a Food Frequency Questionnaire (FFQ). Using the Simpson's Index, aquaculture households had greater diversity and evenness in the distribution of foods and fish species consumed, particularly foods grown on the farm. Using livelihood and dietary factors in a multilevel probit regression on the Household Food Insecurity Access Scale (HFIAS), we found that adopting aquaculture gave households almost two times more likelihood of improving their food security status. Households could further improve their food security outcomes by growing and consuming certain vegetables, especially those that could be integrated along pond dykes.

The study suggests three clear pathways to food security. 1) Increasing wealth and income from the sale of fish and integrated vegetables and/or crops, which can be used to purchase a diversity of foods. 2) Increasing food and nutrition security via the direct consumption of fish and vegetables grown on the farm. 3) Improving irrigation capabilities in integrated aquaculture-agriculture systems that has direct impact on pathways 1 and 2. Aquaculture should be promoted in the region for its crop diversification and food security benefits, so long as it fits the local farming system and livelihood context. Moving away from productivist approaches to small-scale aquaculture widens the scope of uncovering the many benefits of pond farming in smallholder systems.



A NEW START-UP, FUTUREFISH, EXPLORES THE BUSINESS CASE FOR AQUACULTURE IN AFRICA

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FUTUREFISH seeks to advance knowledge, innovation, and investment to improve aquaculture in Africa and Asia. The company mission is to unleash the potential of smallholder-led aquaculture with business solutions that supply affordable, nutritious food for healthy people and the planet, by connecting insights and innovations with networks and investments for a sustainable food system.

FUTUREFISH works closely with innovators and investors to find business opportunities in marginalised aquaculture value chains that can create positive impacts for livelihoods, communities and the environment. The company draws upon an extensive network of partners – research, innovators, industry, and donors – as it seeks to identify innovations, bring the right partners together, and build profitable aquaculture businesses that enhance social and environmental sustainability. During 2022 and 2023, the company has been exploring aquaculture in Africa with various partners.

FUTUREFISH joined the Aqua-Spark-led small informal group of interested organizations and investors who have been working together to share knowledge and experience of aquaculture in Sub-Saharan Africa. This group aims to identify investment, finance, and support opportunities for African aquaculture businesses to grow, as well as suggest how governments can create a better enabling environment for sustainable aquaculture businesses and attract private investment and financing. FUTUREFISH implemented the group's methodology to collate the business and opportunities in Ghana into one open-access directory. The programme leant on an on-going project in Ghana, in partnership with the World Economic Forum, to establish a Blue Foods Partnership Multi-Stakeholder Platform making-up of a network of Ghanaian and global businesses.

In collaboration with the Bill and Melinda Gates Foundation, the business case for investing in smallholder aquaculture and the opportunities for closer pre-competitive cooperation among industry groups are being explored. A CEO Dialogue is being planned for AFRAQ23 in Lusaka - a closed-door roundtable discussion to explore what the future of African aquaculture looks like, and how pioneer companies in the sector can take a proactive lead in developing an evolutionary path forward for the sector. Unpacking the sector's environmental, social, and financial challenges are a central theme of this discussion, to work towards a goal of collaboratively deepening the business case for sustainable aquaculture growth.

SUSTAINING THE AQUACULTURE MOMENTUM IN AFRICA: THE ROLE OF INNOVATIVE FINANCING AND INVESTMENT

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Demand for aquatic blue food is growing significantly across the African continent, amid climate change impacts and stagnating capture fisheries. The potential for aquaculture to bridge the demand supply gap has been demonstrated in Asia as well as in some African countries. Although we have recently recorded high growth rates in few countries, most of Africa still lags behind.

The World Bank is actively promoting sustainable aquaculture and fisheries sectors across the continent to transform them into vibrant economic activities able to satisfy the domestic demand for aquatic blue foods and to target export opportunities. Given that aquaculture currently contributes over 57% of aquatic production globally, the World Bank has recently increased its focus on aquaculture development. The World Bank's blue investments are aimed at addressing the main structural problems of aquaculture in Africa, such as the poor access to quality feed and improved seed, limited technical skills and capacities, limited access to information and innovative technologies, weak aquaculture and policy implementation as well as poor access to credit.

The Aquabusiness Investment Advisory (AquaInvest) Platform funded by the PROBLUE Multi-Donor Trust Fund and administered by the World Bank is an Advisory Service and Analytics (ASA) formed to systematically address these challenges. The AquaInvest Platform is a collaborative initiative between the WB, International Finance Corporation (IFC), Food and Agricultural Organization (FAO), Global Environment Facility (GEF), World Wildlife Fund (WWF), United States Agency for International Development (USAID) and other partners to distill and improve best practices in aquabusiness development for economic, social, and environmental sustainability and support countries with the needed analytics and advisory. As a hub for guidance, tools, and knowledge products, the AquaInvest Platform is preparing global guidelines in sustainable aquaculture investment. In addition, the World Bank's Blue Economy for Resilient Africa Program, announced at COP27, provides multisectoral analytical, financial, and policy support to help fish farming communities adopt climate resilient aquaculture practices.

In this paper, we discuss how the World Bank and partners continues to strengthen financing and analytical support to unlock the potential for resilient aquaculture within the public and private sector with special emphasis on small and medium scale investments across the aquaculture value chain.

THE EFFECT OF ADDING *Bacillus* SPECIES TO THE WATER OF A COUPLED AQUAPONIC SYSTEM ON THE GASTROINTESTINAL MICROBIOTA OF MOZAMBIQUE TILAPIA *Oreochromis mossambicus* (PETERS, 1852)

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A 90-day experiment was conducted to evaluate the effects of the addition of a probiotic mixture of *Bacillus subtilis* and *B. licheniformis* to a coupled aquaponic system on growth and composition of gastrointestinal microbiota of juvenile Mozambique tilapia, *Oreochromis mossambicus*. A total of 96 fingerlings (4.74 ± 0.01 g fish^{-1}) were randomly distributed into replicated independent aquaponic systems, with each containing 24 fish. Aquaponic systems assigned to the *Bacillus* treatment received 5.31 g of a commercial *Bacillus* mixture (Sanolife®PRO-W; 5.0×10^{10} CFU g^{-1}) twice weekly until the end of the experiment. The addition of the probiotic resulted in increased weight gain, specific growth rate, feed efficiency and improved feed conversion ratio. Water quality remained within recommended ranges for tilapia culture, while free ammonia levels were reduced in the treatment systems. Microbial characterisation by Illumina MiSeq sequencing of 16S rRNA gene amplicons showed that bacterial gut communities were dominated by the phylum Fusobacteria, specifically the species *Cetobacterium somerae.* Compared to the control, lower relative abundances of members of the family *Enterobacteriaceae*, represented by genera *Aeromonas*, *Edwardsiella*, and *Klebsiella* were observed in the gut of *O. mossambicus* from the *Bacillus* treatment. The Shannon index values significantly decreased in the *Bacillus* treatment as compared with control, which suggests that the bacterial community was not modified to a large extent by the addition of *Bacillus* spp. This study establishes baseline data for probiotic trials in aquaponic systems.

PROGRAM FOR IMPROVING FISHERIES GOVERNANCE AND BLUE ECONOMY TRADE CORRIDORS IN SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC) REGION (PROFISHBLUE PROJECT): UNLOCKING THE INVESTMENT POTENTIAL IN FISHERIES AND AQUACULTURE IN THE REGION

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The Multinational Program for Improving Fisheries Governance and Blue Economy Trade Corridors in Southern African Development Community (SADC) Region (PROFISHBLUE project) is a four-year initiative of the Southern African Development Community (SADC) and the African Development Bank (AfDB) in response to the African Development Bank (AfDB) 2021 Call for Proposals under the African Development Fund (ADF) 15 Regional Operations financing window (Regional Public Goods envelop). This after the realisation that the region has a huge resource base both inland and marine (Indian and Atlantic) systems for capture fisheries and aquaculture. However, more than 95% of fish production comes from a diversified capture fisheries sub-sector estimated at 3.7 million tons annually which is not enough to satisfy the 380 million people in the region and contributing only 3% to the total global fish production.

The overall objective of the project is to promote sustainable management and use of fisheries resources within the blue growth context in the SADC region to improve food security, reduce poverty levels through employment opportunities, facilitate intra-regional trade, and enhance adaptive capacity of fish value chains and communities against climate change and other external shocks. The project is improving management of shared fisheries resources, increasing productivity and value addition benefits and market access, strengthening capacity for small medium enterprises (SMEs) and cooperatives towards intra-regional fish trade and enhance knowledge, regional partnerships, and decision support for resilience. Through the establishment of the business hubs, incubation programmes, Business-Readiness Pitches, partnerships and building sustainability mechanisms in the SMEs targeting women and youths, the project is unlocking the investment options within the region for the development of the fisheries and aquaculture in the region. By the end of the project, it is expected that the project will contribute 250,000 direct and indirect jobs within the fish value chains in the region. The interventions are being concentrated in Comoros, Democratic Republic of Congo (DRC), Malawi, Madagascar, Mozambique, United Republic of Tanzania (URT), Zambia and Zimbabwe.

PHYSICOCHEMICAL PARAMETERS AND WATER MICROBIAL LOAD IN DIFFERENT KENYAN AQUACULTURE PRODUCTION SYSTEMS

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Water quality is the most important limiting factor in fish production and directly affects feed efficiency, growth rate, fish's health, survival and disease progression. The aims of this study were to evaluate the physicochemical parameters and microbial loads of water samples collected from different pond types, water sources, geographical locations, and aquaculture systems. A cross-sectional study was done in 6 ponds from 6 farms in Nakuru and 4 ponds from 1 farm in Narok counties in the month of July 2023. Water parameters including dissolved oxygen (DO), pH, phosphorous (P), electrical conductivity (EC), turbidity, total suspended solid (TSS), ammonia, and nitrate were measured onsite and *ex situ* following standard methods (Figure 1.) Microbial quantification for the10 water samples was done using the Miles-Misra technique.

The pH ranged between 8.12 to 9.76 in concrete ponds, and 9.28 to 10.41 in liner ponds and was 7.47 in plastic tank ponds. Temperatures ranged from 21^{o}C to 27^{o}C in liner ponds and 27^{o}C to 28^{o}C in concrete ponds. The temperature in plastic tank ponds was 22^{o}C. Total aerobic bacterial counts ranged between 80 to 360 cfu/ml in concrete water tanks and 80 to 3200 cfu/ml in liner ponds. Open system liner ponds showed great variability in bacterial counts hence high variance on overall viable bacterial counts (Figure 1.) The aerobic bacterial count was 40 cfu/ml in the plastic tank pond. The physicochemical parameters and microbial loads were generally higher in open aquaculture system, borehole water and liner ponds and less in closed aquaculture system, river water and tanks. Aquaculture practices influence the overall water characteristics, and aerobic microbial load. Aquaculture practices like closed aquaculture system should therefore be adopted to aid in optimising water quality parameters for fish production.

BOTSWANA AQUACULTURE STRATGY & THE FUTURE ROAD-MAP FOR THE DEVELOPMENT OF AQUACULTURE AND INLAND FISHERIES

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Globally, aquaculture is one of the fastest growing food producing sectors, and a major source of the economy. However,most African countries have not benefited from the opportunities available in this sector. This is also the case with SADCcountries. Subsequently, SADC developed a Regional Aquaculture Strategy and Action Plan to assist Member States to leverage the value and benefits of this sector. The basic methodology followed inthe development of this strategy involved literature review of both published and grey literature, interviews with variousstakeholders, and consultations with key informants.

Several key documents were synthesized to provide the legislative framework for the development of this strategy. Globally, the FAO's Code of Conduct for Responsible Fisheries forms the foundation for aquaculture development, while the SADC Protocol on Fisheries forms the foundation of aquaculture development at the regional level. Currently, the only fisheries centric legislation in Botswana are the Fish Protection Act of 1975 and the Fish Protection Regulations of 2016 which however,focus more on management of wild capture fisheries than on aquaculture. Apart from these, Botswana does not have eithera national fisheries or aquaculture policy. The absence of a policy framework, and an arid climate, has resulted in low growthof the aquaculture sector in Botswana. However, despite these challenges, there have been several developments in the sector which suggest that there are still opportunities for aquaculture growth in the country. These include among others,the presence of one large commercial operation, a national hatchery, permanent water bodies in northern Botswana andseveral dams in south-eastern Botswana. Moreover, the identified weaknesses are challenges that can be addressed through development of robust action plans, while threats can be addressed through proactive regional and international bi-lateral engagements and planning. Through assessing the level of alignment of the national aquaculture strategies/plans/programmes of Botswana with the SADC Regional Aquaculture Strategy and Action Plan; aligning and mainstreaming the regional strategy; an aligned aquaculture strategy has been developed for Botswana.

A resource mobilization (RM) strategy provides an "essential roadmap" detailing how resources should be leveraged to meet the resource requirements of an organization. This resource mobilization strategy was developed as part of the implementation of the Botswana aquaculture strategy (2021-2026). A total of 139 Million BWP (10.3 Million US$) is required for the implementation of this aquaculture strategy for 5 years.

GROWTH PERFORMANCE COMPARISON OF SEX REVERSED *Oreochromis macrochir* (BOULENGER, 1912), *Oreochromis andersoniin* (CASTELNAU, 1861) AND *Oreochromis niloticus* (LINNAEUS, 1758) JUVENILES UNDER POND CULTURE

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A study was carried out at the National Aquaculture Research and Development Centre (NARDC) Fish Farm (12°49'0" South and 28°12'0" East), in Kitwe district of Zambia, to evaluate the effect of 17α-Methyltestosterone on the growth performance of fry of *Oreochromis andersonii*, *Oreochromis macrochir* and *Oreochromis niloticus* raised for a period of ninety days. The first 21 days, the fry (0.04g±0.001) across all treatments were fed on commercial feed incorporated with 17α-Methyltestosterone for the purpose of achieving sex reversal to all males and were held in 1m *x* 1m *x* 1.3 m hapas installed in a 400 m^2 semi concrete pond, at a stocking density of 250 fry per hapa and replicated three times in a completely randomized design. There were no significant differences (*P>0.05*) between the growths (weight gain) of sex reversed fingerlings treated with 17 α Methyltestosterone for 28 days and later fed on a commercial feed for a period of 60 days as indicated in Table 1.

These results indicate that the effect of 17α-Methyltestosterone on the growth of fry of the three species produce similar results. Therefore, the study has demonstrated that these species can substitute the other and still produce similar results, hence a farmer having a wider choice to select from and as well as for the hatchery managers information.

Table 1. Growth performance parameters of *Oreochromis andersonii*, *Oreochromis macrochir* and *Oreochromis niloticus* sex reversed fry (Mean ± SE)

Parameter	*Oreochromis andersonii*	*Oreochromis macrochir*	*Oreochromis niloticus*
IW (g)	0.04±0.161	0.04±0.152	0.04±0.091
FBW (g)	1.824 ± 0.067	2.683±0.322	2.396±0.223
BWG (g)	1.784±0.067	2.643±0.322	2.356±0.223
FSL (mm)	32.485±0.860	37.533±2.932	36.137±0.645
SGR (%/day^{-1})	1.864 ±0.067	2.7233±0.322	2.436±0.223
AFCR	1.742±0.824	1.123±0.185	1.257±0.132
Survival (%)	97.00±0.577	97.67±0.667	99.00±1.000

Means values across the rows are not significantly different (P>0.05)

Note: IW – Initial weight; FBW – Final body weight; BWG – Body weight gain; FSL – Final standard length; SGR – Specific growth rate; AFCR – Apparent feed conversion ratio; SR – Survival.

KNOWLEDGE, ATTITUDES AND PRACTICES RELATING TO ANTIMICROBIAL USE (AMU): SHOULD TANZANIA BE CONCERNED ABOUT AMU IN FISH FARMING?

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Antibiotics are often used in agriculture to promote animal growth and prevent disease in livestock. This study was conducted among fish farmers in Dar es Salaam, Tanzania to assess fish farming practices regarding antimicrobial use and residue in aquaculture and determine the concentrations of sulphonamide and tetracycline residues in the tissues of farmed fish. This cross-sectional study used a structured questionnaire to collect information from fish farmers in Dar es Salaam (n =60) and Antibiotic residues were determined by using an ELISA Kit. Data were collected electronically using the AfyaData App and SPSS Statistics for Windows, Version 26.0. was used for data analysis.

Most of the farmers were males (71.7%), aged > 50 years (51.7%), and (38.3%) were university graduates, with (80%) having no training in aquaculture, and 50% having no access to extension services. The majority were aware of antibiotics (80%), and antimicrobial resistance (93%). However, only 35% of the farmers had a positive attitude towards antimicrobial agents. Although none of the farmers indicated using antibiotics, we noted pond fertilization with manure in 38.3% of the farms. A total of 84 farmed fish were sampled and analysed for tetracycline and sulphonamide residues, of which 100% (n = 84) were positive for sulphonamide residues; 2.38% (n = 2) were positive for tetracycline and 2.38% (n = 2) contained both sulphonamide and tetracycline residues. The concentration of the residues ranged from 0 to 6.95 μg/kg for tetracycline, and 12.68 to 133 μg/kg for sulphonamides, respectively. About 5.95% (n=5) of the samples had sulphonamide residues above the MRL, while none of the samples had tetracycline residues above the MRL. All samples that were positive for tetracycline were within the acceptable daily intake ranges, while 28.47% (n = 24) samples had sulphonamide concentrations above the acceptable daily intake range. Fish farmers in Dar es Salaam have significant gaps in KAP regarding antimicrobial use, and there is a presence of antibiotic residues in farmed fish, issues that need to be addressed.

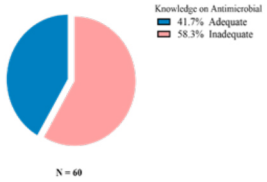


Fig. 1: Knowledge of farmers regarding antimicrobial use

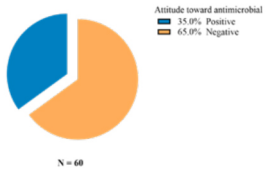
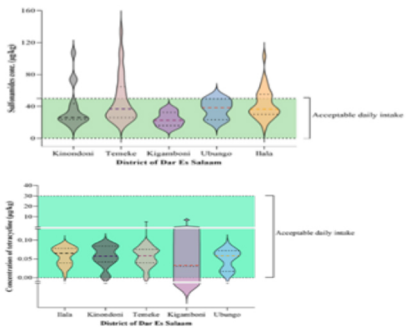


Fig. 2 Farmers' attitudes regarding antimicrobial use



Figs 3&4 Comparison of concentrations of sulphonamides and tetracycline residues with acceptable daily intake

CONTRIBUTION OF UGANDA NATIONAL WOMEN'S FISH ORGANIZATION IN STRENGTHENING SKILLS AND CAPACITIES OF WOMEN IN FISH PROCESSING IN UGANDA

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Women are involved in several activities throughout the small-scale fisheries value chain in Uganda. They are often engaged in post-harvest handling, processing, branding, and marketing. However, limited access to and control of key assets such as capital, skills and technologies limit their engagement in formal fish-related businesses. This greatly restricts their ability to take advantage of new opportunities at regional and international fish markets. The Uganda National Women's Fish Organization (UNWFO) with support from GIZ through the Responsible Fisheries Business Chain Project conducted practical training in environmentally friendly and innovative fish processing techniques and best practices in fish handling. A total of 1,455 trainees from 15 districts attended the business trainings. The business trainings were conducted in the 15 fishing districts on Lake Victoria namely: Bugiri, Buikwe, Busia, Buvuma, Jinja, Kalangala, Kalungu, Kampala, Masaka, Mayuge, Mpigi, Mukono, Namayingo, Kyotera, and Wakiso. The participants included boat owners, fishermen, fish traders, fish processors, and fish by-product processors. The training sessions were divided into theoretical sessions aimed at providing trainees with background knowledge on the personal hygiene, fish processing practices, record keeping, and transportation and marketing of fish products followed by practical sessions, aimed at equipping trainees with practical skills on fish value addition. It is anticipated that the training will reduce post-harvest losses hence making artisanal fish processing and trade more profitable for social-economic development of fisher communities.

COMPARATIVE STUDY OF THE WEIGHT GAIN PERFORMANCE OF TWO TILAPIA STRAINS IN WESTERN DEMOCRATIC REPUBLIC OF CONGO

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Tilapia is one of the main fish of livestock in Africa. However, despite the potential of exploitation that offers this fish breeding seems not yet mastered in sub-Saharan Africa. The West of the DRC specifically in the provinces of Congo-Central, Kwango and Kwilu, tilapia is the main species of livestock. To answer the question whether the low weight of tilapia in the West of the DRC was due to a genetic degeneration or simply the wrong system of breeding, we have introduced a new strain of tilapia that we compared with the strain local. Both strains were fed on basis of the internal are with a complement of 25 kg/ha of concentrated feed (18% PD) and 50 kg/ha of the droppings of chickens every 10 days.

The average weight of 85,94 g; 150,18 g and 182,28 g were obtained with the local strain respectively at 3, 6 and 9 months. While with the introduced strain, the average weight of 83,34 g; 149,12 g and 218,22 g were observed. ANOVA has shown that the differences are not significant. At the end of our investigation, the very low weight of tilapia produced by peasant farmers in the West of the DRC are due to the use of inadequate nutritional practices. Nutrition is currently the limiting factor for performance of tilapia farming in the West of the DRC

UNDERSTANDING THE AQUACULTURE GOVERNANCE LANDSCAPE IN UGANDA: A PRELIMINARY ASSESSMENT USING THE AQUACULTURE GOVERNANCE INDICATORS (AGIs)

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Uganda is one of the largest aquaculture producers in Africa with a remarkable growth attributed to a private sector led industry. However, current aquaculture production cannot meet the national and regional demand of food fish mainly due to: limited access to affordable quality feed and seed, and limited access to knowledge technologies. Several efforts are set to drive aquaculture into a sustainable and equitable sector through participatory innovations and governance.

Governance is a pivotal transformer for aquaculture's growth but there is limited information on Africa's landscape. Therefore, this study assessed the political, institutional, collaborative arrangements /partnerships, and regulatory dimensions that have contributed to the transformation of Uganda's Aquaculture sector using Aquaculture Governance Indicators (AGIs). Preliminary analysis revealed that Uganda has strong legislative framework covering major industry and sea food watch issue areas including effects of aquaculture effluent on the environment, habitat, chemical use, source of stock disease and escapees. However, it needs to be; i) strengthened at National and local levels ii) efficiently coordinated and enforced, and iii) extension support strengthened to increase compliance for small scale farmers. Voluntary and compulsory national standards relating to aquaculture production, inputs, fish processing and marketing guidelines have been developed by the Uganda National Bureau of Standards (UNBS). However, there is need for more awareness and inclusion of stakeholders. Private standards like ASC are generally perceived to be applicable to large scale commercial farms targeting international export of farmed fish, with only one farm reported to have pursued ASC certification. The key collaborative processes are industry-led (Commercial Fish Farmers Associations) or have interactive governance (donor funded projects implemented by government ministries or research institutions in collaboration with market and civil society actors). Governance and partnership arrangements are deemed very relevant to address the main industry issue areas. However, there is need to: i) enhance the visibility of their deliberative processes, ii) strengthen coordination and learning processes within and between collaborative arrangements. This study provides insights to foster learning, better understanding of the challenges within the sector and a starting point for engagement among different stakeholders around identified gaps to ensure sustainable development.

ENHANCING PATHOGEN DETECTION PROTOCOLS: A COMPREHENSIVE VALIDATION APPROACH

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Accurate pathogen detection is vital in clinical laboratories for timely diagnosis and disease management strategies. This study aims to transform research findings into robust clinical protocols through method development, validation, and application. The study focused on two fungal pathogen targets.

The first objective focused on detecting *Batrachochytrium dendrobatidis*, the cause of chytridiomycosis in amphibians, in the environment. This was achieved by developing and optimising a workflow that included methods for collecting eDNA, preserving samples, and sample processing with multiple DNA extraction methods. A standard qPCR assay was used to determine the efficiency of multiple variables at each step. The most effective workflow delivered comparable results to the current gold standard results for the detection of *B. dendrobatidis.*

The second objective was to amplify the target DNA. Two molecular detection assays were developed and optimised: a LAMP assay to detect *B. dendrobatidis* from eDNA and a quantitative real-time assay to detect a different target, *Aphanomyces invadans*, the agent responsible for Epizootic Ulcerative Syndrome (EUS) in fish. A primer set consisting of four primers was designed using the nucleotide sequence of the ITS1-5.8S-ITS2 region of *B. dendrobatidis,* which amplified a fragment of 201 bp. Similarly, a TaqMan primer-probe set was designed for *A. invadans*. This set targets the same gene and amplified a 93 bp fragment of the ITS2 region. The analytical specificity of both sets was validated and confirmed *in silico* and against a panel of single spore cultures of phylogenetically closely related oomycete species and environmental fungi. The performance of the assay was determined to aid in future interpretation of the results. This study addressed real-world challenges encountered during validation, highlighting the intricate balance between sensitivity, specificity, and practical applicability.

In conclusion, this study worked through the transformative process of bringing novel detection protocols to clinical laboratories. It highlights the importance of following the World Organisation for Animal Health (WOAH) guidelines, which emphasise the alignment of protocols with worldwide standards. Our results showcase protocol validation, demonstrating their use in the broader research context.

FINE-TUNING AQUACULTURE: EXPLORING THE BENEFITS OF FUNCTIONAL INGREDIENTS IN FISH DIETS

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Introduction

Aquaculture plays a pivotal role in guaranteeing food security in a world with a fast-growing population. Thus, in recent years, there was a need to increase and intensify the production of aquatic organisms and consequently, applied research led to advances on the optimal farming conditions for several species. With a view to continue improving the performance and sustainability of the aquaculture industry it is now necessary to fine-tune aquaculture practices, aquafeeds, methodologies and analytics. This integrated vision will allow for a more precise and efficient management of resources, improving fish health, growth rates, and overall production.

One of the important steps that has been taken to increase sustainability of the sector and to reduce the impact of aquaculture on marine ecosystems was the inclusion of ingredients of vegetable origin in fish diets. In this regard, the inclusion of macro and microalgae extracts has been explored, particularly because of the bioactive compounds these ingredients contain.

The main objective of this work was to evaluate the impact of algae biomasses and extracts, on overall performance and resilience of gilthead seabream (*Sparus aurata*) and seabass (*Dicentrarchus labrax*) post-larvae, using a multidisciplinary analytical approach.

Experimental trial

Algae extracts were prepared by GreenCoLab and incorporated into aquafeeds by SPAROS, Lda. Fish trials were conducted at the Aquaculture Research Station facilities (EPPO/IPMA) and analytics performed by EPPO/IPMA and S2AQUAcoLAB.

Fish trials were divided in two phases:
1) 33-35 days after hatching (DAH) post-larvae, obtained from EPPO/IPMA broodstock, were fed four different feeds: Winfast (commercial control diet, SPAROS Lda.), BLEND1, BLEND2, and BLEND3 (three diets with different inclusion of micro- and macro-algae extracts). Fish were fed respective diets for 1 week, where they changed to a control feed for a second week, and then back to the functional feeds for another week. Fish were sampled at that point (S1) for growth and survival assessment and effects of the different blends in gene expression and oxidative stress enzymes' activity.
2) At 57-58DAH all fish groups were fed a boost diet for 1 week (BLEND6). BLEND2 was eliminated to give place to a CTRL group that did not receive a boost diet. Fish were sampled previously to stress exposure (S2) to evaluate the boost diet effects.
3) After, larvae were subjected to a stress event (air exposure) and to a challenge test, with a pathogenic bacteria, *Photobacterium damselae* subsp. *piscicida*. Survival was recorded and samples were collected between 6-24h hours after exposure (S3) for gene expression analysis and oxidative stress enzymes' activity.

Results and Conclusions

At the end of trial 1 (S1), the post-larvae fed with diets containing micro- and macro-algae showed no differences in growth. Although not significant, a higher fish survival was observed in the fish fed with the BLEND diets. Regarding gene expression, an increase in stress-related genes, such as GPX1 and GPX4, was observed in all BLENDS when compared to CTRL, in seabream larvae. In S2, the addition of a boost diet (BLEND 6) decreased the expression of antioxidant enzymes to control levels (S2 vs S1). After the stress event (S3), the addition of a boost diet (BLEND 6) increased the expression of antioxidant enzymes such as GPX1 and GPX4, in a dose dependent manner. These results suggest that in the early stages, the performance of fish larvae might benefit by the incorporation of micro- and macro-algae in the diets.

Acknowledgements

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GENE EXPRESSION OF MEAGRE (*Argyrosomus regius*) REARED UNDER HYPOXIC CONDITIONS

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Oxygen is one of the most important factors to consider in fish farming. Maintaining proper oxygen levels is of crucial importance for an improved performance as it impacts fish growth, development and welfare. Adequate oxygen supports disease prevention, efficient nutrient metabolism, and good water quality by preventing the accumulation of harmful substances. The aim of this work was to investigate the impact of three oxygen levels on meagre rearing through the assessment of differentially expressed genes in liver, gill and heart.

A 31 day long trial, performed at EPPO/IPMA (Olhão, Portugal), started with fish with 252.3 ± 29.5g, distributed along 9 tanks (1.5 m^3) at a density of 10.9 ± 0.1 $kg.m^{-3}$ per tank, salinity and temperature kept at 37 and 20.7 ± 1.0°C, respectively. Three oxygen levels were tested: normoxia (DO-1: 6-7 mg L^{-1}); moderate hypoxia (DO-2: 4-5 mg L^{-1}) and severe hypoxia (DO-3: 2.5-3 mg L^{-1}). Oxygen was added automatically, when needed, to maintained the pre-defined levels. Fish were fed with a commercial diet four times a day, *ad libitum*. At the end of the trial, samples from liver, gills and heart were collected from 2 fish per tank for gene expression (6 fish per condition). Total RNA was extracted, quantified and quality verified before cDNA synthesis for RT-qPCR. Liver samples were also collected to evaluate the activity of oxidative stress-related enzymes.

Fish final weight was 391.2±62.0^a, 404.0±60.9^b and 411.5±56.3^b g on DO-1, DO-2 and DO-2, respectively. Liver superoxide dismutase (SOD) presented an increased activity in DO-3 when compared to the Control, however SOD activity in DO-2 and DO-3 were similar, suggesting the activation of this response on moderate hypoxia conditions.

The hypoxia related gene HIF-3α decreased in severe hypoxia in heart when compared with the moderate hypoxia treatment, and in gill the expression decreased in normoxia and severe hypoxia when compared to moderate hypoxia. HIF-3α expression was higher in moderate hypoxia in both tissues and no other genes differed significantly. This suggests a possible adaptation of meagre to cope with low oxygen levels.

These results suggest a modulation on metabolic activity and provide insights into the mechanisms underlying the adaptive response of meagre to hypoxic conditions. However, further research is ongoing to investigate the expression of other stress and hypoxia-related genes and the functional consequences of their regulation in meagre.

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Table 1. Gene expression in heart, liver and gill of meagre exposed to three levels of oxygen. Relative expression data is in comparison to housekeeping's: L13 and ßactin for heart and liver; ßactin for gill, using the Pffafl comparative method. Results are shown as mean ± SD and different letters within the same column are significant different ($p < 0.05$).

	Heart			Gill			
Treatment	HIF-1α	HIF-3α	VHL	HIF-1α	HIF-3α	MT2	PRDX5
DO-1	1.1±0.4	1.1±0.5^{ab}	0.9±0.6	1.7±1.0	1.4±0.6^a	1.9±1.6	1.0±0.6
DO-2	1.0±0.5	1.3±0.5^b	0.9±0.3	1.2±0.8	3.0±1.7^b	1.9±1.3	0.8±0.4
DO-3	1.3±0.6	0.9±0.4^a	0.8±0.5	1.8±1.3	1.9±0.7^a	3.6±3.9	1.5±1.3

	Liver					
Treatment	PRDX5	MT2	GPX	HADH	COX5A	IGF-1
DO-1	1.2±0.9	1.2±0.9	1.1±0.7	1.4±1.2^{ab}	1.0±0.3	0.9±0.5
DO-2	1.3±0.6	1.0±0.5	1.1±0.5	0.9±0.6^b	1.1±0.2	0.9±0.4
DO-3	1.1±0.7	1.0±0.4	0.9±0.2	1.7±1.1^a	0.9±0.2	0.8±0.4

INTRODUCTION TO SUSTAINABLE IN-POND RACEWAY SYSTEM (IPRS) PRINCIPLES IN TANZANIA

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Tanlapia Ltd ("Tanlapia") is a large-scale aquaculture project in Bagamoyo. Since breaking ground in 2020, Tanlapia has grown rapidly, starting to produce fish in 2021 and now harvesting over 30 metric tonnes (MT) of tilapia per month, mostly *Oreochromis nilotica*, per month, making us the largest producers of Tilapia in the country.

One of Tanlapia's key advantages is its location based on a 600-hectare fish farm in Kingani, Bagamoyo, on the floodplains of the perennial Ruvu River around 30 km from the Indian ocean and less than two hours from downtown Dar-es-Salaam.

Tanlapia farm uses a hybrid system consisting of:

- Open semi-intensive ponds for low-tech reliable production of fry in hapa (12-18 fish/gm), followed by a first nursery stage to reach 3-5 gm/fish.
- Semi-intensive ponds with aeration for a second nursery stage, growing, (3-5g to50g)
- In-Pond Raceways System (IPRS) or semi-intensive ponds with aeration for grow-out from 50g to market size (usually 330g -350g), with a final production at harvest (50 to 65 kg.m^3) during 200 days.

IPRS is a state-of-the-art aquaculture technology. Fish are held in 'cells' which are cement-sided, mesh-ended cages within larger earthen ponds. Water is circulated through the cells and earthen pond with the help of electrically powered aerators. This simulates a river, allowing the areas outside of the cells to act like a large biofilter. This keeps the fish healthy and allows them to be closely monitored for any signs of disease or stress. It also keeps water quality stable, reduce water consumption and feed loss, reducing environmental impact and optimizing operating cost which is key for a successful farm.

Main advantages of the IPRS to Tanlapia are to keep water quality stable in earthen ponds in case if salinity will increase seasonally and during high tide in Ruvu River. Meanwhile to be a reducing environmental impact and optimizing operating cost. In addition to decrease water consumption as be an ecofriendly aquaculture system.

Without releasing water or waste into nearby waterways, IPRS technology has the potential to significantly outperform traditional ponds in terms of yields. With high yields and minimal environmental impact, IPRS is a more manageable and controllable approach. The system lowers risk, increases yields significantly, and lowers production costs per unit.

Tanlapia primary product is whole, gutted tilapia for the domestic market. Processing is carried out on site in Bagamoyo. Tanlapia team currently harvest three times a week and sell out the same day locally or to Dar es Salam area.

Tanlapia employ 24 full time employees, with a variety of skills and qualifications. Only one full time employee is not a Tanzanian national. They also employ approximately 50 casual labourers hired from the local area, both men and women. Women predominate in hatchery and plant processing tasks, but some are also in charge of grow-out operations.

USING A PRIVATE-SECTOR APPROACH TO DEVELOPING SMALLHOLDER AQUACULTURE IN NOTHERN ZAMBIA

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Smallholder fish farming in Zambia is constrained by the lack of access to aquaculture inputs, output markets, technical information, and other extension support services. We piloted a private sector-led model to improve access to production inputs, output markets, and disseminate novel technologies, information and training to smallholder fish farmers. The paper reports results of the piloted model.

The paper uses data collected as part of the evaluation and monitoring framework for the project. The project collected farmer census data at baseline, collected routine monitoring data, conducted an independent midterm review, and an independent end-of-term project evaluation and lessons learnt study. The census was conducted in 2020 and 2021 in selected districts in the Northern and Luapula provinces of Zambia. The census utilised the iForm app to collect quantitative data including the spatial location of fish farms, demographic details of fish farmers, fish farming background, resources and fish species cultured, gender and youth involvement, access to markets and extension services, and production constraints and opportunities from 2,341 (2,013 men and 328 women) smallholder fish farmers. The independent mid-term project evaluation employed a mixed-methods design, incorporating observations, participatory evaluation, and the end term evaluation used a gender-sensitive approach which entailed actively targeting women in households and cooperatives for interviews. Additionally, women were interviewed separately from men to express themselves freely. In addition to 83 quantitative interviews, 184 people participated in focus group discussions (FGDs). Six FGDs were conducted with 54 cooperative members, with two of the groups being women cooperatives. For the final evaluation survey, 214 smallholder farmers participated (26% women) from the Northern and Luapula Provinces. The evaluation study collected qualitative and quantitative data to assess achievement of the project's intended outcomes. The project team also documented project activities through field reports and collected routine monitoring data which was used to calculate how much the SMEs invested and the revenues they got.

Our findings show that a private-sector approach designed with vulnerable groups and smallholder farmers in mind can go a long way in integrating them into markets in inclusive ways that address the constraints they face. The interesting part is that the adoption rate for trained women was higher than that of men. The presented model and case study underscore that a private sector-led approach is among the models that can foster smallholder aquaculture development, as evidenced by the linkages that resulted in improved availability and accessibility of production inputs, fish market and technical services that led to the engagement of more smallholder farmers and enhanced fish production and productivity. While this model provides an excellent example of an innovative way that donors, development organisations, research institutions, the private sector and farmers, as well as governments, can employ to develop the smallholder aquaculture sector, there is still a need to establish mechanisms for financial input linkages between financial institutions and smallholder farmers.

AQUAPONICS AND SUSTAINABLE FOOD PRODUCTION: A LOOK AT A PILOT PROJECT IN BUSHBUCKRIDGE LOCAL MUNICIPALITY

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Bushbuckridge local municipality is home to high unemployment rate in the Ehlanzeni district municipality due to shortages of industrial and mining development in the area. Agricultural activities are the main source of income for the poor. However, the community is faced with the challenge of diminishing natural resources such as land and water. The human population is rapidly increasing while natural resources are limited implying that if sustainable/green agriculture is not accelerated man's basic needs such as food etc. will one day not be met. As a result, agricultural land is converted to business development activities such as shopping centres, game lodges, guest houses, recreation etc. This has resulted in conflict between farmers, community members and the business sector.

The human population is rapidly increasing while natural resources are limited implying that if sustainable/green agriculture is not accelerated man's basic needs such as food etc. will one day not be met. In search for a solution, scientists have recommended aquaponics as an alternative system of sustainable food production which is adaptive to climate change. Hence, the aquaponics pilot project is implemented in Acorns to Oaks High school in Bushbuckridge. Aquaponics is the concept of combining aquaculture and hydroponics systems into one cohesive closed loop system that cycles nutrients and water to the mutual benefit of the plant and fish species within the system (Fox *et a*l. 2010)

This paper sought to investigate the sustainability and viability of aquaponics as a system of food production. In particular, the main focus was on answering two main questions namely: Is aquaponics a sustainable system of food production? How beneficial is the aquaponics project in the local community? This survey took on a mixed approach; hence both qualitative and quantitative questions were explored. A questionnaire was used as the main method of data collection. The results indicate that aquaponics is not only a sustainable system of food production but it is also adaptive to climate change. Furthermore, it has benefitted the community in various ways, such as employment opportunities, access to fresh food, water conservation, tourism and youth attraction to agriculture.

IMPROVING THE SUSTAINABILITY AND PERFORMANCE OF INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEMS BY COMBINING AQUACULTURE BIOFILTERS

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There is a critical need to develop innovative and sustainable aquaculture technologies to expand production of seafood to meet the growing demand by consumers for safe seafood resources, to reduce fishing pressure on declining wild fish populations, and to improve the environmental sustainability of our seafood production systems. Mote Aquaculture Research Park (Mote) scientists are working together with our research partners at the University of South Florida's College of Engineering (USF) and the National Mariculture Center (NMC) in Israel to develop integrated multi-trophic aquaculture (IMTA) or marine aquaponics farming systems to expand the availability of healthy seafood for local communities. These integrated systems are engineered to efficiently use nutrients, water and energy to produce marine fish and edible sea vegetables. The integration of periphyton biofilters into the recirculating aquaculture system (RAS) improves water quality, nutrient resource recovery, microbiome diversity and water treatment efficiency. Incorporation of periphyton biofilters into the Mote IMTA not only improved water quality by reducing total ammonia nitrogen (TAN), nitrite, nitrate and carbon dioxide, but produced dissolved oxygen and repurposed nutrients that can be used as a potential ingredient for fish feeds. Some of the nutrients that were removed from the water (TAN, nitrite, etc.) can be reclaimed by harvesting from the nets once per month. Mote has developed a brackish water IMTA with a periphyton biofilter as a demonstration pilot-scale marine aquaponics farming system. This system can be managed by family or farmer-owned cooperatives, to supply communities with locally produced fresh seafood and provide expanded job opportunities in rural and urban communities.

AQUATIC GENETIC RESOURCES AND AQUAGRIS: FAO RESOURCES IN SUPPORT OF EFFECTIVE MANAGEMENT OF AQUATIC BIODIVERSITY IN AFRICAN AQUACULTURE

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The Food and Agriculture Organization of the United Nations (FAO) has been requested by its Members, through the Commission on Genetic Resources for Food and Agriculture, to assess the status of aquatic biodiversity used in aquaculture and to develop tools and policy responses to address the principal needs and challenges for effective management of this key resource. Following on from the publication of *The State of the World's Aquatic Genetic Resources for Food and Agriculture* in 2019, FAO developed, in active consultation with members, *The Global Plan of Action for the Conservation, Sustainable Use and Development of Aquatic Genetic Resources for Food and Agriculture* as a policy response. This Global Plan of Action is a voluntary, non-binding policy framework, adopted by FAO Members in 2021, that identifies key strategic priorities and actions that countries and the international community should undertake for a more responsible management of aquaculture species, and their farmed types (the equivalent of livestock breeds and crops for the aquaculture sector) and wild stocks.

Information is power and availability of clear, consistent and harmonized information on the status of genetic resources, especially at the level below species (farmed types and wild stocks), promotes clearer understanding of the priority needs prevalent in individual countries and can inform the development of appropriate strategies, policies, management plans and human resource capacity. Very few countries possess information systems on their aquatic genetic resources and those that exist are not harmonized. FAO is addressing this need through the development and application of AquaGRIS, a global information system for aquatic genetic resources. A prototype of AquaGRIS was release in 2021 and a fully functional version was released in late 2023. FAO is now supporting countries to develop national registries of their genetic resources.

Whilst Africa has very few developed farmed types (strains and varieties) the continent is home to key reservoirs of genetic diversity for several key global aquaculture species, most notably the tilapias, mullet and Clariid catfish. Due to the limited numbers of farmed types in African aquaculture and the paucity of information on wild stocks, the scale of the task for the creation on national registries is quite achievable for many African countries. FAO is looking to engage with national focal points for African members to support them to create national registries of their aquatic genetic resources which can not only inform the effective conservation and sustainable use of these resources but can also be the basis for effective measures for access and benefit sharing related to resources of global significance.

THE GLOBAL PLAN OF ACTION FOR THE CONSERVATION, SUSTAINABLE USE AND DEVELOPMENT OF AQUATIC GENETIC RESOURCES FOR FOOD AND AGRICULTURE AND ITS RELEVANCE TO AFRICAN AQUACULTURE

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Species diversity in African aquaculture is relatively low compared to other regions, with countries reporting the culture of just 13 species with production levels over 10,000 tonnes, and only three species (Nile tilapia, mullets and North African catfish) make up over 75% of production. Despite this low species diversity, the continent is home to key reservoirs of genetic diversity for these species, which are all indigenous to the region but also globally significant aquaculture species. Given the low species diversity used in aquaculture and the relatively nascent state of aquaculture development in most African countries, it might be tempting to consider that effective management of genetic resources is a relatively low priority for African aquaculture.

However, there are already a range of issues at play regarding genetic resource management within aquaculture development in Africa including the risks and benefits of native vs non-native species, the potential degradation of genetic quality of existing domesticated farmed types, and the potential for genetic improvement to act as a catalyst for expansion and intensification of aquaculture production in the region.

The Global Plan of Action for the Conservation, Sustainable Use and Development of Aquatic Genetic Resources for Food and Agriculture (Global Plan of Action) was developed by FAO, in consultation with members, as a policy response to some of the needs and challenges identified in global aquaculture, many of which are highly relevant to African aquaculture. It is a voluntary, non binding policy framework, adopted by FAO Members in 2021, and focuses on four priority areas in relation to genetic resource management: inventory, characterization and monitoring; conservation and sustainable use; development of genetic resources for aquaculture; and policies institutions and capacity building. It identifies key strategic priorities and actions, under these four priority areas, that countries and the international community should undertake for a more responsible management of aquaculture species, and their farmed types (the equivalent of livestock breeds and crops for the aquaculture sector) and wild stocks. This presentation will review some of the key strategic priorities in this Global Plan of Action most relevant to African aquaculture.

IMPROVING PRODUCTIVITY AND SUSTAINABILITY IN THE TILAPIA VALUE CHAIN IN COLOMBIA – A STRATEGIC PARTNERSHIP PROJECT

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Tilapia production in Colombia has doubled in volume over the last decade and it is now one of the main exporter countries of fresh tilapia to the US. This Strategic Partnership project was funded by NORAD (Norwegian Agency for Development Cooperation) and PHARMAQ part of Zoetis and implemented best aquaculture and fish health management practices to support the continued sustainable growth of the Colombian tilapia farming sector and bring about wider societal and economic benefits. The project was led by Caritas Norway and involved key partners from the private sector, PHARMAQ AS, Zoetis Colombia, the Colombian-Norwegian Chamber of Commerce, and Piscícola Botero, one of the largest Colombian producers and exporters of tilapia.

The overall aim of the project was to increase productivity, profitability, and sustainability in the tilapia value chain in the regions of Huila and Caquetá, by using a combination training in fish health management and fish vaccination, disease surveillance, adoption of vaccination, promotion of environmental sustainability, and the stimulation of business alliances between producers and buyers at local, national, and international level.

The project provided a framework for partners to cooperate and deliver agreed project outcomes, which included delivery of theoretical and practical training in fish health management, the first use of vaccines on 7 tilapia farms in Huila, and the execution of a disease surveillance program. These outcomes and some of the wider benefits of the project will be presented and discussed.

The Strategic Partnership model proved to be effective at encouraging collaboration between private enterprises, public and non-governmental organizations, enabling participants to share knowledge, experiences, know-how, and expertise. The project outcomes provided measurable contributions against several of the UN's Sustainable Development Goals. The project also demonstrated that the openness of Colombian tilapia farming industry to improving in fish health management, including adoption of vaccination, adoption of technological developments and implementation of better routines in fish farms to further improve the productivity and sustainability.

REPRODUCTIVE PERFORMANCE AND OFFSPRING QUALITY OF WILD BROODSTOCK OF THE GIANT AFRICA RIVER PRAWN *Macrobrachium vollenhovenii* FED FOUR DIFFERENT DIETS

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Macrobrachium vollenhovenii is the largest and the main candidate for fisheries and aquaculture of indigenous freshwater prawn in Africa. Though many reports have shown a progressive decline in the wild stock of this species, its culture technique is still under research. This work was to remature wild broodstock of *M. vollenhovenii* in captivity using four different feeds in view to evaluate their reproductive performance and offspring quality.

Experiment was conducted in two phases. In phase one, spent broodstock of *M. vollenhovenii* fed experimental diets: commercial maturation feed (control, T0), maggot (T1), fresh mackerel (T2) and locally formulated feed (T3) and their reproductive performances were evaluated. In phase two their offspring quality in a recirculation system with three replicates per treatment (TL0, TL1, TL2 and TL3) were evaluated for 30 days.

The duration of the gonadal development was significantly different among all the treatments, respectively 28.67 ± 0.58 days and 16.33 ± 1.15 days for T0 and T1 (Table 1). T1 recorded the best GSI (16.08 ± 0.2%). The number of larvae per gram female was significantly different between T0 and other treatments, with T0 recording the least value (519 ± 77 larvae g−1 female). Larval development in TL1 and TL3 were significantly faster than TL0 and TL2. However, survival rate was the best in TL3 (32.17 ± 0.57%) followed by TL0 (29.63 ± 0.33%). The results of this study are evidence of the possibility of successfully re-maturing and breeding this prawn in captivity.

Table 1. Mean ± SD values for the broodstock reproductive parameters in the four treatments

Reproductive parameters	T0	T1	T2	T3
GSI (%)	10.93 ± 0.93^{a}	16.08 ± 0.2^{b}	15.16 ± 0.26^{b}	15.01 ± 0.43^{b}
Duration of gonadal development (days)	28.67 ± 0.58^{a}	16.33 ± 1.15^{b}	19.33 ± 1.53^{c}	24.33 ± 0.58^{d}
Duration of embryonic development (days)	15 ± 1^{a}	16.33 ± 2.52^{a}	15.33 ± 1.15^{a}	15.67 ± 1.53^{a}
Larval fecundity (larvae g−1 female)	519 ± 77^{a}	865 ± 65^{b}	934 ± 135^{b}	813 ± 43^{b}

WETLAND FARMING SYSTEMS IN THE CONTEXT OF GREENHOUSE GAS EMISSIONS POTENTIAL IN MALAWI

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Malawi is endowed with wetland ecosystems that provide essential services to the country's people and the environment. Like the rest of the world, the wetlands are, however, facing challenges to sustain their services due to, among others, lack of research-based evidence to support farming system that balances food production and effort to mitigate greenhouse gas (GHG) emissions. This chapter critically analyzes the link between Malawi's dominant wetland farming systems and GHG emissions. We addressed the following research questions: To what extent will converting wetlands for aquaculture and rice production contribute to GHG emissions, and what could be the potential implications? Given the trade-offs in climate change mitigation efforts and food production, to what extent will integrating the two farming systems mitigate GHG emissions? The chapter instigates debate to uncover much-needed data on how much GHG Malawi's wetland farming contributed to global emissions, its implication, and the future intervention.

FACTORS TO CONSIDER IN TILAPIA BROODSTOCK MANAGEMENT THE CASE OF *Oreochromis andersonii*, GENETIC IMPROVEMENT PROGRAM IN ZAMBIA

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Broodstock management is a critical component of successful aquaculture operations, as it directly influences the quality and quantity of fish seed produced. Effective broodstock management is essential in a genetic improvement program, in view of the high level of investment in terms of time, financial and technical resources required to make the program successful. The following factors have been essential in establishing the breeding program at the Aquaculture Research and Development Centre in Mwekera, Zambia, and may be helpful to other tilapia programs in the region.

The selection of high-quality, genetically diverse founder broodstock. Genetic diversity is essential in maintaining robust and resilient populations that can adapt to changing environmental conditions.

Proper quarantine and health assessment procedures should be carried out to prevent the introduction and spread of pathogens within broodstock populations. In addition, biosecurity measures should always be practised in all farm sections.

Proper feeds and feeding- which includes choosing the correct type of feed, adequate feeding amounts and frequency comprised a critical component of broodstock care at the breeding Centre. A good nutrition plan ensures broodfish receive balanced, species and stage-specific diets that meet their unique nutritional requirements and promote optimal reproductive performance.

Monitoring and record-keeping are integral to broodstock management, all fish are tagged to ensure traceability of individual fish and track their performance in each generation. This data-driven approach supports informed decision-making and the selection of the best broodstock for future generations. When mating, one should consider pairing fish that are unrelated to minimise inbreeding.

Finally, responsible broodstock management should uphold the ethical treatment of broodfish and species welfare. Welfare considerations encompass proper housing, handling, and minimising stress for all handling activities. Broodstock management, therefore requires an understanding and implementation of these key strategies.

Oreochromis andersonii broodstock harvest at the National Aquaculture and Development Centre, Mwekera.

OVERVIEW OF THE BLUE ECONOMY SECTORS IN THE COMESA REGION

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COMESA region is endowed with marine and some of the most ecologically diverse freshwater systems, supporting millions of people with drinking water, food, transport, trade and livelihoods including the largest lakes in Africa, namely, Victoria, Tanganyika, Malawi and Tanna. Three major African rivers, namely, Nile, Congo and Zambezi are present in the region. The region's 21 Member States comprise nine coastal countries, eight landlocked countries and four Ocean States. The estimated population of COMESA is about 583 million (2019 estimates), with a Gross Domestic Product of US$ 805 billion and a global export/import trade in goods worth US$ 324 billion.

COMESA countries have a great blue economy potential that is hugely underdeveloped or underutilised. Traditional sectors such as fisheries, tourism, energy, mineral extraction and marine and river transport are showing evidence of significant development capacities while emerging sectors such as aquaculture, renewable energy (hydro, wind, wave, tidal, solar), marine biotechnology and bioprospecting, blue carbon (carbon storage in mangroves, seagrass and salt marshes), desalinisation do not feature in national priority lists.

The emerging and promising sectors including blue fisheries and aquaculture, tourism, energy, transport /shipping, underwater extractive industries, environment, blue research and innovation, Blue marine biotechnology and bioprospecting remain underdeveloped in the COMESA region. The countries of the region and the COMESA Secretariat are facing strategic and technical challenges in the implementation of the Blue Economy. These challenges are largely interlinked and cut across all Blue Economy sectors and components. These challenges are strategic and technical in their features/characteristics, it needs consorted and harmonized efforts.

NO FISH WITHOUT WOMEN: GENDER-BASED CHALLENGES IN FISH VALUE CHAINS OF EASTERN AND LUAPULA PROVINCES OF ZAMBIA

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Zambia has a highly developed fish value chain, dominated by catches from artisanal fishing on natural water bodies, but increasingly also from aquaculture. Most value-chain actors are from the informal, artisanal sector, which makes the trade dynamic, efficient and resilient to change, but also exposes actors to risks that need careful consideration. Women are an integral part of the fish value chain, particularly in the processing and trade of fish, while men predominate in the production (by aquaculture or fishing) and transport of fish. A 2019 baseline survey for the Fish for Food Security in Zambia project suggested that women working as vendors and marketeers in the fish value chains of Eastern- and Luapula Provinces of Zambia had lower earnings per unit time compared to their male counterparts. In 2022, a more in-depth value chain study was commissioned to understand the gender-based patterns and challenges in these provinces.

A diverse sample of value chain actors (n=330) was interviewed as key-informants at 14 sites in the two provinces, with a focus on places of trade. The results showed remarkable consistency in socio-economic trends between the fish-poor (net-importing) Eastern Province and the water-rich (net-exporting) Luapula Province. Production (fishing on wild fish stocks, but also small-scale aquaculture production) was dominated by male respondents (even though female household members also tend fishponds), as was the transport of fish. Wholesalers of fish were spread evenly across genders, but processors and vendors of fish to the final buyer/consumer was very clearly a female-dominated role.

There were components of the value chain which were clearly dominated by one or the other gender (e.g., men dominating production and transport, while women dominated processing and vending), while some roles (such as wholesale) were more evenly shared. An income gap between male and female traders was confirmed qualitatively. Factors identified were time spent on unpaid work (chores) and unpaid fish processing, selling on behalf of male relatives who produce the fish through fishing or aquaculture, more optimal selling times (early morning) for male traders (while women are still conducting family chores), as well as lost trading days due to menstrual cycles and inadequate and inappropriate sanitary facilities at markets. Interventions to reduce this inequality are explored.

THE ROLE OF THE WORLD AQUACULTURE SOCIETY – AFRICAN CHAPTER (WAS-AC) IN SERVING AND ADVANCING SUSTAINABLE AQUACULTURE DEVELOPMENT IN AFRICA

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The World Aquaculture Society (WAS) was founded in 1969 and its membership has grown significantly in over 100 countries, representing the global aquaculture community. In order to meet the expanding international nature of the Society and to address specific needs in various areas of the world, the WAS has created Chapters in the United States, Japan, Korea, Latin American and Caribbean region, Asian-Pacific region and most recently in Africa.

The African Chapter of the World Aquaculture Society (WAS-AC) was established in November 2018 as a platform to address the needs and aspirations of the African aquaculture sector. The annual meetings of WAS are recognized as the "premier" aquaculture conferences and exhibitions - bringing together a wide variety of aquaculturists from the commercial, academic, governmental, developmental partners and other actors in the field – in line with WAS's vision and strategic plan. In addition to conferencing, the WAS and its partners regularly collaborate on some educational, technological, knowledge building and information exchange initiatives through joint research programmes, seminars/webinars, dialogues, special training courses, general networking, honors and awards programmes, expositions and student development programmes. We encourage aquaculture actors in Africa to join WAS and be part of a network and community active in advancing sustainable aquaculture development in Africa.

FISH RESPONSE TO THE OCCURRENCE OF PATHOGENS FED WITH DIETS WITH PLANT-BASED INGREDIENTS

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In the current context of aquaculture growth, the supplementation of fish diets with alternative plant-based ingredients becomes important, particularly due to its positive impact on fish health and welfare. Evaluating this response can be achieved by subjecting marine fish to challenges with pathogenic bacteria and then assessing their mortality.

The main objective of this work was to evaluate the impact of algae biomasses and extracts, on the gilthead seabream (*Sparus aurata*) and seabass (*Dicentrarchus labrax*) fish survival after a challenge exposure to a pathogenic bacteria.

Based on fish trials performed at Aquaculture Research Station (EPPO/IPMA), where fish were fed four diets with different inclusion of micro- and macro-algae extracts (BLEND1, BLEND2, and BLEND3) and a commercial control diet (Winfast, SPAROS Lda.), according to the plan:

1) 33-35 days after hatching (DAH) post-larvae, were fed the respective experimental diets for 1 week before switching to a control feed for a second week, and returning to the functional feeds for another week.
2) 57-58DAH all fish groups were fed a boost diet for 1 week (BLEND6). BLEND2 was eliminated to give place to a CTRL group that did not receive a boost diet.
3) After, fish were subjected to a stress event (air exposure) and to a challenge test, with a pathogenic bacteria, *Photobacterium damselae* subsp. *piscicida*.

At the end of the challenge tests, the fish fed with diets containing micro- and macro-algae showed no differences in mortality. Although not significant, a tendency for higher survival was observed in the fish fed with the diets containing microalgae extracts. These results suggest that in the early stages, the performance of fish might benefit from the incorporation of micro- and macro-algae in the diets.

Acknowledgements
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CREATION OF A TOOL FOR FISH FARMERS TO IDENTIFY FAST AND SLOW GROWING FISH

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Growth is one of the most important physiological parameters for a sustainable and profitable aquaculture industry. However, a common problem in fish farming is juvenile dissimilar growth that can reduce the market value of harvested fish, increase the production cost, cannibalism and disease susceptibility. As a mitigation strategy in intensive production, frequent grading procedures are employed in the larval and juvenile stages, however, this practice is not financially viable for other production systems. Since growth is related with hereditary genetics, it is essential to better understand genes and regulatory mechanisms controlling this relevant economical trait. This project aims at developing a prediction tool, composed of a panel of biomarkers, including differentially expressed genes and other physiological markers, between fast and slow-growing fish. This tool is designed to improve rearing efficiency, activity sustainability and, most importantly, will help farmers to make informed decisions.

Several gilthead seabream and seabass trials have been conducted at the Aquaculture Research Station of Olhão (EPPO/IPMA). Each trial began when the initial batch started showing growth dissimilarities on weight sampling. After the sampling, fish were sorted into small and big fish, according to the batch average weight. Each condition was separated into tanks on a flow-through system and fed with a commercial diet, four times a day, until apparent satiety. Density was always kept the same, regardless the treatment, in each trial.

Liver, muscle and intestine samples were collected from 6 fish from each treatment for differential gene expression analysis, in each trial. Total RNA was extracted, quantified and quality verified by gel electrophoresis before RNAseq.

Results showed that fast growing outperformed slow growing fishes in both species, indicating a better growth potential of some individuals. Results from the RNA Seq (genes differentially expressed among small and big fish) will be selected to integrate a panel of biomarkers for the construction of the decision tool.

These results are relevant for aquaculture production and genetic prediction programs and can be used as biomarkers for growth. Additionally, it will offer quick and reliable results for farmers and researchers.

Acknowledgments: This study was funded by the project NanoPEIXE - Identification of biomarkers for the creation of a selection tool for giltheads with different growth profiles in aquaculture productions (ALG-01-0247-FEDER-070032).

Table 1. Fish weight on the first and second trials of sea bream (*Sparus aurata*) and the first trial of sea bass (*Dicentrarchus labrax*) separated on small and big fish. Results are shown as mean ± SD and different letters within the same column and trial are significantly different ($p < 0.05$).

Sampling time		Initial weight (g)	Middle weight (g)	Final weight (g)
Gilthead Seabream 1	Small	72.3 ± 8.9^a	-	125.5 ± 13.3^a
	Big	106.8 ±12.3^b	-	200.4 ± 21.5^b
Gilthead Seabream 2	Small	11.6 ± 1.6^a	90.6 ± 27.4^a	215.2 ± 53.6^a
	Big	18.1 ± 1.6^b	190.1 ± 15.8^b	590.9 ± 22.4^b
Seabass 1	Small	27.0 ± 3.1^a	71.2 ± 7.1^a	135.2 ± 17.3^a
	Big	47.1 ± 3.9^b	164.1 ± 10.0^b	297.3 ± 25.5^b

S2AQUAcoLAB: YOUR STRATEGIC PARTNER IN AQUACULTURE

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The S2AQUAcoLAB is a private non-profit institution, founded in 2021, whose mission is to elevate aquaculture to a new level by playing an interface role between academia, research and industry. The coLAB performs research in production optimization, identification of health and welfare markers, climate change adaptations and development of new products for market diversification. Its members include 1 state laboratory (IPMA), 2 higher education institutions (UAlg and PL), 3 R&D centres (CCMAR, UAlg/CIMA and ARDITI), 1 municipality (CMO), 2 producer's associations (Formosa and COOPAQUA) and 9 private companies (Flatlantic, Sparos, Necton, P. Espargueira, Atlantik Fish, Oceano Fresco, Riasearch, SoFish, Docapesca). The S2AQUAcoLAB has 49 associated researchers with proven experience and countless scientific publications in the area and hired, until now, 27 highly qualified human resources. The ongoing research lines comprise: 1) Training of specialized human resources; 2) Optimization of the production of several marine organisms; 3) Analytical tools for the evaluation of bioindicators of health and welfare and the development of *in vitro* systems; 4) Environmental monitoring and adaptation to climate change; and 6) New products, technological development and market. The S2AQUAcoLAB and its network of partners have the infrastructure, equipment and means to pursue scientific research of excellence whilst is exceptionally well-positioned to establish the link between scientific outputs and stakeholders.

The main goal of the S2AQUAcoLAB is to carry out R&D activities with a view to innovation for sustainable and intelligent aquaculture It aims to play an active role in the transfer of knowledge and technology, provide services that increase food safety, and diversify aquaculture products.

Acknowledgments: Project ALG-05-3559-FSE-000021 and Programa Interface (aviso AAC n.º 01/C05-i02/2022)

EMPOWERING AFRICAN COUNTRIES THROUGH TRAINING PROGRAMS FOR A SUSTAINABLE AND SMART AQUACULTURE DEVELOPMENT

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The S2AQUAcoLAB is a private non-profit institution, founded in 2021, whose mission is to elevate aquaculture to a new level by playing an interface role between academia, research and industry. Among its research lines, which include production optimization of several marine organisms, the development of analytical tools to evaluate bioindicators of health and welfare, the development of *in vitro* systems, environmental monitoring and adaptation to climate change and new products, technological development and market, we consider that investing in the training of specialized human resources is of crucial importance for the development of a sustainable and resilient industry, capable of facing future challenges of global food security.

The historical, linguistic and geographical ties between Portugal and the Community of Portuguese Language Countries (CPLP) simplify the communication and cooperation between these territories. Furthermore, Portugal possesses a wealth of experience and expertise in aquaculture and the S2AQUAcoLAB is committed recognize the role of the aquaculture sector and boost its growth. By leveraging this knowledge and providing support, Portugal can facilitate a more efficient and tailored transfer of skills and technology. Additionally, Portugal's status within the European Union allows for easier access to funding and collaborative initiatives, which can significantly benefit the African countries in their aquaculture development efforts. Overall, Portugal's engagement enhances the effectiveness and sustainability of aquaculture development in Africa.

In collaboration with our partners and stakeholders, we have designed training programs tailored to the specific needs of the industry. These programs address critical gaps and focus on both soft and technical skills essential to aquaculture technology. S2AQUA's training initiatives are categorized into three main streams: Essential, Tailored, and Innovation programs, all with the overarching goal of empowering individuals, catalyzing the growth of the aquaculture sector, and stimulating innovation.

Taking advantage of our multidisciplinary team's vast experience in the field of aquaculture, offering these programs is an essential component and a strategic approach to strengthening the aquaculture sector in African countries. In doing so, we aim to pave the way for sustainable economic growth and strengthen the Aquaculture industry, an emerging sector in Africa, crucial to guarantee the food security in the region.

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CABO VERDE AQUACULTURE SPATIAL PLAN

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The aquatic environment, and the livelihoods it sustains, are of enormous relevance for the economic and environmental prosperity of Cabo Verde. The linkage between ecological health and economic prosperity is well established, and aquaculture plays a vital role in growing the blue economy. Cabo Verde's maritime exclusive economic zone has around 700 thousand square kilometres, and its sustainable development requires a forward-thinking roadmap to develop and sustain aquaculture activities.

The Cabo Verde Aquaculture Atlas had the aim of building a world-class governance structure for aquaculture to grow, based on an ecosystem approach to aquaculture while promoting food security and contributing towards the development of the blue economy. The cloud-based Cabo Verde Aqua (CVA) (https://www.cva.blue/) improves decision making to ensure the sustainable management of oceanic resources, placing aquaculture areas as the foundation for sustainable protein and the protection of ecosystems. The Atlas allows exploring onshore and offshore aquaculture areas across Cabo Verde's archipelago, displaying suitable highly suitable and moderately suitable areas for aquaculture development. CVA advocates smart, science-based spatial planning for aquaculture and the blue economy paving the way for a vibrant and sustainable future.

AQUAPONICS, A WAY TO PRODUCE HEALTHY FOOD

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The aquaponic system includes combined production of fish and plants in which the wastes and metabolites produced by farmed fish are removed from the environment through nitration and absorbed by plants. The plants and fish produced in this system are healthy due to the absence of fertilizers and pesticides. In the present study, the quality of tilapia and plant products produced in the aquaponic system have been investigated. Also, sensory evaluation of the cooked tilapia fillet was surveyed

The aquaponic system involves the integration of the hydroponic system with recycling aquaculture in which the wastes and metabolites obtained from farmed fish are removed from the environment through nitration and their uptake by plants. Plants improve water quality by removing compounds from fish waste, as a biological filter. Development of production in aquaponic system is mainly based on water conservation and productivity, independence from agricultural soil, reducing the use of fertilizers and pesticides.

In the present study, the quality of tilapia and plant products produced in the aquaponic system including mint, peppermint, pennyroyal, green basil, purple basil, fodder beet, Swiss chard, various cultivars of lettuce, watercress, celery, and tomato have been investigated. sensory evaluation of the cooked tilapia fillet showed high score for sensory parameters. In all plant products, the amount of nitrite and nitrate were considerably lower than permissible limit of consumption. Peppermint, fodder beet, Swiss chard, watercress and celery had the lowest proline content, while peppermint, fodder beet, Swiss chard were also richer in chlorophyll. Higher levels of proline were obtained in lettuce and basil, indicating more severe environmental stress conditions for them. The amount of protein and iron in plant products were high, however calcium and potassium were a few lower than the desired amount.

EFFECTS OF BLACK SOLDIER FLY (*Hermetia illucens*) MEAL ON GROWTH, FEED UTILIZATION, AND INTESTINAL HEALTH OF NILE TILAPIA (*Oreochromis niloticus*) JUVENILES

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Insect meal is a potentially sustainable novel protein source to replace conventional feedstuffs such as fishmeal and soybean meal that are facing sustainability issues in the face of a rapidly expanding aquaculture industry. The black soldier fly (BSF: *Hermetia illucens*) has shown promising properties among insect species. This study investigated the effects of BSF meal on growth, feed utilization, and intestinal health of Nile tilapia (*Oreochromis* niloticus) juveniles.

A 5-week feeding trial was conducted with Nile tilapia juveniles (initial body weight: 7.28 ± 0.09 g) in tanks (13 L each) in a Recirculatory Aquaculture System (RAS). Three isonitrogenous and isolipidic diets were prepared based on the known nutritional requirement of tilapia to contain 0 % (Control: BSF0), 20 % (BSF20), and 40 % (BSF40) defatted BSF meal. The fish were divided into 3 groups of 16 fish in triplicate tanks and were fed with the diets at 5 % biomass. After the trial, growth performance (weight gain, SGR) and feed utilization (FCR, PER) were improved significantly by BSF meal compared with the control diet. Intestinal mucosal fold length (MFL), muscularis thickness (MT) and goblet cell count (GCC) were significantly increased by BSF meal compared with the control diet. Intestinal goblet cell coverage area (GCCA) was increased in the BSF20 fed fish while microvilli length (MVL) and intraepithelial lymphocytes (IELs) levels were elevated in BSF40 fed fish, compared with the control fed fish. Therefore, these results suggests that BSF meal could successfully be used as an alternative protein source in the diets of Nile tilapia juveniles to promote growth and intestinal health.

Table 1: Experimental diets composition (g/100g)

Ingredient (g/100g)	*Experimental diets*		
	BSF0	BSF20	BSF40
Soybean Meal	38.00	25.00	11.35
Black soldier fly meal	0.00	20.00	40.00
Corn Gluten Meal	25.09	16.22	3.00
Sunflower meal	25.00	25.00	36.00
Sunflower oil	5.50	4.74	3.88
Corn starch	3.15	5.81	2.70
Fish Meal Coppens	1.00	1.00	1.00
Carboxymethylcellulose	0.50	0.50	0.50
Fish premix (0.3%)	0.50	0.50	0.50
Fish oil	0.50	0.50	0.50
Lysine HCL	0.46	0.43	0.27
Gelatin	0.30	0.30	0.30
Total	100.00	100.00	100.00
Proximate composition (g/100g, dry matter basis)			
Dry matter	91.48 ± 0.23	91.92 ± 0.54	92.03 ± 0.92
Crude protein	45.94 ± 1.26	45.69 ± 0.50	45.05 ± 0.35
Crude Lipid	7.03 ± 1.38	7.14 ± 0.25	7.16 ± 1.42
Ash	4.82 ± 0.06	5.43 ± 0.33	6.29 ± 0.87

Table 2: Growth and feed utilization (Mean±SEM) of Nile tilapia juveniles fed with BSF meal.

Parameter	*Dietary administration*		
	BSF0	BSF20	BSF40
Initial body weight (g)	7.25 ± 0.13	7.38 ± 0.00	7.21 ± 0.07
Final body weight (g)	14.02 ± 0.48^{a}	16.71 ± 0.32^{b}	17.96 ± 0.19^{c}
Weight gain (g)	6.77 ± 0.40^{a}	9.34 ± 0.32^{b}	10.75 ± 0.22^{c}
Specific growth rate (%/day)	1.88 ± 0.07^{a}	2.33 ± 0.05^{b}	2.61 ± 0.04^{c}
Feed conversion ratio	1.75 ± 0.07a	1.38 ± 0.04^{b}	1.20 ± 0.02c
Survival Rate (%)	97.91 ± 3.61	93.75 ± 6.25	100.00 ± 0.00
Feed efficiency	0.57 ± 0.02^{a}	0.72 ± 0.02^{b}	0.83 ± 0.02^{c}
Protein efficiency rate	1.24 ± 0.07^{a}	1.58 ± 0.03^{b}	1.85 ± 0.04^{c}
Condition Factor	1.65 ± 0.00^{a}	1.66 ± 0.02^{a}	1.71 ± 0.02^{b}

Table 3: Intestinal histology (Mean±SEM) of Nile tilapia juveniles fed with BSF meal.

Parameter	*Dietary administration*		
	BSF0	BSF20	BSF40
MFL (µm)	130.16 ± 4.19^{a}	145.20 ± 4.30^{b}	140.04 ± 3.38^{b}
MT (µm)	15.09 ± 0.54^{a}	18.47 ± 0.90^{b}	20.07 ± 0.67^{b}
LP (µm)	16.58 ± 0.68	17.01 ± 0.72	19.04 ± 0.83
IELs (n/100 enterocytes)	20.82 ± 0.30^{a}	21.76 ± 0.31^{ab}	22.29 ± 0.22^{b}
GCC (per 100 µm)	7.87 ± 0.31^{a}	10.44 ± 0.33^{b}	10.04 ± 0.34^{b}
GCCA (µm)	3.79 ± 0.32^{a}	4.95 ± 0.27^{b}	4.65 ± 0.32^{ab}
MVL (µm)	0.86 ± 0.01^{a}	0.87 ± 0.01^{a}	0.98 ± 0.01^{b}
MVD (%)	94.06 ± 0.07	93.75 ± 0.83	94.32 ± 0.51

CHICOA FISH FARM: LESSONS IN INDUSTRY BUILDING

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Chicoa Fish Farm was established in 2015 on Lake Cahora Bassa, Mozambique. It was built to be an anchor farm for a new sustainable Aquaculture industry. From experience, we had seen that smallscale farmers tend to develop around commercial farms, where inputs are readily available. The commercial viability of the farm is also dependent on overcoming the regulatory hurdles of a new industry, which lays a groundwork for new entrants.

The Chicoa peninsula was virgin bushland in 2015. We built a 3 km road to the farm site, which was completed in our first 6 months of operations. The farm spent the first 4 years without electricity. We pioneered using offshore breeding (which does not need electricity) as an alternative breeding technique.

Today, Chicoa has an installed capacity of 3,500 tonnes per annum and a processing facility with freezing capacity. We employ over 200 local members of the community at the farm. Our tilapia fish is sold into Zambia, Mozambique and Malawi. Through our partnerships with the Ministry of Fisheries, we are supporting smallscale aquaculture in four provinces within Mozambique. Since 2015, we have raised over USD 15 million in equity, debt and repayable grants.

Our development projects are ongoing in Tete, Manica, Maputo, Sofala, Inhambane, Niassa and Zambezia provinces. Our projects can be grouped as follows:

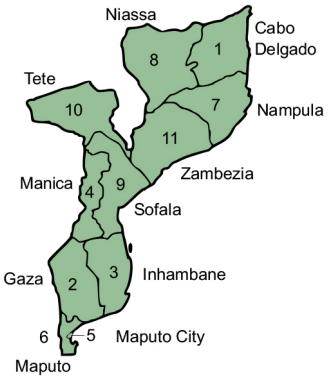
Small-scale farmer development: aquaculture training, technical assistance, access to inputs and identifying routes to market.

Informal or small trader market development: fish handling training, technical assistance, access to fresh or frozen product, equipment and delivery of fish into markets.

Nutritional security: at a national developmental scale, Chicoa is actively addressing the protein deficit prevalent in Mozambique by producing affordable, sustainably grown proteins that low-income consumers are able to access.

Cross-cutting through our impact projects is a gender-intentional approach. We also prioritise a livelihoods approach whereby we seek to ensure that all our activities are actively increasing the incomes of those involved or partnering with us.

In our contribution we will share the lessons that we have learnt in how to approach industry development in our context, the opportunities to accelerate this process, and how to build a business model that attracts appropriate investment.



SECOND ANNUAL FINANCING & INVESTMENT SESSION: UNLOCKING THE POTENTIAL OF AFRICAN AQUACULTURE

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The First Financing and Investment Session was held during the Africa's inaugural AFRAQ Conference in Alexandria, Egypt in March 2022. To continue the dialogue towards tangible results, the 2nd Finance and Investment Session during AFRAQ23 will build from these discussions and set forth a roadmap.

The potential of aquaculture development for Africa's economic growth is well recognized and supported with a considerable "blue food" demand that is consistently unmet by capture fisheries. A great deal of projects both globally and in Africa, have been financed with mixed results. There is increasing interest by the private sector, development finance institutions and governments to invest in aquaculture value chains in Africa. Global investment companies are exploring opportunities to establish financing and investment mechanisms to further support aquaculture businesses in the African continent, including those that are not yet of direct commercial interest to the commercial companies. A coordinated, strategic and innovative approach to financing and investment is needed to ensure that national, regional and continental policies, strategies and aspirations are met and that initial investments are used to catalyze additional financing to fully realise aquaculture value chains in a viable and sustainable manner.

The First Financing and Investment Session held during the 2022 AFRAQ Conference, successfully convened a wide range of stakeholders to share experiences and identify some of the priority actions. These ranged from improving coherency in the national and regional policy environment, to promoting innovative investment models, and leveraging existing financial instruments to support the small-scale entrepreneurs in Africa, to establishing a pan-African mechanism for collecting and sharing information on aquaculture issues and investment opportunities.

Using the above as a point of departure, a small informal multi-stakeholder group of interested organizations and investors have collaborated since the last AFRAQ event to share knowledge and identify ways to support aquaculture businesses through increased investments into sustainable aquaculture within the region. In order to drive tangible results for finance and investment the industry, the 2nd Finance and Investment Session during AFRAQ23 will build from these discussions and set forth a roadmap.

BIOFLOCS TECHNOLOGY IN FRESHWATER AQUACULTURE: VARIATIONS IN CARBON SOURCES AND CARBON – TO – NITROGEN RATIOS

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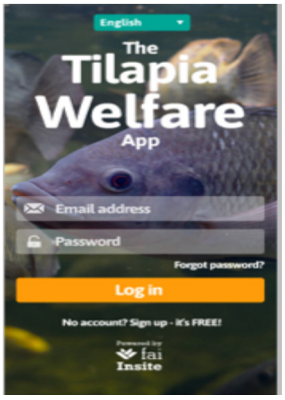
As the world population grows steadily, worldwide food production needs to increase to fill the gap in supply and demand. Aquaculture is one of the fastest food-producing sectors contributing half of the food fish destined for human consumption. Nevertheless, aquaculture production still needs to increase to fill the gap in supply and demand for fish as the capture fisheries is stagnating over the years. Therefore, intensification of the aquaculture production system by increasing inputs such as feed has been devised as an alternative. On the other hand, intensive aquaculture has been associated with concerns related to environmental pollution in the past decades. Moreover, the increased cost of feed ingredients for aquaculture species such as fish meal has hampered the intensification of the sector. Therefore, alternative production systems such as biofloc technology were developed to mitigate the environmental impacts of intensive aquaculture and also to produce extra feed for cultured organisms. Biofloc technology is a production system in which C: N ratio adjustment is conducted to immobilize the toxic nitrogenous wastes in to microbial cells to maintain the water quality of the culture water to optimum levels and production of extra feed in the form of single cell protein for cultured species. Due to their omnivorous feeding habit and tolerance to higher levels of suspended solids, freshwater finfishes such as tilapia, catfish and carp have been the most cultured species in this system. Manipulation of the C: N ratio of the culture systems is prepared either by adding organic carbon sources to the culture water or by adjusting the formulation of a diet in such a way that the C: N ratio is above 10. The organic carbon sources used in the biofloc system are agricultural and industrial by-products which are cheap and readily available making the technology economically feasible. Although C: N ratios of 6 and 30 are also applied, 10, 15 and 20 have been the most applied C: N ratios in the culture of freshwater aquaculture finfishes covered in this review. Biofloc technology can be a promising alternative for freshwater aquaculture in developing countries such as Ethiopia in which intensive fed aquaculture is limited due to lack of capacity for better quality feeds and culture systems such as recirculation aquaculture systems. However, challenges related to knowledge gap and higher energy requirement may hamper its application in freshwater aquaculture in developing countries. Therefore, capacity building and alternative sources of energy such as solar energy can be applied to tackle the limitations.



USING OPERATIONAL WELFARE INDICATORS FOR BETTER TILAPIA WELFARE IN AQUACULTURE

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In contrast with livestock, animal welfare in aquaculture remains a highly neglected topic. Where the few welfare standards for aquaculture exist, the implementation model is usually top down, meaning that certification bodies are the ones stepping in to address rising consumer awareness about poor farming conditions. However, this model has its limitations as it relies on a niche of educated and sympathetic consumers. Little effort has been made to understand, support, and encourage farmers' own intrinsic motivation to achieve good animal welfare. Farmers are the most important actors driving improvements in aquaculture production chains and their willingness to produce food in better ways can be supported through practical farm assessments that align both business and animal welfare objectives.

Farm animal assessment

Working with scientists and farmers in Brazil, Thailand and China, Food Animal Initiative (FAI) has developed a new bottom-up approach for the assessment of farm animal welfare. The assessments help farmers understand what good animal welfare looks like and show them how it can naturally lead to the better fulfilment of the animals' nutritional, health, environmental and behavioural needs. Welfare assessments can kickstart a positive spiral of improvements, tapping into farmers' innate need to be better and do better. If a problem is identified, actions are likely to be taken to fix or improve it, resulting in better animal welfare. The assessment protocol and tool developed by FAI can be used by farmers and/or other stakeholders. The tool users are guided through a series of simple questions that will help them to monitor and drive progress regarding welfare and best practices.

What will the framework deliver to the tilapia farming and supply chain?

- Protocols that use scientific and operational indicators for tilapia;
- Support for other scientists and practitioners who want to use our rigorous methodology to develop welfare indicators for other species;
- A free application for farmers to perform self-assessment and help them monitor and improve welfare and production outcomes. The app monitors progress, identifies improvement gaps, and provides immediate feedback to the user; and
- Free online training series aiming to guide those involved in the sector.

Conclusion and next steps

With the proven successful application of the framework and tools in Brazil, Thailand and China, we understand that Egypt would be the next logical region in which to introduce this, given it is one of the major tilapia producing countries in the world. FAI and partners aim to develop partnerships in Egypt to replicate this initiative in a way that is tailored to the country's culture and production systems, whilst being driven by science and practical knowledge.

ECOLOGICAL AND PRODUCTION CARRYING CAPACITY OF LAKE KARIBA ZAMBIA AND ZIMBABWE

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Excessive loading of Phosphorus from cage fish farming and the catchment into lakes can lead to eutrophication. Therefore, this study was designed to estimate the ecological and production carrying capacity of Lake Kariba and its four basins. Furthermore, to investigate the total catchment export of P and the impact on production carrying capacity on basin four. In the current study, three models, two lake capacity models, the Dillon & Rigler (1975), and Organisation for Economic Cooperation and Development (OECD) (1982) models, and a catchment loading model, the Nutrient Deliver Ratio (NDR) were used. The ecological and production carrying capacity of the whole lake according to Dillon & Rigler model were 1613.8 tonnes P yr−1 and 109040 tonnes of fish yr−1, respectively. Furthermore, the ecological carrying capacity of Mlibizi, Binga, Sengwa and Sanyati basins were 118, 167, 556 and 877 tonnes P yr−1, respectively according to Dillon & Rigler while 0.006, 0.120, 0.530 and 0.954 tonnes P yr−1 were the ecological carrying capacity estimated using OECD for the same basins. Moreover, the production carrying capacity for the same basins according to Dillon & Rigler were 797, 11316, 37562 and 59274 tonnes yr−1, while OECD estimated 432, 8650, 38100 and 68500 tonnes yr−1. Also, a total of 3239 tonnes of surface P were produced in the catchment but only 406 tonnes of P were exported to Sanyati basin, reducing the estimated production capacity by almost 50%. We recommend gradual and careful increase in cage fish farming, physical carrying capacity and further studies using advanced lake P modelling tools in Lake Kariba.

INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) MODEL FOR CO-CULTURE OF SEAWEED AND SEA CUCUMBERS: EXPERIENCE FROM A SEA-BASED COMMUNITY FARM IN PEMBA, ZANZIBAR, TANZANIA

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Mariculture has proved to be an important source of income generation and improvement of livelihoods for coastal communities worldwide including Tanzania. However, most of the mariculture development initiatives in Tanzania are hampered by unavailability of quality and affordable seedstock, feeds and simple technologies. Most of the seedstock, especially for marine organisms (such as sea cucumbers), are collected from the wild which threatens the depletion of wild populations and decreases the chances of reproduction of these sessile animals. Integrated multi-trophic aquaculture (IMTA) involves farming of two or more organisms from different trophic positions or nutritional levels in the same system to improve efficiency, reduce waste, and provide ecosystem services. A study of the development of blue future through piloting an IMTA was conducted to assess the feasibility for piloting integrated seaweed-sea cucumber model. The study also aimed at using the IMTA in the production of sea-cucumber seeds for sustainable mariculture. A local sea-based community seaweed (*Eucheuma denticulatum*) and sea cucumber (*Holothuria scabra*) farm was established at Chokocho, Mkoani District in South Pemba. A site suitability assessment was successfully conducted where special emphasis was given to socio-ecological conditions that support integrated seaweed/sea cucumber mariculture. Evaluation of community perceptions of the IMTA indicated that almost all respondents supported this mariculture farming system. Farmers reported that integrated faming of either seaweed and sea cucumber or milkfish and sea cucumber would improve their income generation and living standards. All respondents recommended scaling up the IMTA model because it has a potential to increase income, maximize productivity, provide employment and alleviate poverty.

THE ECOLOGICAL, SOCIAL AND ECONOMIC FACTORS HINDERING AND CONTRIBUTING TO SUSTAINABLE AQUACULTURE DEVELOPMENT

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The aquaculture sector in South Africa forms part of Oceans Economy narrative, and this sector has a significant growth potential due to the rising global demand for fish products; the eagerness of the middle-class to raise their income in emerging nations; and the increased knowledge of the dietary benefits afforded by fish products. There are numerous roadblocks to aquaculture's progress in meeting global food security and economic growth goals as well as reducing strain on wild-caught fisheries stocks. However, in comparison to its potential, the aquaculture sector is underperforming. It contributes minimally to the country's fisheries products, gross domestic product, and revenue. Noticeably, some significant barriers for aquaculture development includes shortage of zoned and serviced land constraints, rising production costs, access to capital and markets, unsupportive legislation, undeveloped value-chains, and regulatory environment. The paper aims at evaluating the status of aquaculture development and challenges hindering the development of the sector and come with a formative tool that addresses its potential challenges and aquaculture growth prospects. The Ecological Economics lens will be adopted to examine the ocean benefits, conservation, economic opportunities, value chains, economic spin-off, suitable species farming, and environmental protection.

This paper will adopt pragmatism to carry out the study. This study will employ a mixed method approach to collect data in order to provide a more collaborative and complex perspectives on aquaculture development, experiences, explanations, and thoughts through questionnaires, interviews, and observations. Using purposive sampling, seventeen key role players in the national, provincial, local government, aquaculture associations, academics, farmers affected by the aquaculture development will be interviewed to gather meaningful information from experts and professionals. Probability approaches will also be used to sample 300 respondents and structured questionnaire will be administered to them. For data processing and analysis, the researcher will employ NVIVO and SPSS software to synthesize the key themes surrounding the economic, policy, and challenges affecting the development of aquaculture and thereby thematically discuss them. The study is intended to contribute to the body of knowledge of aquaculture development and improve its footprint that considers the economy, society and environment, and simultaneously securing investments and providing more skills.

DEVELOPING RESPONSIBLE AND SUSTAINABLE AQUACULTURE OF *Oreochromis niloticus*: THE CASE OF LAKE HARVEST, ZIMBABWE

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Background

Studies indicate that aquaculture is growing fast in South East Asia and China. While Africa's production growth potential in this lucrative farming is enormous, a lot needs to be done. A recent report indicates that since 2000, aquaculture production in sub-Saharan Africa (SSA) has grown by 11% annually on average. This represents almost twice as fast growth compared with the rest of the world, with a few countries growing at 12–23% per year (FishStatJ 2019). SSA continues to account for less than 1% of global aquaculture production (FishStatJ 2019). To meet the large supply demand of fish, SSA's fish imports were 1.5 times higher between 2015 and 2019 than its aquaculture production (Chan, C. Y. et al. 2019). Due to overfishing, catches have declined and Africa has to increase fish farming by 250% to maintain the same rate of consumption says the New Partnership for Africa's Development. Private sector investments led to aquaculture expansion across SSA's inland water, from 9 cages in 2006 to more than 20,000 in 2019.

The story of Lake Harvest

Established in 1997 in Zimbabwe, Lake Harvest boasts of having the most integrated indigenous fish farming operations in Africa. The company has managed to develop a sustainable aquaculture which is considered as the biggest aquaculture undertaking of Oreochromis niloticus in Africa. It has operations in three countries and has distribution networks in seven countries. According to FAO (2020), aquatic value chains require innovations to make them more efficient, transparent, responsive, inclusive and equitable. Its value chain is made up of breeding fingerlings in hatcheries, fish feed, harvesting, logistics, marketing and consumers. It also runs a fish processing plant and a feedmill to produce fish feed. The bream is sold fresh or frozen locally and exported to seven African countries.

Nile tilapia

The *Oreochromis niloticus* is a native fish to many parts of Africa, the Maghreb or the Levant (especially Israel and Lebanon)[1] and much of Southern Africa. It is commonly known as the Nile tilapia. It is a species of tilapia, a cichlid fish. In Zimbabwe where it is farmed extensively by Lake Harvest it is referred to as the bream. The Nile tilapia reaches up to 60 cm (24 in) in length (Froese et al. 2015), and can exceed 5 kg or 11 lb (Nico et al 2019). The Nile tilapia thrives in fresh and brackish waters but is unable to withstand long-term saline water. It would appear that the Nile tilapia has been a celebrated culinary dish in Primordial Egypt and it is seen in pieces of art (Nico, Schofield; and Neilson 2019).

Froese, Rainer; Pauly, Daniel (eds.) 2015. Oreochromis niliticus. Fishbase.

GENDER IMPACTS OF AQUACULTURE INTERVENTIONS IN CLIMATE HOTSPOTS IN ZAMBIA

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Using the Pro-WEAI to measure empowerment, the research in Northern Zambia evaluated the gender-related impacts of aquaculture projects. The research objectives included assessing the effects of two aquaculture interventions on gender-equal access and control over resources, technology, and information among smallholder farmers, evaluating the impact on climate resilience among smallholder fish farmers, and examining overall gender equality and women's empowerment in aquaculture. The research employed a mixed-method design, combining quantitative surveys, qualitative interviews, and discussions. Data was collected from 322 households (644 respondents) in treatment districts and 178 households (356 respondents) in control districts. Data analysis involved descriptive analysis, impact analysis using Average Treatment Effect (Ate) Propensity Score Matching, and a women empowerment analysis using pro-WEAI.

Women in treatment districts had a higher aggregate pro-WEAI score (0.88) than those in control districts (0.83), indicating greater empowerment among women in the treatment areas. The proportion of empowered women was higher (65%) in treatment districts compared to control districts (58%). The average empowerment gap between women and men within households suggested reduced disparity between female and male farmers in treatment districts. The main indicators contributing to disempowerment among women in the treatment district were access to credit and decision-making, work-life balance, and visiting important locations.

The interventions enhanced women's involvement in aquaculture, improved gender equality in access and control over resources, technology, and information, promoted gender equality in climate-resilient practices, and enhanced women's empowerment. However, there was limited evidence to support improved gender equality regarding benefits from the food system.

GENETIC DIVERSITY AND POPULATION STRUCTURE OF FARMED AND WILD NILE TILAPIA (*Oreochromis niloticus)* IN UGANDA: THE POTENTIAL FOR AQUACULTURE SELECTION AND BREEDING PROGRAMS

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Nile tilapia is one of the most important aquaculture species globally, providing high-quality animal protein for human nutrition and representing a source of income to sustain the livelihoods of many people in low and middle-income countries. This species is native to Africa, but the genetic makeup of its wild and farmed populations remains poorly characterized. Additionally, there has been important introgression and movement of farmed (and wild) strains connected to tilapia aquaculture, but the relationship between wild and farmed populations is also unknown in most of the continent. Genetic characterization of African populations has the potential to support the conservation of the species and selective breeding to improve the indigenous strains for profitable aquaculture production.

In the current study, a total of 382 fish genotyped for 60,785 genome-wide single nucleotide polymorphism loci were utilized to investigate the genetic structure, ancestry, diversity, and inbreeding levels within and between farmed and wild Nile tilapia populations in Uganda. The presence of putative signatures of selection was also investigated in the genomes of the studied tilapia populations. The wild fish in the current study were sourced from Lake Albert, Lake Kyoga, and Lake Victoria, while the farmed fish were sourced from 10 hatchery farms located mostly in the catchment regions of the three lakes (Figure 1).

We observed a clear genetic structure of the fish sourced from the lakes, with L. Kyoga and L. Albert populations showing higher genetic similarity. However, L. Victoria's population was genetically distinct from fish of both L. Albert and L. Kyoga. Among the farmed populations, we also observed noticeable genetic structure among farmed populations, with most of them being genetically similar to L. Albert and L. Kyoga fish. Indeed, our admixture results showed a higher (4 – 53.2%) contribution of L. Albert / L. Kyoga strains to Uganda's farmed fish than the strain from L. Victoria (0.8 – 31.7%). We observed relatively high genetic diversity and low inbreeding rates across both wild and farmed populations, but some farms had sizable numbers of highly inbred fish, raising concerns about management practices. Finally, we identified a genomic region on chromosome 5, harbouring a key innate immune gene *BPI* and the key growth gene *GHRH,* putatively under selection in the Ugandan Nile tilapia population. In addition, this region overlaps with the genomic region previously identified to be associated with growth rate in farmed Nile tilapia.

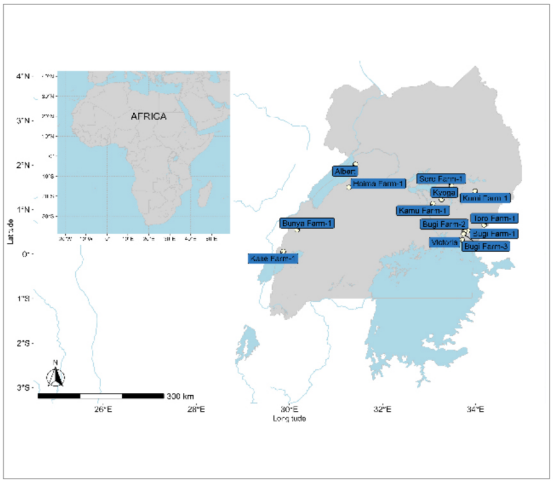

Figure 1*: Map of Uganda showing the locations where Nile tilapia samples used in the current study were collected.*

THE IMPACT OF TECHNOLONOLOGIES FOR AFRICAN AGRICULTURAL TRANSFORMATION AQUACULTURE COMPACT ACTIVITIES IN ZAMBIA

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This submission highlights the Technologies for African Agricultural Transformation (TAAT) Project activities in Zambia for the period 2018 to 2020. The project was an initiative of the African Development Bank (AfDB) through WorldFish which was aimed at disseminating and upscaling aquaculture technologies across Africa to increase the productivity and income of fish farmers, increase fish protein consumption and enhance sustainability across the aquaculture value chain. Zambia was one of the focal Country of the ten (10) African countries in which the TAAT activities were implemented. The activities of the compact centred on the use of hapas in the production of tilapia mono sex fingerlings, use of fish feeds, fish processing using improved solar dryers and smoking kilns for improved fish productivity. Mukasa Agrosolutions which operates a fish hatchery based in Kabwe in the Central part of the country was identified as national demonstrator of the use of hapas in the improvement of the fingerings production.

The use of hapas increased the sex reversal rate from 90% to 98%. This is because the technology enhanced the oral treatment and administering of methyl testosterone (MT). Consequently, the production capacity of the fish hatchery increased from 360,000 in 2018 to 3 million fingerings annually by the end of 2020.

The TAAT impacted youths and women in Zambia positively as it demonstrated that with the utilisation of the technologies that aquaculture is a viable business for them to engage in. The programme has managed to reach to 2,140 youths and women who work on fish nutrition improvement interventions which has helped them improve their revenue base. A total of 250 fish farms and fish value addition businesses have since been established by the trained youths and women resulting into the creation of approximately 10,000 jobs both indirect and direct within fish value chain.

SAPROLEGNIOSIS IN *Oreochromis andersonii* AND *Clarius gariepinus*: CONFIRMATION AND PREVENTION METHOD IN CENTRAL PROVINCE OF ZAMBIA

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Promotion of aquaculture in Zambia has contributed to the exploitation of different culturing systems and species. This promotion has led to utilization of intensive systems which are associated with high stocking densities and poor water quality, a scenario that renders fish to high risk of diseases characterized with clinical signs such as tail and fin rot, gill rot, red spot and dropsy. In Zambia Saprolegniosis has been a serious threat to the aquaculture industry. Therefore, this study evaluated possible treatments for saprolegnia in aquaculture in Zambia following its identification. The objective was to investigate Saprolegnia occurrence in diseased fish and elaborate on possible preventive treatment. The investigation was carried out by isolating and identifying Saprolegnia using phenotypic methods followed by a treatment regime of boric acid.

A total of 20 fish of each species (*Oreochromis andersonii* and *Clarius gariepinus*) showing signs of Saprolegniosis were picked from the culture systems and postmortems conducted on site and organs were extracted for media culture on Sabouraud dextrose agar (SDA). Saprolegnia was seen growing on *Oreochromis andersonii* specimens while no growth was observed on Clarius samples. At farm level the same number of fish were exposed to different levels of Boric acid concentrations ranging from 0.2g/L, 0.4g/L, 0.6g/L and 0.8g/L for 10days. It was observed that in the tank with a concentration of 0.8g/L, complete recovery.

In conclusion results from this study will help fill the knowledge gap on effective control of Saprolegnia in *Oreochromis andersonii* and *Clarius gariepinus* cultured for increased productivity as there will be few losses of fish resulting from disease.

MIXED FEEDING SCHEDULE OF LOW AND HIGH FREQUENCY IN THE DIET OF NILE TILAPIA (*Orechromis niloticus*) FINGERLINGS: EFFECT ON GROWTH PERFORMANCE, BODY COMPOSITION AND HAEMATO-IMMUNOLOGICAL, STRESS RESPONSES AND ECONOMICS IN LOW INPUT PONDS

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The high costs of fish feeds and chemical fertilizers have been a major bottleneck to the development of Nile tilapia farming. Stable carbon and nitrogen isotopes was used to assess the relative contribution of commercial diet and natural food sources to the growth Nile tilapia reared in ponds. Haematological, biochemical, and body composition of fish were also examined. Nile tilapia fingerlings (5.6 ± 0.14 g; mean±SE) were fed following a mixed feeding schedule with the feeding cycle of 28 days that consisted of either 28 days feeding once/day daily (28d-1/d) or 4 times/day daily (28d-4/d), or 14 days feeding once/day and 14 days feeding four times/day (14d-1/d+14d-4/d) or 21 days feeding once/day and 7 days feeding four times/day (21d-1/d+7d-4/d) or 25 days feeding once/day and 3 days feeding four times/day (25d-1/d+3d-4/d) for 90 days. Fish and water quality were sampled after every 28 days, while blood and various feed sources were sampled after 84 days. Stable carbon and nitrogen isotopes were carried out to determine the relative contribution of the nutrient sources to fish growth. Higher ($P < 0.05$) growth and better health condition were found in the 14d-1/d + 14d-4/d group, which was similar to 21d-1/d+7d-4/d group. The highly enriched $\delta^{15}N$ values of cattle dung in relation to phytoplankton and zooplankton in all the treatments suggest minimal contribution of cow dung to primary or secondary productivity. However, beyond their value as fertilizer, chicken droppings represent an immediate source of food for tilapia. Natural feed is the main contributor to the growth of Nile tilapia, hence enhancing natural productivity should be underscored under SIFS, especially for small-scale fish farmers whose profit margins tend to be marginal.

EFFECT OF *Faidharbia albida* ON THE GROWTH AND SURVIVAL OF *Oriochromis andersonii* GROWN IN HAPAS

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The effect of graded levels of *Faidharbia albida* leaf meal on the growth and survival of the three spotted bream, *Oreochromis andersonii* was investigated. Different concentrations of *F. albida* leaf meals; 0 (control), 10, 20, 30, and 40% were incorporated into the 35% crude protein diet of *O. andersonii*. One hundred and twenty (120) *O. andersonii* fingerlings (4.2-11.2g pooled weight and 6.2-10.3cm pooled standard length) were randomly allotted to four *Faidharbia albida*-based diets at a stocking density of eight (8) fingerlings per net hapa (50 x50 x 50cm deep) installed in three (3) 2 x 1.2x 1m concrete ponds in a completely randomized design. The fingerlings were fed with *Faidherbia albida* leaf meal diets for 45 days. The results show that fingerling fed with a 10 % *Fairdhabia albida* leave-based diet had better weight gain (7.13g), specific growth rate (0.50%/day), and survival rate (95.86%). *Faidharbia albida* leaf meal can be added to the diet of *O. andersonii* at 10 -20 % per kg of diet to improve growth and survival in *Oreochromis andersonii*.

MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF THE THREE SPOTTED BREAM *Oreochromis andersonii* (CASTELNAU; 1861)

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Zambia is the sixth largest aquaculture producer in Africa. However, the aquaculture sector in Zambia still faces challenges which include, among others, inadequate supply of quality seed, inappropriate farming technologies and high cost of feed. The industry is dominated by tilapia species, with the majority of fish farmers still using inferior stocks, particularly the local species. To address the challenge of inferior stocks, the government has initiated the genetic improvement of *O. andersonii*, a key local species in Zambia. However, there are gaps regarding the genetic diversity of the species. A study was therefore undertaken to investigate the morphological- and genetic diversity- among four populations of *O.andersonii* in Zambia using two approaches; geometric morphometrics and microsatellite markers, respectively.

In the first approach, data for geometric morphometrics, was collected by taking digital images of four different populations of *O. andersonii*, these images were processed by TPSDIG software and analyzed using MorphoJ program. The spline deformation grids showed different forms of deformations across the populations, especially in the head region, and the deformations on the mouth were clearly visible. The space defined by the first two canonical vectors disclosed two groups of populations, one formed by the Zambezi population; and a second representing the Mwandi, Kafue and Luangwa populations.

The second approach used molecular characterization to assess the genetic variability of *O. andersonii* across six microsatellite loci among the four populations. The Luangwa population had the maximum degree of variation (He = 0.528) whilst the Zambezi population had the least degree of variation (He = 0.351). Sub-structuring was found and a rooted phylogram of the populations showed two major distinct branches, with the Zambezi distinct from the rest of the populations.

These preliminary results indicate variation among the populations of *O. andersonii* under this study, providing evidence of potential genetic improvement in the species.

INCREASING TILAPIA SMALL-SCALE PRODUCER BENEFITS VIA INSECT BASED FEED IN ZIMBABWE

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The nutritious larvae of black soldier fly offer great potential to improve autonomy and resilience of small-scale tilapia farmers in Zimbabwe. Together with the Chinhoyi University of Technology (CUT) and thanks to the support of the European Union, The German Federal Ministry for Economic Cooperation and Development and the Organisation of the ACP States, FAO led FISH4ACP is trialing black soldier fly production – and black soldier fly-based fish feed with four small-and medium-scale enterprises.

Tilapia consumption in Zimbabwe has gained in popularity but is more expensive than other fish. High costs of production are mainly due to a reliance on imported feeds and feed ingredients, which are affected by macroeconomic factors such as foreign currency exchange rates and inflation.

Black Soldier Fly (BSF) larvae have gained prominence world-wide as a protein rich alternative feed ingredient for many livestock feeds. They are widely recognized for their good nutritional potential and a strong immune system that prevents the spread of diseases. Other benefits include a low carbon footprint, being pro-poor and supporting local autonomy as they can be produced locally using local waste products at either smaller or larger scales.

Farmers and government officers have been trained in BSF production and feed formulation and are ready for production and feeding trials – both on selected farms and at the university. Using live larvae as a feed supplement, rather than a feed ingredient, will be compared as well, both in terms of feed conversion ratio (FCR) and the costs-benefits.

THE EFFECTS OF *Carica papaya* SEED POWDER IN *Oriochromis andersonii* AS AS A MEASURE TO REDUCE REPRODUCTIVE PERFORMANCE

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The present study was carried out to evaluate the ability to use Pawpaw seeds powder as a natural reproductive inhibitor for three spotted bream (*Oreochromis andersonaii*) to control their propagation. The experiment was divided into two treatments T1 and T2 and a commercial feed, both T1 and T2 replicated twice each; the first was treatment one (T1) during which the *O. andersonaii* were treated with Pawpaw seeds powder 5g for 45 days and the second was the T2 whereas the *O. andersonaii* was treated with 4g of Pawpaw seeds powder. The juveniles were obtained from the ponds and graded according to sex manually, the males and the females were close to the sexual maturation or breeding stage. The male juvenile fish and female juvenile fish were placed in different ponds to prevent early breeding before they were fed different levels of Pawpaw seeds powder. This was done to avoid biases in the results. The Pawpaw seeds powder was added to the fish meal diet at different levels of 4g and 5g/kg diet for 45 days. According to the observation of this study, the result shows that. Also, the high levels of Pawpaw seeds powder (5 g / kg diet) caused obvious histological alternations of the testes and ovaries of *O. andersonii* which reduce the fertility of both males and females. Consequently, it could be recommended that the effective use of Pawpaw seeds powder as a natural reproductive inhibitor for *O. andersonii*.

Moringa oliefera FEED ADDITIVE AS A NUTRIENT SUPPLEMENT FOR AQUAPONICS LETTUCE AND *Clarias gariepinus* PRODUCTION

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Aquaponics is a symbiotic relationship among plants, fish and beneficial bacteria that convert ammonia and nitrite, both toxic to fish, into less toxic nitrate that plants can use. The main challenge in such a system is the imbalance of nutrients between the fish and plants grown, as each has different nutritional requirements. The requirements of fish are met through fish feed and those of plants by supplementing nutrients, especially trace elements, through nutrient solutions, which adds extra costs to the production system. The aim of this study was to design a feed that fulfills a dual role: provide optimal nutrition to *Clarias gariepinus* and optimize lettuce production.

The experiment was conducted for 60 days in triplicate with two treatments: T1 = *C. gariepinus* commercial feed (control) and T2 = *C. gariepinus* commercial feed with *Moringa oleifera* leave powder; in two separate lines of a deep-water recirculating aquaculture system of three (100 L) containers. The stocking density was 25 juveniles (Mean weight = 49.1±.51g) per tank. They were fed at 5% body weight, three times a day. Lettuce seedlings were simultaneously planted in perforated plastic cups with pebbles and placed in holes on the raft floating on each of the fish tanks.

The fresh biomass of lettuce leaves in T2 recorded the highest weight increase (90.62±0.81 g) which differed significantly (P<0.05) from T1 (57.00±1.23 g). Fish weight gain was significantly higher in T2 (300.3±6.55 g) than T1 (231.9±5.24 g). There was no significant difference (P>0.05) in fish length in T1 (24.93±.16 cm) and T2 (24.89±.13 cm).

This study revealed that the inclusion of *M. oleifera* as feed additives in *C. gariepinus* feed improved lettuce growth and fish weight gain. It can be concluded that *M. oliefera* leaves contains enough minerals that can be used to reduce or even eliminate the need to supplement plants with nutrients in an aquaponics system. It could therefore be recommended that *M. oleifera* leaves be included in *C. gariepinus* feed in aquaponics production system.

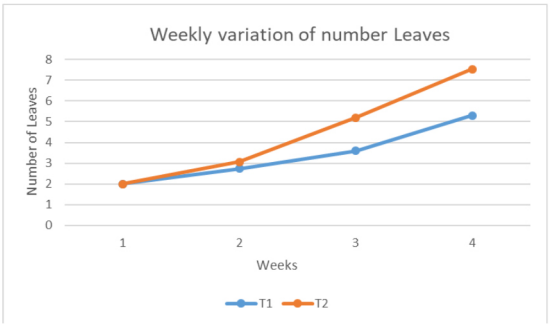

Fig1. Weekly evaluation of lettuce leaves in the two treatments

Table 1. *Clarias gariepinus* growth parameters during experimentation

Parameters	T1	T2	P-Value
Initial Length (cm)	14.84±.15	14.64±.21	0.450
Final Length (cm)	24.93±.16	24.89±.13	0.852
Mean Length Gain (cm)	10.08±.30	10.24±.28	0.707
Initial Weight (g)	49.1±.51	49.1±.97	0.952
Final Weight (g)	281.0±5.25	349.47±6.60	0.000
Mean Weight Gain (g)	231.9±5.24	300.3±6.55	0.000
Condition Factor (k)	24.62±2.50	29.62±2.30	0.153

DETECTION OF BACTERIAL PATHOGENS FROM DISEASED NILE TILAPIA (*Oreochromis niloticus*) IN POND AND CAGE CULTURE SYSTEMS IN ZAMBIA

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The study investigated disease outbreaks in farmed *Oreochromis niloticus* (Nile tilapia) establishing bacterial etiological agents. The study was conducted in central and southern regions in Zambia among large commercial producers. A total of 172 fish samples (fingerlings, grow out and breeders) from 6 farms in 4 districts were were aseptically collected and bacteria isolated from the kidney, liver, brain, and spleen. The isolates were identified by their morphological characteristics, conventional biochemical tests. Furthermore, virulence genes of *Aeromonas* spp and *Lactococcus garvieae* were detected through PCR. From the survey samples, a total of 97 isolates of the 3 genera of bacteria of interest were identified. Co-infection of 2 or 3 bacterial species was observed in the internal organs (brain, liver, kidney) of the diseased fish.

Among the mono-infections, *Aeromonas* spp was the most prevalent bacterial pathogens isolated from brood stock (25/100, 25%) and grow out fish (13/63, 20.6%).

The 2-pathogens co-infection, *Lactococcus garvieae and Aeromonas* spp, were the most prevalent combination of bacterial pathogen which was observed in Fingerlings (22%), grow out (15.9%) and brood stock (17%). The 3-pathogen co-infection, *Lactococcus garvieae, Aeromonas spp and Flavobacterium columnare,* was only recorded in fingerlings (11.1%) and brood stock (3%).

The detection of virulence genes in *Aeromonas* spp revealed that the hemolysin (*hly*) was the commonest (50%) among single virulence genes detected in diseased grow out (26.5%) and broodstock fish (23.5%). With *Lactococcus garvieae* isolates, Hemolysin 3 (*hly 3*) was the commonest (55.3%) single virulence gene that was detected in all diseased fish types.

Table 1: Prevalence of bacterial isolates from diseased fish.

Bacterial Isolates	Broodstock (n=100)	Grow out (n=63)	Fingerlings (n=9)
Mono-infections			
Aeromonas spp	25(25.0)	13 (20.6)	0 (0.0)
Lactococcus spp/*Streptococcus* spp	3(3.0)	4 (6.4)	1 (11.1)
Co-infections			
Lactococcus spp/*Streptococcus* spp *and Aeromonas spp*	17(17.0)	10 (15.9)	2 (22.2)
Lactococcus spp/*Streptococcus* spp *and Flavobacterium columnare*	4(4.0)	0 (0.0)	1 (11.1)
Aeromonas spp and Flavobacterium columnare	5(5.0)	3 (4.8	1 (11.1)
Aeromonas spp and Francisella spp	1(1.0)	0 (0.0)	0 (0.0)
Lactococcus spp/*Streptococcus* spp, *Aeromonas spp and Flavobacterium columnare*	3(3.0)	0 (0.0)	1 (11.1)

To our knowledge, this is the first study to establish the occurrence of several bacteria species and their virulence genes infecting tilapia in both cage and pond culture systems in central and southern Zambia. The current study provides baseline information for future reference and fish disease management in Zambia.

LETHAL DOSE AND CLINICOPATHOLOGICAL FINDINGS ASSOCIATED WITH *Aeromonas veronii* BIOVAR *Sobria* RECOVERED FROM AN AQUACULTURE FARM WITH HIGH FISH MORTALITY IN KENYA

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Aquaculture is the fastest growing food production sector in the world. In Africa's food systems, fish and other aquatic foods play a multifaceted role in generating income and providing a critical source of essential micronutrients. Kenya is ranked the fourth in aquaculture in Africa and is endowed with a vast network of aquatic resources comprising freshwater lakes, rivers, and an extensive ocean resource base. Fisheries and aquaculture sector in Kenya contributes about 0.8% to the Gross Domestic Product (GDP) but it faces severe losses due to bacterial diseases among them being Aeromonasis.

This study determined the lethal dose ($LD_{50\text{-}240h}$) of *A. veronii* biovar *sobria* and also investigated the clinicopathological changes after intraperitoneal inoculation of Nile tilapia (*Oreochromis niloticus*) (n=80). Post-fingerlings fish specimens (15±5g) were inoculated with 0 (control), $1.5x10^4$, $1.5x10^5$, $1.5x10^6$, $1.5x10^7$, $1.5x10^8$ and $1.5x10^9$ CFU/ml for the determination of LD_{50}. The lethal dose ($LD_{50\text{-}240h}$) of *A. veronii* biovar *sobria* was found to be $1.5x10^8$ CFU/ml. Typical clinicopathological changes of *A. veronii* biovar *sobria* were observed and included: darkening of the skin (16.25%), hemorrhages over the body surface (21.25%), scale loss exposing the underlying skin at the base of caudal fin (13.75%), hemorrhages and enlargement of the liver (22.5%), congestion and enlargement of the spleen (22.5%), ascites (17.5%), distended gall bladder (20%), congestion on the operculum (20%), congested and hemorrhagic gills (15%), inflamed vent (13.75%), erosion of the fins (6.25%), cloudiness of the eye (32.5%), exophthalmia (18.75%), increased mucus on the skin surface (13.75%), erratic movement with loss of balance (42.5%), reduced feed consumption (48.75%), swimming at the bottom of the aquarium (40%), irregular breathing (20%) and lethargy (41.25%). There was 85.71% mortality in $1.5x10^9$ CFU/ml inoculation group within 48 hours of inoculation and 55%, 30.43%, 14.28% and 5.88% mortalities in $1.5x10^8$, $1.5x10^7$, $1.5x10^6$ and $1.5x10^5$ CFU/ml inoculation groups respectively between day 3 and day 9 of experiment. However, there was no mortality in $1.5x10^4$ CFU/ml and 0 CFU/ml inoculation group. It is recommended that more studies should be conducted on the pathogenicity of *A. veronii* biovar *sobria* to help formulate better management protocols in fish farming.

EFFECTS OF POSTBIOTICS SUPPLEMENTATION ON GROWTH PERFORMANCE AND FEED UTILIZATION OF NILE TILAPIA FINGERLINGS

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Aquaculture significantly contributes to global food and nutrition security while also serving as a critical source of employment and income for millions of people worldwide. Despite its significant contributions, aquaculture faces persistent challenges such as disease management and the optimization of growth. One promising solution to address these issues is the utilization of postbiotics, which offer an eco-friendly alternative to antibiotics. This study aimed to evaluate the effect of dietary postbiotics on growth performance and nutrient utilization of Nile tilapia *Oreochromis niloticus* fingerlings.

A feeding trial of 55 days was conducted in which Monosex tilapia fingerlings (6.79 ± 0.11 g) were obtained and acclimatized for two weeks. They were then randomly assigned to aerated 12 aquariums at a density of 25 fish per aquarium. The aquariums were then categorized into 4 groups, each in triplicate and fed on a diet supplemented with different levels of postbiotics. The four levels of postbiotic inclusion were 0g (control), 2g, 4g and 6g postbiotic/Kg of feed. The baseline diet for all treatments was formulated to contain 30 % crude protein and 3000 Kcal of DE per kilogram and feeding was done three times a day at 3% body weight. Sampling was conducted every 10 days to assess parameters of growth and feed utilization indicators.

Treatment 2 (4g postbiotic) exhibited the most remarkable performance in terms of final mean weight (FMW), mean weight gain (MWG), specific growth rate (SGR), feed conversion ratio (FCR), and protein efficiency ratio (PER), followed by T3 (6g postbiotic) and T1 (2g postbiotic), while the Control (0g postbiotic) had significantly lower performance. The Control group exhibited significantly lower survival compared to T1, T2, and T3. These results demonstrated that yeast-based postbiotic supplementation of up to 4g kg^{-1} can be effectively recommended as an important growth promoter for tilapia culture.

Table 1: Growth and feed utilization indicators of *O. niloticus* fish

Variable	Control	T1	T2	T3
Initial mean weight	6.84±0.04	6.89 ± 0.07	6.80 ± 0.00	6.64 ± 0.34
Final mean weight	14.19±0.07^a	15.96±0.50^b	18.77±0.24^c	17.83±0.38^c
Mean weight gain (g)	7.35 ± 0.06^a	9.07 ± 0.49^b	11.97± 0.24^c	11.19± 0.29^c
SGR	1.33 ± 0.01^a	1.53 ± 0.06^b	1.85 ± 0.02^c	1.79 ± 0.02^c
Condition factor	1.40±0.003^a	1.42±0.008^a	1.40±0.003^a	1.41±0.003^a
Survival rate (%)	69.33 ± 1.3^a	84.00± 2.31^b	92.00± 4.62^b	92.00± 2.31^b
FCR	2.14± 0.01^a	1.90 ± 0.03^b	1.69 ± 0.11^c	1.72 ± 0.10^c
PER	1.57±0.06^a	1.80±0.03^b	2.31±0.20^c	2.10±0.28^c

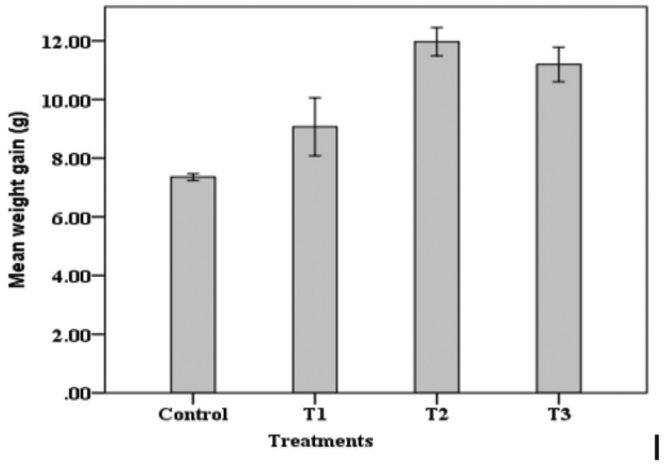

Fig. 1: The mean body weight gain graph comparing the treatments

EFFECT OF STOCKING DENSITY ON THE GROWTH AND SURVIVAL OF *Oreochromis andersonii* KAFUE BREAM NURSED OVER WINTER IN CONCRETE PONDS IN ZAMBIA

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This study was conducted to investigate the effect of stocking density on the growth and survival of *Oreochromis andersonii* Kafue bream nursed over winter in tarpaulin lined concrete ponds (35 m^3). The aim was to help find mitigation measures against adverse effects of the cold season (May to August) on tilapia hatchery and grow-out operations in Zambia.

Mono sex tilapia fry (2g) were cultured in hapas (1m^3) for a period of 10 weeks. Five stocking densities of 25 (T1), 50 (T2), 100 (T3), 200 (T4) and 400 (T5) fry/hapa with three replicates were used. Fry were fed twice daily, except on weekends, with a commercial feed containing 45% protein at 5% of total biomass. To preserve water temperatures, the ponds were covered with a transparent polyethylene sheet (200µm) and water exchange was done once a week.

Temperature was maintained at an average of 23.5±1.74°C, which was 6.5 degrees higher than the average winter temperatures of open ponds. After 10 weeks, there were no significant differences ($p<0.05$) between the weights of fish, fry survival rates and Specific Growth Rate (SGR) for all treatments (Table 1).

These findings could mean *O. andersonii* fry adapt well to overcrowding under favorable water temperatures, well maintained water quality and an appropriate feeding regime.

We conclude that stocking density had no significant effect on growth and survival of *O. andersonii*. However, the current study did not reach the carrying capacity, hence we are not able to state an optimum stocking density of fry in the hapa system.

We recommend culture of fry in hapas at a high density (400 fry/m^3) in covered concrete ponds to help overcome the challenges that come with nursing of fry during winter. This could also be a good way to ensure an early onset of the grow–out season by providing ready to stock fingerlings immediately after the winter season. We recommend further studies to establish the optimum stocking density of tilapia fry in the hapas.
Key words: *O. andersonii*, hapas, stocking density, winter

Table 1: Growth and survival of tilapia fry after 10 weeks. No significant effect ($p<05$) were recorded for all treatments

Stocking density (number /m^3)	Final weight (g)	Weight gain (g)	Weight gain (%)	SGR (g/day)	Survival (%)
25	12.57±5.4	10.50±5.4	81.04±10.7	2.66±0.78	100.00±00
50	12.40±2.4	10.40±2.4	83.45±3.26	2.74±0.30	100.00±00
100	12.77±1.4	10.76±1.4	84.21±1.74	2.81±0.16	98.0±2.00
200	13.00±2.7	11.00±2.7	84.16±3.33	2.81±0.32	97.5±2.59
400	19.20±6.8	17.20±6.8	88.66±3.97	3.36±0.54	98.8±1.71

SPAWNING INTERACTIONS BETWEEN HATCHERY-REARED AND WILD NATURALIZED RAINBOW TROUT (*Oncorhynchus mykiss*, WALBAUM, 1792) IN A HIGH-ALTITUDE TROPICAL STREAM IN KENYA

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Rainbow trout (*Oncorhynchus mykiss*) is among the most widely translocated fish species in the world. The current study evaluated the spawning interactions between naturalized and wild rainbow trout from a high-altitude second-order stream, in Kenya. Data on total length, weight, condition factor, fecundity, fertilization, egg diameter and fry survival were collected on spawning rainbow trout between March to December 2022. Length-weight showed parabolic equations as $W = 0.0144L^{2.900}$, $W = 0.0069L.^{3.0285}$ and $W = 0.00027L^{3.175}$ for wild fish stock, hatchery-reared and wild × hatchery-reared rainbow trout respectively. Total fecundity differed significantly among the hatchery-reared, wild fish, and the cross of the two ($P = 0.0045$). The fertilization rate showed significant differences ($P = 0.0057$), with no discernible difference observed between the hatchery-reared and crossed. There was a positive correlation between the total fecundity to female egg weight, female body weight, fertilization rate and eyed egg survival in all the populations. We recommend the use of crossed (wild and hatchery-reared) populations for fry production for use in aquaculture since they presented the highest fecundity and gives the best outcome of fry with high survival.

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

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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. With increasing food production challenges like dwindling capture fisheries and impacts of climate change becoming more eminent, solutions to food insecurity and malnutrition in Kenya must bring 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. Aquaculture, the controlled land-based or open-ocean farming of aquatic organisms such as tilapia, catfish finfish, shellfish and plants, is the fastest growing food sector globally alongside terrestrial crop and livestock production. Fish provides protective effects on a wide range on health including obesity, stroke, high blood pressure, and coronary heart disease. Fish has a nutrient profile superior to all terrestrial meats, an excellent source of high quality animal protein, omega-3 polyunsaturated fatty acids (PUFAs) and vitamins. Unfortunately, in Kenya, fish has been only marginally included in the national debate on reduction of micronutrient deficiency, precisely where it could potentially have the largest impact.

ANTIFERTILITY EFFECTS OF *Acacia nilotica* (LINNAEUS 1753) AQUEOUS PODS EXTRACT IN MALE *Oreochromis shiranus*

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Lack of a cheaper and effective way to produce reproductively sterile fish for better growth to boost production is a big problem that Malawian fish farmers face. This study examined cytotoxic and antifertility effects of *Acacia nilotica* aqueous pod extracts on *Oreochromis shiranus* as one way of producing sterile fish. Brine Shrimp Lethality Assay was used to assess cytotoxicity of extracts on concentrations of 0, 20, 40, 60, 80 and 100 mg mL^{-1}. The results showed highest mortality at 100 mg mL^{-1} concentration (40% mortality) and lowest in 0-40 mg mL^{-1} (0% mortality). There was no linear component in mortalities of nauplii ($p>0.05$). Using Meyer's toxicity index the extract was non-toxic as its LC_{50} value was 108.95 mg mL^{-1}. An assessment on antifertility effects used four treatments 0, 5, 10, 15 g $kg^{-1}$of *A. nilotica* aqueous pod extract-feed inclusions. *Oreochromis shiranus* were fed for 16 weeks and reproductive performance was investigated. Gonads developed black spots and atrophy with an increase in inclusion level. Decreasing gonad weight was observed in the following order: 0g kg^{-1} (0.6±0.07g), 5g kg^{-1} (0.45±0.08g), 10g kg^{-1} (0.41±0.01g) and 15g kg^{-1} (0.31±0.04g). As in gonad weight, decreasing motilities were observed in the following order: 6.1±0.23, 4.8±0.05, 3.58±0.14 and 2.31±0.1 minutes respectively. There was a linear relationship in gonad weight and sperm motility with inclusion levels ($p<0.05$). Testicular histology analysis for control fish showed a high concentration of spermatogenic cysts, normal lumen and interstitial tissue. Testes of fish fed on *A. nilotica* aqueous pod extract-feed inclusions showed severely depleted with very insignificant amount of spermatozoa, the lumen expanded, interstitial tissue highly shrunk, seminiferous tubules were deshaped, necrosis and vacuolization. *Acacia nilotica* aqueous pod extract displayed cytotoxicity and antifertility effects in *Oreochromis shiranus*. Gonadal changes and reduced sperm motility were observed with extract inclusion. This suggests that potential use as a reproductive inhibitor in *Oreochromis Shiranus*. Further research is needed to assess its effects on female *Oreochromis shiranus* (Ovaries).

STATUS OF AQUACULTURE IN GHANA

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The domestic fish production of Ghana over the years have been inadequate to meet the country's national requirement, hence a net consumer of fish. For example, in 2022, annual fish production stood at 657,472.31mt as against a requirement of 1,308,219.64mt.

Dwindling stock in the capture fisheries coupled with rapid national population growth rate of 1.96 in 2022 (United Nations, World Populations Prospects) is the result of the deficit. Fish food and nutritional insecurity is widening among the populace, particularly women and children. Aquaculture has been identified as one area to help bridge this production deficit gap.

In more recent years, aquaculture has become a major income earner for improving rural and urban livelihoods, providing employment and animal protein to help address protein malnutrition problems. The main fish produced through aquaculture in Ghana are Tilapia (Oreochromis Niloticus) and Catfish (Clarias gariepinus). There are however, other indigenous fishes that hold the potential for aquaculture production (Amisah and Agbo, 2015).

Aquaculture in Ghana for the past eight (8) years have shown an average increase rate of 59.48%. The sector's contribution to AGDP and GDP in 2022 was 22.1% and 1.2% respectively (Ghana Statistical service report 2022).

However, notwithstanding the growth of aquaculture in Ghana, challenges such as quality fish seed and feed, high cost of fish feed and inputs, and climate change have been identified as major factors impeding the growth rate.

AQUACULTURE IN NIGERIA: SPOTLIGHTING OPPORTUNITIES & MANAGING RISKS

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Nigeria's aquaculture sector exhibits significant growth potential, driven by the growing young population and increasing domestic demand for fish as a vital, efficient, and affordable protein source. This country report underscores the sector's growth trajectory, challenges, and opportunities.

Although, Nigeria produces 11.12% of Africa's aquaculture supply with 262,000MT, the country's consumption of fish per capita at 13.3kg/p/yr is considerably lower than average global consumption of 20.5kg. Aquaculture also accounts for only 26% of current consumptions, lower than global contribution of 49.2% of total food fish supply. The data estimates high growth and investment potentials for the industry if its wicked challenges can be tamed.

Farmers utilize diverse systems, including pond, cage, and pen culture, adapted to reflect the unique socioeconomic dynamics of the industry. Production predominantly features catfish, tilapia, and shrimp, but diversification is becoming a strategic commercial focus.

Despite its promise, the sector faces enormous challenges. On a macro scale, the industry is challenged with inadequate infrastructure, limited access to credit, insufficient policy support, and sociopolitical and economic instability. Farm-level obstacles that impact farm productivity include input supply, particularly access to quality fingerlings, high quality feeds, and affordable technology. Post-harvest hurdles that require actions include impediments arising from unregulated product quality, certification issues, and market access complexities.

Key findings from the country report reveal that aquaculture production is steadily growing again after a 9.6% contraction in 2020, providing substantial employment opportunities for youths, women, and rural populations. Policy and regulatory improvements are noted, but there's a clarion call for more supportive and streamlined guidelines. In recent years, the amplified activism of non-state actors and stakeholder groups has catalysed government interest in the sector. Sustainable aquaculture growth for Nigeria also mandates conscious efforts at responsible environmental practices, with a focus on efficient water management and waste reduction.

In conclusion, the potential for investment, technology adoption, and capacity building in Nigeria is enormous. Nigeria's aquaculture sector is a beacon in the quest to bolster food security and economic development in Sub-Saharan Africa. Investment in technology, market development and expansion, and sustainable practices is pivotal to unleash its full potential.

EVALUATION OF INACTIVATED DRY YEAST PRODUCT DY-PRO AS REPLACEMENT FOR FISH MEAL IN AFRICAN CATFISH *Clarias gariepinus* DIETS

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Availability of cheap animal protein ingredients remains a major constraint in the growth and development of commercial fish farming as the traditional fish meal being used as protein in aqua-feeds is scarce and expensive. Therefore, the study evaluated the effects inactivated dry yeast product DY-PRO as partial replacement for fish meal in the production of African catfish, *Clarias gariepinus*.

Five diets were formulated with different levels of DY-Pro yeast as replacement for fish meal at 0% (diet 1), 2.5% (diet 2), 3.75% (diet 3), 6.25% (diet 4) and 8.75% (diet 5). The diets were fed to African catfish (*Clarias gariepinus*) (3.53±0.12g) in triplicates in for 84days.

Results revealed that inactivated dry yeast marginally improved the fish weight gain, specific growth rate, feed efficiency and feed conversion ratio better than in the fish fed 100% fish meal, (Table 1) indicating that the yeast can replace up 8.75% of fish meal in diets of African catfish. Carcass minerals also showed no differences (P>0.05) among the treatments (Table 2) Serum biochemical profile also indicated that addition of yeast in the diets improved the total protein, SOD and catalase, but reduced AST and malondialdehyde (MDA).

Table 1: Growth performance and nutrient utilization of African catfish fed experimental diets.

	1(0%)	2(2.5%)	3(3.75%)	4(6.25%)	5(8.75%)
Initial Weight	3.59 ± 0.10[a]	3.46 ± 0.05[a]	3.51 ± 0.15[a]	3.57 ± 0.18[a]	3.50 ± 0.13[a]
Final Weight	21.5 ± 3.76[a]	25.02 ± 3.76[a]	25.18 ± 3.76[a]	25.45 ± 3.76[a]	24.62 ± 3.76[a]
Weight Gain	17.91 ± 3.76[a]	21.56 ± 4.04[a]	21.67 ± 2.48[a]	21.88±10.34[a]	21.12 ± 5.08[a]
SGR	2.13 ± 0.18[a]	2.36 ±0.19[a]	2.45 ± 0.76[a]	2.34 ± 0.46[a]	2.32 ± 0.23[a]
FER	0.44 ± 0.02[a]	0.51 ± 0.05[a]	0.45 ± 0.12[a]	0.45 ± 0.06[a]	0.61 ± 0.07[a]
FCR	2.25± 0.11[a]	1.96 ± 0.19[a]	2.24 ± 0.55[a]	2.23 ± 0.07[a]	1.64 ± 0.32[a]

Table 2: Mineral composition of the experimental fish (mg/g)

	1(0%)	2(2.5%)	3(3.75%)	4(6.25%)	5(8.75)
Ca	38.75 ± 3.2[a]	37.57 ± 8.25[a]	39.02 ± 2.83[a]	28.95 ± 7.76[a]	35.07 ± 5.02[a]
Mg	47.2 ± 1.95[a]	47.28 ± 5.74[a]	43.3 ± 2.82[a]	45.97 ± 5.23[a]	43.37 ± 5.98[a]
Mn	0.38 ± 0.14[a]	0.32 ± 0.05[a]	0.44 ± 0.17[a]	0.44 ± 0.15[a]	0.31 ± 0.05[a]
Zn	2.06 ± 0.06[a]	2.35 ± 0.43[a]	2.37 ± 0.58[a]	2.48 ± 0.36[a]	2.15 ± 0.18[a]
P	12.0 ± 1.38[a]	13.80 ± 3.38[a]	11.44 ± 1.48[a]	12.17 ± 2.74[a]	11.92 ± 2.67[a]

WATER CIRCULATION PATTERNS' IMPLICATIONS ON SUITABLE SITES FOR CAGE AQUACULTURE IN LAKE VICTORIA

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This study focuses on comprehensively understanding Lake Victoria's hydrological dynamics and their implications for fisheries, aquaculture management, water resource planning, and climate studies. It utilized the Regional Ocean Modeling System (ROMS) to simulate critical factors such as water temperature and circulation patterns. The analysis reveals distinct seasonal cycles governing thermo-stratification and mixing in the lake's water column, with thermo-stratification occurring from September to May and mixing prevailing from June to August. Surface water temperatures follow seasonal patterns, peaking in May and June before gradually decreasing to annual lows in August and October.

Over time, significant changes in temperature, precipitation, and cloud cover have been observed, particularly preceding fish kills in the lake. These changes impact thermal dynamics, nutrient cycling, and species distribution within the ecosystem. The study emphasizes the vital role of water circulation, highlighting areas with poor circulation as susceptible to stagnant water conditions and fish kills, while areas with strong currents maintain better water quality. The findings lead to key management recommendations, including enhancing water circulation, mitigating algal bloom threats, monitoring and managing temperature dynamics, improving water quality monitoring, enhancing watershed management practices, fostering stakeholder collaboration and knowledge exchange, and adapting to climate change impacts.

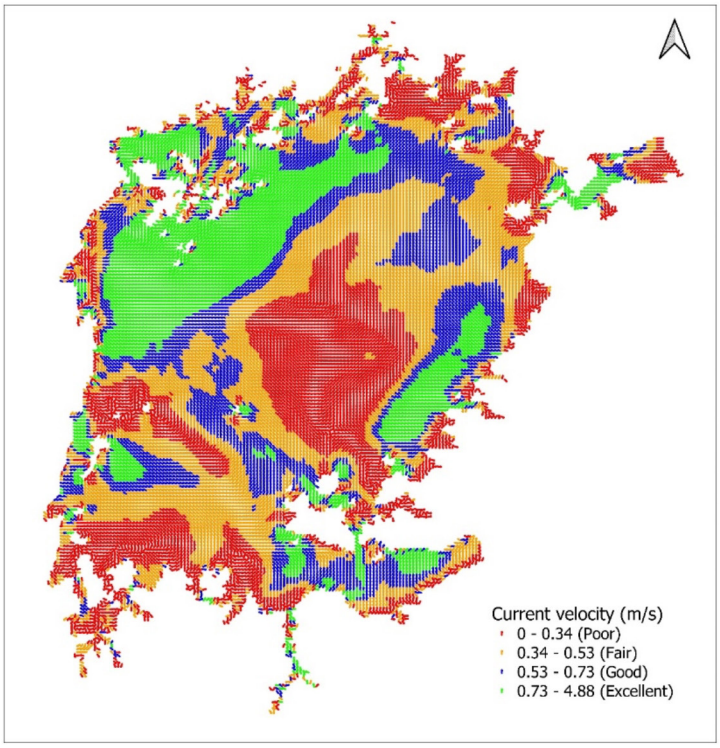

FIGURE 1 Categorization of Lake Victoria's suitability in terms of water circulation (average over the simulation period, Jan 2015 to May 2023) and vulnerability to fish kills.

MORPHOLOGY, GROWTH PERFORMANCE, FEED UTILIZATION AND SURVIVAL OF DIFFERENT *Oreochromis andersonii* (CASTELNAU 1861) STRAINS

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A study was undertaken to assess the morphology, growth performance, feed utilization and survival of three *Oreochromis andersonii* strains (Zambezi, Luangwa and Kalimba) for recommendation in the species' culture and its genetic improvement. Ten brood fish from each strain were used to assess morphological characteristics while fry bred from each of the strains were used to assess the growth performance, feed utilization and survival.

The study revealed that Kalimba strain was significantly shorter ($p < 0.001$) than Luangwa and Zambezi strains in lengths from anterior dorsal to anterior anal (ADAA = 51.27±0.56mm, 58.83±0.78mm and 57.65±0.68mm), anterior dorsal to posterior anal (ADPA = 60.56±0.36mm, 66.99±0.63mm and 64.48±0.70mm) and anterior dorsal to pelvic-fin origin (ADP2 = 36.22±0.45, 41.98±0.55mm and 40.99±0.34mm) respectively. Kalimba had significantly smaller ($p = 0.0009$) horizontal eye diameter (HED = 18.93±0.89mm) than Zambezi (HED = 22.71±0.28mm) while Luangwa (HED = 20.64±0.30mm) did not differ significantly ($p > 0.05$) with both strains. Luangwa strain had significantly lower ($p < 0.05$) body weight gain (BWG) of 4.99 ± 0.5g compared to that of Kalimba and Zambezi which had 13.11 ± 0.31g and 13.87 ± 28g respectively. The strains did not differ significantly ($p > 0.05$) in feed utilization and survival rate.

The differences noted among the three strains of *O. andersonii* in the current study may be due to possible genetic variations among them making the species a good candidate for a selective breeding programme. This study recommends that fish farmers in the North Western part of Zambia should continue using Kalimba and Zambezi strains. The inclusion of all the three strains in a genetic improvement program to further exploit traits of economic importance is also recommended.

EFFECTS OF DIFFERENT DIETARY PROTEIN SOURCES ON WATER QUALITY AND GROWTH PERFORMANCE OF NILE TILAPIA *(Oreochromis niloticus)* FINGERLINGS

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Freshwater aquaculture is the dominant type of aquaculture in Kenya, with *Oreochromis niloticus* favored due to its adaptability to a wide range of environmental conditions and rapid growth. However, the success and economic viability of aquaculture sector is significantly impacted by the type and quality of fish feeds in the culture systems. To address this crucial aspect, a study was conducted to investigate the effects of different sources of protein in fish diets on water quality, hematological parameters and growth performance of *O. niloticus* fingerlings fed with diets containing three different protein sources.

Three locally sourced protein sources, namely, Black Soldier Fly larvae (BSF) meal, Freshwater shrimp meal (FSM), and Soybean meal (SBM), and a commercial feed purchased from UNGA feed millers (Kenya) were fed to groups of 25 fish replicated 3 times for each group in a completely randomized design. The study was performed for a period of 55 days at the fish holding unit at the Department of Veterinary Pathology, University of Nairobi. The results showed that the weight gain of juvenile *O. niloticus* fed on BSF (103.7%), FSM (93.7%), and SBM (82.8%) were higher than the control (59.2%). There were statistically significant effects of the different diets on the growth rates of fish ($p < 0.05$) with the highest growth rate and survival reported for BSF (SGR = 1.295) and 82.2% respectively during the study period (table 1).

Water quality parameters remained within acceptable ranges, with temperature and phosphorus levels varying significantly across treatments ($p = 0.002$) and ($p = 4.3e\text{-}05$) respectively. Specifically, water from fish fed on diets based on BSF had relatively higher Phosphorus levels than the other feeds. This study demonstrates the advantages of BSF as a superior protein source for the culture of *O. niloticus*. The work also highlights the importance of BSF larvae as a partial replacement of fishmeal in aquaculture as well as the importance of suitable feed formulations in order to maximize fish performance and reduce costs. The study's outcome can improve food security for millions of people through the use of BSF as an alternative protein source to fish feed.

Table 1. Growth performance *Oreochromis niloticus* under different protein sources

Parameter	Control	T1	T2	T3
IW/ (g)	$8.53^{a}\pm0.011$	$8.51^{a}\pm0.003$	$8.53^{a}\pm0.009$	$8.54^{a}\pm0.014$
FW/ (g)	$13.58^{d}\pm0.01$	$16.48^{b}\pm0.01$	$15.58^{c}\pm0.009$	$17.40^{a}\pm0.015$
WG (g)	$5.05^{d}\pm0.006$	$7.97^{b}\pm0.01$	$7.06^{c}\pm0.003$	$8.86^{a}\pm0.003$
SGR	$0.85^{d}\pm0.001$	$1.20^{b}\pm0.001$	$1.10^{c}\pm0.001$	$1.29^{a}\pm0.002$
FCR	$2.79^{a}\pm0.006$	$1.76^{c}\pm0.003$	$1.99^{b}\pm0.002$	$1.59^{d}\pm0.003$
Survival %	$60.0^{c}\pm1.92$	$75.56^{b}\pm1.11$	$72.22^{b}\pm1.11$	$82.22^{a}\pm1.11$
CF	$1.09^{a}\pm0.01$	$1.02^{b}\pm0.009$	$1.00^{b}\pm0.0006$	$0.92^{c}\pm0.008$

T1 – Freshwater shrimp; T2 – Soybean meal; T3– Black soldier fly; SGR – Specific Growth Rate; FCR – Feed Conversion Ratio; CF – Condition Factor; Values in a row with different superscripts are significantly different as determined by ANOVA followed by Tukey's test ($P < 0.05$).

HANDLING-RELATED STRESS ALTERS THE GROWTH INDICES, BEHAVIOURAL RESPONSE AND WELFARE OF *Clarias gariepinus* (Burchell, 1822)

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Handling stress such as netting, crowding and subsequent air exposure are common practices during fish sorting, transportation and other aquaculture practices that could affect the growth and welfare of cultured fish species. Here, we examined the growth and behavioural response of *Clarias gariepinus* exposed to sub-lethal handling-related stress. 180 *C. gariepinus* (12.556±1.48g) were exposed to sub-lethal handling stress (crowding and air exposure) under laboratory conditions. The fish species were exposed to a control group (T1), netting plus 30 secs of crowding (T2), netting plus 60 secs of crowding (T3), netting plus 30 secs of air exposure (T4), netting plus 60 secs of air exposure (T5) to simulate durations of handling-related stress in the aquaculture sector fortnightly in triplicates for 84-days culture period. Growth indices (weight gain (WG), specific growth rate (SGR) and Feed Conversion Ratio (FCR) were observed weekly. Behavioural traits (latency to feed (LF) feed intake (FI), and aggression (agonistic behaviour (AB)) were monitored fortnightly. Statistical analyses were performed using the generalized linear models in the R statistical package.

The treatments affected (χ^2= 91.541, df= 4, p = 0.02) the growth parameters of the fish species with similar (p>0.05) growth responses in T3 and T5. Fish in the control group grew better and SGR was similar (P>0.05) between treatments (Table 1).

LF was significantly (p<0.05) different across the treatments (Fig 1) and FI was lowest (p<0.05) in T5 (Fig 2). AB was similar in T3, T4 and T5 (Fig 3). The treatments applied did not result in mortality during the study.

In conclusion, handling-related stress altered the behavioural response of *C. gariepinus* with increased agonistic behaviour and reduced mean weight gain. Thus, the level of handling stress should be reduced during aquaculture activities to prevent repeated acute welfare impairment in these fish species.

Table 1: Growth parameters of *C. gariepinus* exposed to handling-related stress

Treatment	MWG	SGR	FCR
T1	40.31±3.16^{c}	1.15±0.23	1.03±0.01
T2	39.14±2.69^{bc}	1.14±0.20	1.01±0.01
T3	37.41±2.14^{a}	1.10±0.15	0.96±0.00
T4	38.83±2.54^{b}	1.12±0.18	1.02±0.01
T5	36.97±2.08^{a}	1.11±0.17	0.92±0.00

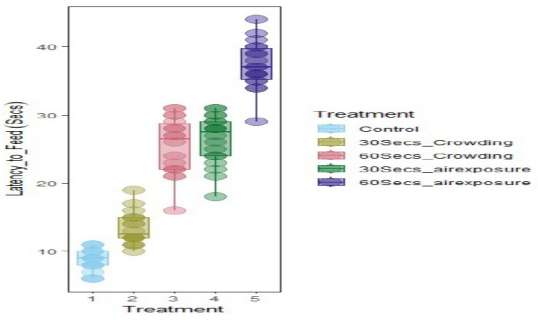

Figure 1: Effect of handling-related stress on the latency to feed of *Clarias gariepinus*

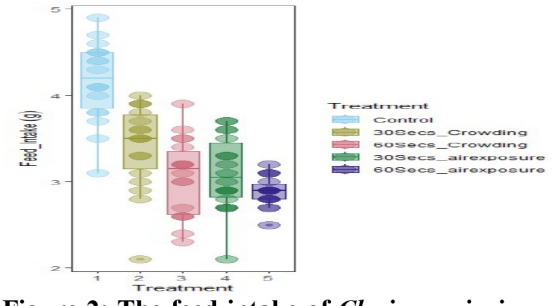

Figure 2: The feed intake of *Clarias gariepinus* exposed to handling-related stress

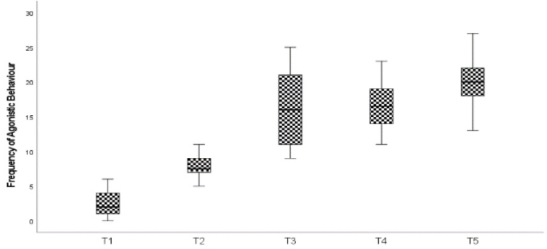

Figure 3: The agonistic behaviour of *C. gariepinus* exposed to handling-related stress

BIO-ECONOMIC ASSESSMENTS OF NOVEL AQUAFEED SOFTWARE ON AFRICAN CATFISH (*Clarias gariepinus*) (BURCHELL 1822) RAISED IN RECIRCULATORY AQUACULTURE SYSTEM

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The creation of software for fish feed formulation is evolving as a result of developments in computer technology. This study examined the impact of a newly developed aquafeed formulation software named AQUAFEEDAPP on the bio-economic performance of African catfish fingerlings raised in a Recirculatory Aquaculture System (RAS) for eight weeks. A total of 750 fingerlings with an average weight of ±4g were randomly distributed across 15 fiber tanks measuring 1m×1m×1m, with 50 fish per tank in triplicate treatments. The fingerlings were fed twice a day, between 8.00 hrs. to 9.00 hrs. and 17.00 hrs. to 18.00 hrs GMT for eight weeks under a recirculatory aquaculture system. The control treatment utilized Pearson square feed formulation, while the first treatment used WINFEED. The study measured various zootechnical parameters, including standard growth rate, final weight gain, feed conversion ratio, feed efficiency ratio, and mortality rate. The feed efficiency ratio was significantly higher in the fish fed WINFEED and AQUAFEEDAPP compared to those fed the control diet (Pearson square feed formulation). The cost index also showed significant differences ($p \geq 0.05$), with the AQUAFEED treatment having the lowest mean value, followed by WINFEED and the control diet. The carcass proximate composition of the fish was observed, with only moisture showing a significant difference. In summary, there were no significant differences between the control, WINFEED, and AQUAFEEDAPP treatments in terms of standard growth rate, final weight gain, feed conversion ratio, feed efficiency ratio, and mortality rate. However, the AQUAFEEDAPP software demonstrated its potential as a low-cost feed formulation method without compromising feed quality, based on its significantly lower cost index value.

REPLACEMENT OF FISH MEAL WITH MEAT AND BONE MEAL: EFFECT ON GROWTH, TISSUE HISTOLOGY AND INTESTINAL MORPHOMETRY OF *Clarias gariepinus* JUVENILES

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Global fish culture has grown in leaps and bounds in the past three decades with projections revealing potentials for further growth provided the different bottlenecks bedevilling the industry, such as quality, locally available, environmentally-friendly and cost-effective feed and feed ingredients, are addressed (Hua et al., 2019). Many solutions have been suggested to tackle these challenges but on a general note, investigators agree that re-use of waste stream or by-product, after its valorization, could be a pragmatic and sustainable approach (Tham et al., 2023; Verreth et al., 2023). Meat and bone meal (MBM) is a byproduct from a slaughter processing plant and it has previously been suggested as a promising substitute to fish meal (FM) in aquafeed because of its high protein and digestibility (Moutinho et al., 2017; Lee et al., 2023). Against this background, we investigated the suitability of MBM as an alternative to FM in diets for *Clarias gariepinus* juveniles.

Four isonitrogenous (40% crude protein) and iso-energetic (18.42 kJ/g) diets were formulated. The control diet contained 33% FM with no MBM (MBM0) and three other diets in which MBM progressively replaced FM at 11 (MBM11), 22 (MBM22) and 33% (MBM33). The diets were fed to triplicate groups of *C. gariepinus* juveniles (16.21±0.05 g) and their growth, carcass composition, tissue histology and intestinal morphometry were assessed after a 60-day feeding period. The least weight gain (77.61 g/fish) and specific growth rate (3.11 %/day) were observed in the group fed diet MBM33 and these values were significantly ($P<0.05$) lower than the group that received diets MBM0 and MBM11 (Table 1). Similar trend was observed in the diet utilization parameters expressed as feed conversion and protein efficiency ratio. The cost of production (USD/kg) in the group that received MBM33 and MBM22 were significantly ($P<0.05$) higher relative to those of MBM0 and MBM11 fed groups. Histology of the intestine showed that the villi across dietary groups were well differentiated; however, they were significantly ($P<0.05$) reduced in length in the MBM33 fed group. Villi width, crypt depth and survival were unaffected ($P>0.05$) by dietary treatment. The study revealed that only 33% (110 g/kg) of FM protein can be substituted by MBM without impairing growth, feed and economic efficiency of *C. gariepinus* juveniles.

Table 1: Growth performance, nutrient utilization, economic efficiency and intestinal morphometry of *Clarias gariepinus* fed varying levels of meat and bone meal.

PARAMETERS	MBM0	MBM11	MBM22	MBM33	SEM	*P* value
WG (g/fish)	113.26^{a}	113.48^{a}	88.88^{b}	77.61^{b}	5.25	0.004
SGR (%/day)	3.71^{a}	3.73^{a}	3.33^{b}	3.12^{b}	0.09	0.002
FCR	1.12^{c}	1.10^{c}	1.30^{b}	1.42^{a}	0.04	0.000
PER	2.25^{a}	2.30^{a}	1.94^{b}	1.77^{b}	0.07	0.000
Cost of feed ($/kg)	0.90	0.87	0.84	0.81		
ECR ($/kg)	1.01^{b}	0.95^{b}	1.09^{a}	1.15^{a}	0.03	0.001
Villi length (μm)	789.70^{a}	802.25^{a}	794.30^{a}	728.30^{b}	11.55	0.010
Villi width	217.90	212.55	203.50	194.50	4.73	0.370
Survival	86.67	93.33	93.33	90.00	2.60	0.821

SPECIES COMPOSITION AND LENGTH-WEIGHT RELATIONSHIP OF FRESH WATER CLAMS IN NUN RIVER BAYELSA STATE NIGERIA

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Data of clam species in Nigeria have not been properly documented. Hence this research study the identify species of clam in Nun River with Morphological criteria: Samples were harvested monthly and taken to the laboratory for identified and Morphometric measurements. Six species where identified (*Alasmidonta undulata, Anodonta implicate, Elliptio complanata, Lampsilis cariosa, Stophitus undulates and Toxolasma parvum)* belonging to the family of Unionidea. Mean length-weight of clam shows, *Stophitus undulatis* had the highest significant mean weight (124.01 g) and mean length (8.53 cm). The least mean weight (73.94 g) and mean length (6.83 cm) was in *Alasmidonta undulata*. The growth patterns and condition factor of Clam from Nun River showed negative allometric growth for all clam species, except *Toxolasma parvum* which had positive allometric growth with highest 'b' value (3.259) among species. There was significant different ($p<0.05$) among species condition factor. The correlation coefficient 'r' recorded the highest (0.97) in *Anodonta implicata* and least (0.75) in *Stophitus undulates*. However, there was strong positive relationship between length - weight and condition of Clams species in the Nun River.

Table 1: Length – Weight Relationship of Clam from Nun River

	Total weight		Total length		$W=aL^b$
Species	Mean	Range	Mean	Range	
Alasmidonta undulata	73.94±24.79 [b]	44.6-127.3	6.83±0.89 [b]	5.25 - 8.61	$W=-0.126L^{2.292}$
Anodonta implicata	89.17±14.96 [b]	79.5-106.4	7.28±0.64 [b]	6.76 - 8	$W= 0.902L^{1.806}$
Elliptio complanata	77.99±28.28 [b]	21.4-140.8	7.15±0.87 [b]	5.16 - 8.61	$W=-1.496L^{2.947}$
Lampsilis cariosa	86.87±13.20 [b]	78.8-102.1	7.05±0.53 [b]	6.61 - 7.64	$W=0.597L^{1.981}$
Stophitus undulatis	124.01±28.46 [a]	84.5-188.2	8.53±0.60 [a]	7.61 - 9.68	$W=-0.215L^{2.343}$
Toxolasma parvum	90.19±27.94 [b]	44 - 129.4	7.42±0.71 [b]	6.21 - 8.32	$W=-2.068L^{3.259}$

*Means with different superscripts in the same column are significantly different ($p<0.05$)

Table 2: Mean (±SD) of Clam species morphometrics harvested from Nun river

Species	Edible Weight	Width	Shell Thickness	Shell Weight
Alasmidonta undulata	9.71±3.15	5.33±0.54 [b]	3.61±0.64	47.04±12.49 [b]
Anodonta implicata	11.73±2.77	5.82±0.72 [ab]	3.83±0.63	58.43±20.22 [ab]
Elliptio complanata	15.26±17.91	5.39±0.70 [b]	3.37±0.67	46.29±18.37 [b]
Lampsilis cariosa	13.58±1.40	5.70±0.28 [ab]	3.11±0.58	47.77±2.89 [b]
Stophitus undulatis	14.49±5.35	6.28±0.48 [a]	4.18±0.74	73.37±18.27 [a]
Toxolasma parvum	11.96±4.09	5.56±0.58 [b]	4.21±1.72	53.43±15.22 [b]

*Means with different superscripts in the same column are significantly different ($p<0.05$)

Table 3: Mean (±SD) condition factor and growth pattern of Clam from Nun River

Species	K	a	b	r	r^2	Growth pattern
Alasmidonta undulata	0.91±0.09 [c]	-0.126	2.292	0.951	0.903	Negative allometric
Anodonta implicata	2.39±0.08 [a]	0.902	1.806	0.974	0.949	Negative allometric
Elliptio complanata	0.22±0.04 [d]	-1.496	2.947	0.885	0.783	Negative allometric
Lampsilis cariosa	2.10±0.08 [b]	0.597	1.981	0.97	0.94	Negative allometric
Stophitus undulatis	0.84±0.12 [c]	-0.215	2.343	0.746	0.556	Negative allometric
Toxolasma parvum	0.14±0.02 [e]	-2.068	3.259	0.929	0.863	Positive allometric

*Means (±SD) with different superscripts in the same column are significantly different ($p<0.05$). *K - condition factor; "a" is the constant; "b" – slope; "r" - correlation coefficient.

SELECTIVE BREEDING FOR NILE TILAPIA, A STRATEGY FOR SUSTAINABLE AQUACULTURE DEVELOPMENT IN KENYA

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The aquaculture subsector is important in Kenya for food and nutritional security. The rapid growth of the subsector is evident especially in the widespread culture of Nile tilapia (*Oreochromis niloticus*); however, the gains made in the industry may be curtailed by inadequate quality seed. Currently, hatcheries are plagued by inbreeding, hybridization of related stocks, and poor-quality broodstock due to lack of proper selective breeding plans or strain improvement for broodstock development and maintenance of pure breeds. Properly designed selective breeding programs in both public and private hatcheries will be the solution to provision of quality seeds for sustained aquaculture growth. Currently, the fingerlings produced exhibit a low growth rate under culture conditions. This paper discusses the significance of genetic improvement of *Oreochromis niloticus* through selective breeding in Kenya with reference to current and previous global experiences and reports. Genetic improvement of Nile tilapia is important in provision of quality seeds to farmers for growth in body weight and sustainable aquaculture development. Body weight, survival, and resistance to diseases are heritable traits that can be improved through selective breeding for a long-term genetic gain and trait improvement. Kenya is working on a strain improvement program that encompasses establishment of breeding nuclei and programs for monitoring and evaluation of hatcheries, based on the existing standard operating procedures for tilapia seed production. When this is in place, it will ensure adherence to the procedures for stock improvement and sustainable growth of aquaculture in Kenya.

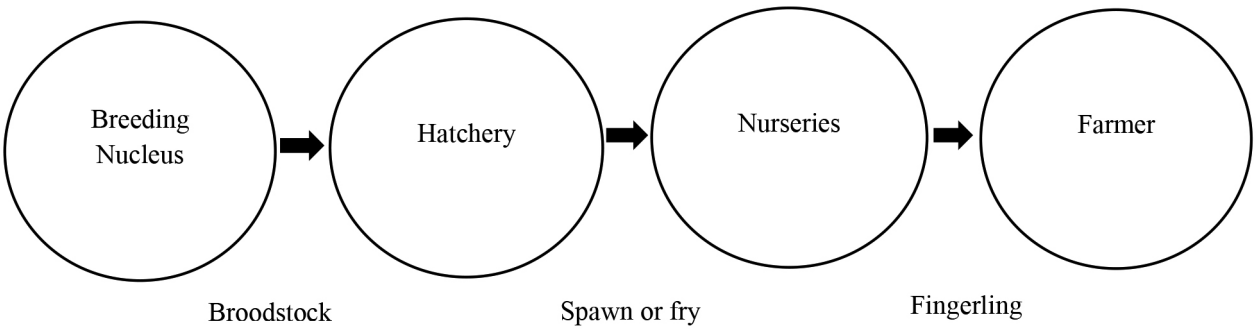

Figure 1: Proposed genetic improvement model for *O. niloticus* in Kenya

LESSONS FROM CARE'S WORK ON FISHERIES AND AQUACULTURE IN AFRICA AND OUR FARMER FIELD AND BUSINESS SCHOOLS APPROACH

Faith Owuor and Shashank Bibhu*

*Presenting author

CARE is a major international humanitarian agency delivering emergency relief and long-term international development projects in over 100 countries to save lives, defeat poverty and achieve social justice. I all our work, we put women and girls in the center because we know that we cannot overcome poverty until all people have equal rights and opportunities.

Over the past years, CARE has implemented projects in Africa on Fisheries and Aquaculture. Our work on Fisheries' and aquaculture is nested in our 'She Feeds the World Framework' and pays particular attention to gender equality and the empowerment of women in fish value chains. We aim to achieve the following with our fisheries work:

a. Protect marine and freshwater ecosystems through environmental, climate change and disaster risk management interventions.
b. Enhance maternal and child nutrition given the importance of fish to maternal and child nutrition and wider food security in many resource poor and vulnerable communities where we work in.
c. Collaborate with community groups, Local governments, WWF, World Fish, FAO among others and strengthen their capacities.

This presentation provides information on the lessons we have learnt implementing fisheries and aquaculture projects in 5 African countries (Benin, Egypt, Mozambique, Malawi and Ghana), our integrated and Gender Transformative 'Farmer Field and Business School (FFBS)' approach for training farmers, the evidence of success and impacts we have generated so far from the FFBS approach and how we are now scaling-up this approach to different sectors including Fisheries and Aquaculture in collaboration with FAO.

HISTORY OF CULTURED AQUATIC SPECIES INTRODUCTIONS IN ZAMBIA WITH SPECIFIC REFERENCE TO BIODIVERSITY CONCERNS

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A review of historical introductions and transfers of aquatic species for fisheries and aquaculture purposes generally within southern African river basins, and a detailed account of more recent events. The methodology used will be described along with the original rationale for these interventions, and the results and current status thereof will be summarised.

A discussion of the costs and benefits of these efforts will then be presented.

EFFECT OF NANOSILVER SUPPLEMENTED DIET ON GROWTH PERFORMANCE AND THE EXPRESSION OF IMMUNE GENES IN *Labeo rohita* INFECTED WITH *Aeromonas carviae*

Omoniyi Michael POPOOLA[1,2*] and Bijay Kumar BEHERA[2]

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The rapid development in food fish production has effect on the health of cultured species with potential stressors and infectious diseases. There is need developing novel feeds and formulations with fresh perspectives and distinctive traits, such as silver nanoparticles (AgNPs). These nanoparticles are strong bactericidal substances that work in low doses as growth promoters and immunological boosters. The impact of nanosilver (AgNPs) supplemented diet on the immune system, and growth performance of *Labeo rohita* infected with A. carviae was examined in this study.

L rohita (n:180; av wt 55.20 ± 0.04 g) were randomly grouped into four treatments (three replicates/treatment, 15 fish/tank); a control diet without the addition of AgNPs served as the basis for the other three diets, with each contained 10, 15, and 20 µg kg-1 of the AgNPs throughout a 52-day feeding period. Isolation of total RNA from fish kidneys, liver, and muscle was done using TRIzol, Nanodrop, and RNAse-free DNAse I. Synthetic cDNA was reverse-transcribed into first-strand cDNA and diluted to 750 ng/mL. Reference primers were IL-10, 5-CTGTGAAGGCATGGGTGTG-3/5' ATCACTTTCTTCACCCAGGG-3', and TNF-.5'-CAAGCAATTGGCGAGTGTGT-3'/5'-CAGTTCCACTTTCCTGATTACTCTGA -3' β-actin was used as reference gene.

The fish in the 15 µg kg1 group had better growth performance and a considerably higher (P< 0.05) relative percentage survival (RPS, 70%) after the *A. carviae* challenge (Table 1). TNF- expression in the liver was considerably higher (P < 0.05) in T3 than those in other treatments, with T4 having the highest levels of TNF-α and IL-10. IL-10 levels in the muscle rose significantly (P< 0.05) in T2, T3, and T4, and IL-10 levels in the kidney, gills, and muscle were all elevated (P< 0.05) (Fig. 1).

This research finding suggests that AgNPs can beneficially influence fish growth, and control *A. carviae* infection by enhancing the immune response of *L. rohita.*

Table 1. Growth and survival of *Labeo rohita* given various levels of AgNPs.

Diets (μgKg^{-1})	Initial weigh t (g)	Final weight (g)	Weight gain (WG%)	FCR	Survival (%)
0 (control)	29.28 ±0.01^{a}	44.37± 0.31^{d}	55.63± 3.14^{d}	2.09±0.10^{a}	80^{c}
10	30.22 ±0.02^{a}	57.12± 0.29^{b}	89.01± 3.20^{b}	1.62±0.10^{c}	90^{b}
15	30.78 ±0.03^{a}	59.49± 0.34^{a}	93.27± 4.67^{a}	1.48±0.11^{d}	100^{a}
20	29.98 ±0.05^{a}	51.89± 0.29^{c}	73.08± 2.47^{c}	1.79±0.12^{b}	90^{b}

The values reflect the mean and standard deviation consisting of three duplicate groups. The mean values with contrasting superscripts differ significantly (P< 0.05).

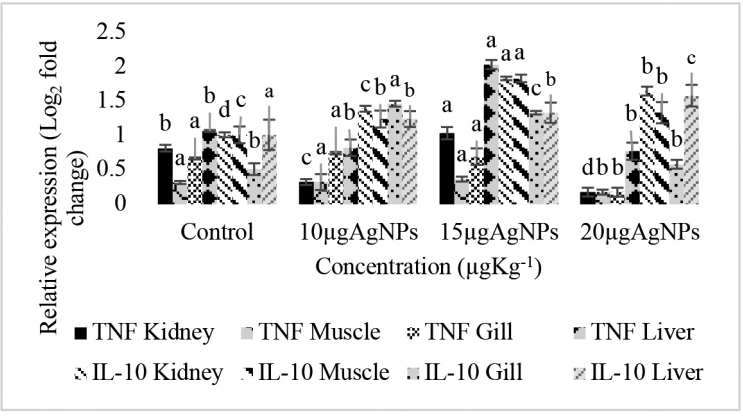

Fig. 1 Relative transcription of IL-10 and TNF-α genes in *Labeo rohita* Kidney, muscle, gill and liver fed various amounts of dietary silver nanoparticles and infected with *A. carviae* (AgNPs). The transcript levels were normalized against β-actin. (The mean values with contrasting superscripts differ significantly (P< 0.05).

EPPO: A PORTUGUESE RESEARCH FACILITY SPECIALIZED TRAINING AND CAPACITY BUILDING AT DIFFERENT LEVELS

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Marine aquaculture is increasingly playing a key role in food production to face world's population continuous growth and to cope with the ever-decreasing availability of land area and freshwater scarcity as well as the unpredictable impacts of climate change.

The Portuguese Institute for the Ocean and Atmosphere (IPMA) possess a strong cluster of competences for the ocean, marine resources, and the atmosphere. Aquaculture Research Station (EPPO) is a facility of IPMA, specialized in marine aquaculture, dedicated to conduct research and development from benchtop to a pilot, semi-industrial scale and for specialized training, knowledge transfer and capacity building at different levels. It has an area of about 7ha with more than 250 tanks gathering unique experimental conditions on aquaculture at national and international levels.

The EPPO is equipped with hatchery facilities for research and experimental production with different rearing circuits (broodstock, larvae, juvenile), a pre-fattening area (for earthen ponds and sea cage production) and RAS systems.

In this center we have broodstock for 8 different species of fish (*Sparus aurata*, *Dicentrarchus labrax*, *Solea senegalensis*, Argyrosomus regius, *Diplodus sargus*, *Sardina Pilchardus, Epinephelus marginatus* and *Seriola rivoliana*) as well as sea urchins (*Paracentrotus lividus*) with rearing protocols already developed or under development. Macroalgae, microalgae and live feeds are also produced.

EPPO is also equipped with analytical laboratories (biochemical, histological, molecular and cellular biology, microbiology and fish pathology).

Industry support, technical training as well as production of new marine species, nutrition, welfare, environmentally friendly production systems and assessment of onshore and offshore and production systems for fish grow-out are some of the research lines developed at EPPO.

Specialized training at various levels, internships and training in an industrial context are offered through specific programs.

Acknowledgements
PACTO DE INOVAÇÃO BIOECONOMIA AZUL (Project No. C644915664-00000026), AQUARAS (MAR-02.01.02-FEAMP-0223) and SAUDE&AQUA (MAR 02.05.01-FEAMP-0009).

EPPO: A PORTUGUESE RESEARCH FACILITY FOR THE DEVELOPMENT OF AQUACULTURE

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The Portuguese Institute for the Ocean and Atmosphere (IPMA, I.P.) is a public research institute and act as a counselor to the national authorities on the sea and atmosphere. IPMA, I.P., possesses a strong cluster of competences for the ocean and marine resources related to research, carried out by different groups, particularly dedicated to aquaculture and fisheries.

The Aquaculture Research Station of Olhão (EPPO, figure 1) stands out for the unique experimental conditions on aquaculture at the national and international levels. This marine core facility is equipped to carry out production studies at every scale from bench-top laboratory work to a much larger semi-industrial level. EPPO has an area of about 7ha with more than 250 tanks, including an hatchery fully equipped for research and experimental production with different rearing circuits (for broodstock, larvae, juvenile production, research with live animals and recirculation systems), a support building (with rooms for trophic chain production, daily routines and biological sampling), three RAS systems for research purposes, several analytical laboratories (biochemical, histological, molecular, microbiological and fish pathology), an unit for seafood packing, an area for pre-fattening (for earthen ponds and sea cages production) and 17 earthen ponds. It holds breeders of several marine fish species (e.g. meagre, gilthead seabream, seabass, Senegalese sole and sardine among others), microalgae and invertebrates as well as the know-how on the production of these species.

Production of new species, nutrition, welfare, environmentally friendly production systems and assessment of onshore and offshore and production systems for fish grow-out are some of research lines developed at EPPO (figure 2).

Acknowledgments: The research lines are partially funded by AQUARAS (Mar-02.01.02-FEAMP-0223) and PACTO DE INOVAÇÃO BIOECONOMIA AZUL (Project No. C644915664-00000026).

Figure 1 - Aerial view and RAS system on EPPO

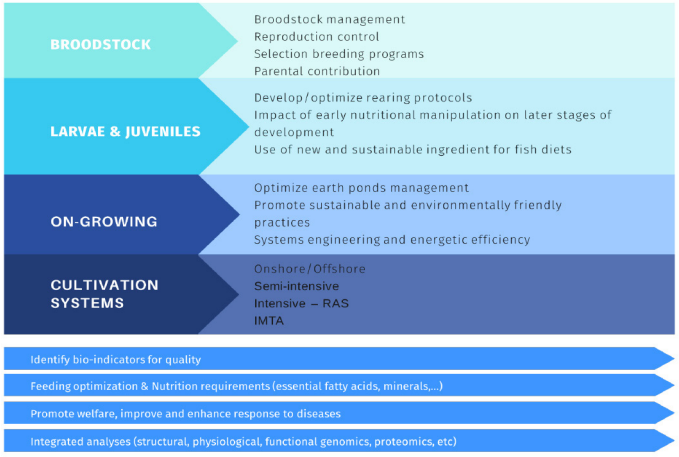

Figure 2 - On going research lines at EPPO

ANALYTICS IN EARLY LIVE STAGES OF MARINE FISH

Pedro Pousão-Ferreira[1,2]*, Florbela Soares[1,2], Barbara Requeijo[2], Marisa Barata[1], Sara Castanho[1], Mafalda Rocha[2], Ana Candeias-Mendas[1], Iris Silva[2], Luis E. Conceição[3], Hugo Pereira[4] and Cátia Lourenço-Marques[1,2]

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The production of marine fish in aquaculture plays a fundamental role within the scope of guaranteeing food security. In order to obtain raw materials for compound feed, in recent years there has been a need to increase the use of alternative meals and oils to those originating from the fisheries. Several vegetable meals, like wheat gluten, corn gluten, rapeseed, soy and oleaginous plants, have been used to successfully replace fishmeal. The production of marine micro and macroalgae is also seen as a promising alternative to with potential uses, including their incorporation into marine fish feed, utilizing ingredients such as their protein, lipids and vitamins, as well as other compounds with bioactive properties.

Algae, due to their smaller production compared with other terrestrial vegetable ingredient sources, have been used more in larval or post-larval stages where their consumption is incomparably lower than in the pre-fattening and ongroing. Additionally, the role of bioactive compounds is more important to guarantee the survival and welfare at early life stages.

In this work we present the trials that were carried out to evaluate the impact of the incorporation of algae biomass into feed. Moreover, we give an overview of the several analytics that can be used to access the impact on fish (Fig. 1), considering the constraints of using smaller and limited samples. It is intended that the various fine analytical processes will allow to predict the impact of these incorporations on a long-term basis, beyond the end of each test.

Acknowledgements
This study was funded by PACTO DE INOVAÇÃO BIOECONOMIA AZUL (Project No. C644915664-00000026), AQUARAS (MAR- 02.01.02-FEAMP-0223) and SAUDE&AQUA (MAR 02.05.01-FEAMP-0009).

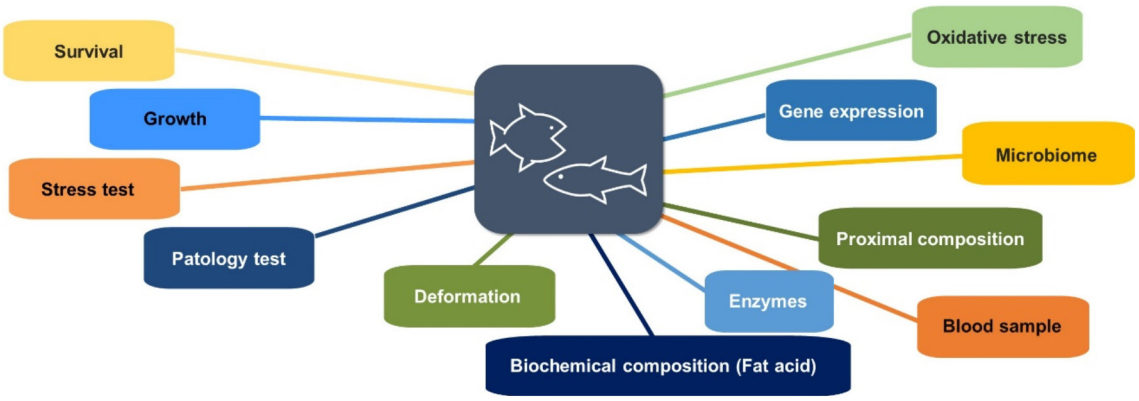

Figure 1- Analytics used in marine fish trials to access on fish growth and wellfare

COMMERCIAL AQUAPONICS: WHAT IT TAKES TO PROFIT OFF THE ECOSYSTEM

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Integrated Aquaculture (IA) is a working commercial aquaponic farm based in Gauteng, South Africa. The company is in its tenth year of operation and is projected to achieve a sustainable EBITDA breakeven by December 2023.

This presentation includes lessons learnt from the duration of operation of IA and includes an explanation of several critical partnerships forming the extended ecosystem. This ecosystem is critical to the profitability and sustainability of a commercial aquaponics facility.

Agriculture and more specifically Aquaculture and Aquaponics are extremely complex vocations for entrants into the industry. Aquaculture and Aquaponics are relatively new industries requiring collaboration on many levels to ensure success. Climate change is a reality and a focus on the Sustainable Development Goals (SDG's) points to climate controlled, intensive production systems. Recirculating Aquaculture Systems (RAS) and Aquaponic growing methods are perfect for inclusion in climate-controlled systems.

The presentation talks about the reason for inclusion and the challenges encountered with each partnership and the underlying importance of them in achieving profitability. These relationships include but are not limited to the following entities: Government, Finance, Technical Partners, Human Resources, Land Ownership, Market Establishment, Expertise, Certification, Distribution, and Supplier Relationship.

This presentation is for the Aquaculture/Aquaponic enthusiast and investor that has the desire and determination to run a profitable, sustainable business that includes the adoption the triple bottom line accounting framework (Profit, People, Planet).

INSTALLATION OF SIMPLE LOW-COST STRUCTURES FOR TILAPIA CULTURE IN BIOFLOC SYSTEM

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The production of tilapia fish in the biofloc system has received attention in recent years. Due to the limitation of water resources, it is important to use methods that guarantee water conservation. In addition, the control of aquaculture wastewater and ensuring that live tilapia samples do not escape from reproduction and breeding workshops are emphasized by the environmental point of view. On the other hand, reducing production costs helps the development of tilapia fish aquaculture industry. In this study, the construction of simple tanks using available and low-cost facilities in a greenhouse for the production of tilapia in the biofloc system has been surveyed.

Production and consumption of Nile tilapia *Oreochromis niloticus* have increased in the world. The development of tilapia fish production in Iran is in the early stages and is limited to central areas that have closed water sources and do not have access to open waters. Different aspects of tilapia aquaculture in Iran have been studied based on a research project, since 2008. At present, the development of intensive tilapia culture schemes is the agenda of Fisheries Organization of Iran. Challenges such as water limitation, disease and different inputs are especially the most important limiting factors of the development of tilapia culture. This review aims to reduce production costs and low-cost domestic setup with limited capital facilities. The results of the study showed that the construction of the proposed structure reduced the cost of investment in tilapia fish farming by 70%.

REPRODUCTIVE FREQUENCY OF NILE TILAPIA PARENTS*

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* Funding by FAPESP 2021/11955-8

The number of tilapia producers in Brazil follows the growing demand of the national aquaculture sector. The Brazilian territorial area is very wide, having a climatic division with six regions: equatorial, tropical, semi-arid, high-altitude tropical, tropical Atlantic and subtropical, which can directly influence the production process of fish. Considering only the São Paulo State, we found several climatic micro-regions, each one has particularity like high and low annual rainfall indices, regions between valleys and plains, different photoperiods, rainfall indices and temperature. These differences can directly influence the management of fish farms, reflecting on the storage biomass, reproductive period and egg production and influencing the production costs, harming the breeder.

The present study aims to evaluate the reproductive frequency of Nile tilapia matrices in "hapas", analysing the absolute fecundity, hatching rate and total number of larvae produced. Nile tilapia (150 specimens) were stocked in January 2023: 100 were females (300 ± 20 g) and 50 males (300 ± 20 g) distributed one family per "hapa", totaling 25 families. The "hapas" (1.0 mm mesh, measuring 3.0 x 1.5 x1.5 m) were installed in two earthen nurseries (300 m^2), the animals (2 females/1 male) identified and conditioned for starting the cohort and copulation in the "hapas". Reproduction units were evaluated weekly, collecting the eggs in the mouth of the females, and taken to the laboratory. Absolute fecundity (number of eggs per clutch), hatching rate (number of hatched larvae 100/number of incubated eggs) and total number of larvae were evaluated for each female eggs. Six samples were carried out between January and February 2023. In January the reproductive frequency was 31.21 ± 2.09% and in February 16.67 ± 11.03%, with a reduction of 51.81%.

When evaluated the absolute fecundity between the months, was observed in January 2,311.60 ± 104.80 eggs per clutch and in February, 1,670.47 ± 343.33, with a reduction in the number of eggs produced of 27.74%. The mean hatching rate in January was 50.70 ± 6.45 % and in February it was 32.53 ± 11.5 %, with a reduction of 36%. Total number of hatched larvae also followed the same pattern, 16,505 larvae produced in January and 10,033 in February, a reduction of 40%. The water temperature did not vary between the two months with an average of 27.4°C. Reproductive period of Nile tilapia in the tropical regions of Brazil varies from October to March, it was observed the reproductive frequency decreases throughout the reproductive cycle, so studies that determine the best reproductive phase are of paramount importance to optimize financial resources. and biological for an increasingly sustainable production system.

EXTRACELLULAR VESICLES ARE ASSOCIATED WITH ANTIOXIDANT ACTIVITY AND CONTAIN NON-CODING RNAs THAT MAY BE LINKED TO SPERM QUALITY

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Extracellular vesicles (EVs) are nanometer-scale lipid bilayer-enveloped spherical vesicles that carry a wide range of bioactive molecules, like proteins, lipids, enzymes, and nucleic acids (RNA and DNA). They are actively released by various cells and can be found in biofluids like urine, blood, saliva, cerebral spinal fluid, and seminal plasma. EVs play a vital role in cell-to-cell communication and various biological processes. Notably, miRNAs contained in EVs are believed to impact the reproductive process in various species, including fish. In the case of Senegalese sole (*Solea senegalensis*), a promising aquaculture species, its reproduction cycle is not fully controlled and relies on wild broodstock. Under cultured conditions, the male progeny of wild broodstock often exhibit reproductive behavioural dysfunctions, producing limited and poor-quality sperm or sometimes failing to engage in courtship for egg fertilization.

To overcome these challenges, we have conducted a feeding trial utilizing control diets and diets supplemented with algae to improve their reproductive performance and sperm quality. After 6 months, we collected blood plasma and isolated EVs based on their size (~30-10000 nm), employing size-exclusion chromatography with qEV 70 nm Gen2 single columns from Izon (Figure 1). Subsequently, these EVs were characterized by measuring their concentration and size using tunable resistive pulse sensing in the Exoid (Izon). Finally, we extracted total RNA from the samples and prepared small RNA libraries to characterize and identify specific miRNAs associated with antioxidant activity that may serve as molecular markers for assessing sperm quality in Senegalese sole.

The findings of this study are expected to have significant implications for enhancing the reproductive success of Senegalese sole in the cultured industry.

Acknowledgement: This work was funded by the BREEDFLAT project (EEA and Norway Grants, ref. PT-INNOVATION-0080).

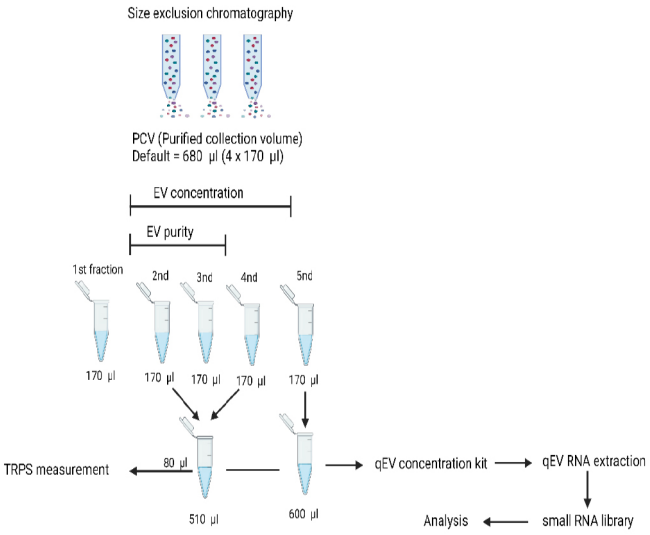

Figure 1. Workflow of extracellular vesicle (EV) isolation and analysis.

HARNESSING THE POWER OF FISH FOR A RESILIENT FUTURE

Stephen R. Reichley, Mark L. Lawrence, Gina Rico Mendez, Masey Smith, Kelly Stewart, and Laura Zseleczky

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The Feed the Future Innovation Lab for Fish, funded by the U.S. Agency for International Development (USAID), aims to reduce poverty and improve nutrition, food security, and livelihoods in partner countries by supporting research on sustainable aquatic food systems. The Fish Innovation Lab is managed by the Mississippi State University Global Center for Aquatic Health and Food Security. It is one of 21 Feed the Future Innovation Labs which are leveraging the expertise of U.S. universities and developing country research institutions to tackle some of the world's greatest challenges in agriculture and food security.

From 2018-2023, the Fish Innovation Lab supported 24 activities focused on applied research, 15 of which were in African countries: Ghana, Kenya, Nigeria, and Zambia. The lab also had activities in Bangladesh and Cambodia, as well as one activity that focused on Peru, the Philippines, Madagascar, and the Pacific Islands region. In this last phase of funding, which concluded in September 2023, the lab's program areas included improving productivity, mitigating risk, and improving human outcomes. Additionally, the Fish Innovation Lab had four cross-cutting themes, which were incorporated into each funded activity and guided the lab's work overall: mainstreaming gender equity and youth inclusion, advancing human and institutional capacity development, strengthening resilience, and advancing nutrition.

The Fish Innovation Lab's activities in Africa included aquaculture and fisheries. All of the Nigerian activities investigated different ways to improve aquaculture production and provide better quality fish products to consumers. The Kenya and Ghana activities worked to improve the sustainability of local fisheries and provide nutrition training and information to promote consumption of aquatic foods for better nutrition amongst fishers, mothers, and children. Activities in Zambia captured a wide range of work, from fish vaccine development to reduce aquaculture losses to assessing population ecology and current distribution of introduced invasive crayfish in the Kafue Floodplain and Lake Kariba. Additionally, two Zambia activities aimed to increase nutrition and food security for families by collecting information from participants to determine leverage points to impact postharvest loss, food security, gender equity, entrepreneurialism, and economic empowerment among fishers, processors, and traders at Lake Kariba. One of these activities developed a fish powder along with recipes for enhanced nutrition, particularly benefiting mothers and infants in vulnerable households.

The Mississippi State University Global Center for Aquatic Health and Food Security was recently awarded a five-year extension to continue management of the Fish Innovation Lab to address global food security challenges through aquatic food systems. For information on funding opportunities and to learn more about the activities of the Fish Innovation Lab, visit our website at www.fishinnovationlab.msstate.edu and subscribe to our newsletter at https://rb.gy/j17i6.

THE FEED THE FUTURE INNOVATION LAB FOR FISH

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The Feed the Future Innovation Lab for Fish works to reduce poverty and improve nutrition, food security, and livelihoods in partner countries by supporting research on sustainable aquatic food systems. From 2018–2023, the Fish Innovation Lab brought together over 40 partners to implement 24 research activities in 10 countries, primarily in Africa and Asia, focusing on three areas of inquiry: (1) improving productivity, (2) mitigating risk, and (3) improving human outcomes. These research activities contributed to the development of 54 innovations in the aquaculture and fisheries sectors that are in different stages of development and uptake. As the Fish Innovation Lab embarks on a second five-year phase of research, this presentation will explore how partnerships were developed and strengthened to maximize impacts and results advancing global food security and nutrition goals through the production, capture, and consumption of aquatic foods.

The Mississippi State University Global Center for Aquatic Health and Food Security was recently awarded a five-year extension to continue management of the Fish Innovation Lab to address global food security challenges through aquatic food systems. For information on funding opportunities and to learn more about the activities of the Fish Innovation Lab, visit our website at www.fishinnovationlab.msstate.edu and subscribe to our newsletter at https://rb.gy/j17i6.

BRAZILIAN TILIAPIA VALUE CHAIN: FACTORS THAT INFLUENCE EXPORTS

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Tilapia is the most farmed fish in Brazil, its production continues to expand being consumed almost entirely by the domestic market. Despite your important role in world production and the growth of aquaculture, Brazil has exported only 2% of its tilapia production in average over the last five years (2018-2022).

In this context, the research aimed to identify the firm's critical factors for Brazilian tilapia exports. Between April and August 2022, we interviewed 8 stakeholders that are involved in more than half of the export of tilapia in Brazil.

The research mapped the organization of tilapia export value chain and the flow of the export process. In general, the interviewed companies have less than two years of experience in the tilapia export activity, and some of them having expertise in the export of other animal proteins.

Finally, we identified some factors that influence the amount of Brazilian exportations, but it was not possible to identify a single critical factor. On the other hand, the survey pointed out logistical and legal bottlenecks that in general that obstruct Brazilian exports.

PROPOSTA DE ESTUDO DE VIABILIDADE ECONÔMICA DE SISTEMA AQUAPÔNICO NO TOCANTINS (BRASIL)

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A técnica de produção aquapônica integra de forma simbiótica a aquicultura e a hidroponia. Na aquaponia é possível atingir significativa produtividade de peixes e plantas agregando valor ambiental ao sistema produtivo. Contudo, são escassas as pesquisas que analisam a viabilidade econômica desses sistemas, sobretudo, com peixes nativos no Norte do país. Nesse contexto, o projeto de pesquisa tem como objetivo analisar a viabilidade econômica da produção de hortaliças (rúcula e alface) e tambaqui, em sistema aquapônico de pequena escala.

No projeto serão estimados os custos de implantação do sistema, assim como coletados dados de custo de operação e venda dos produtos no mercado local, ao longo de 2023 e 2024. Para fins de análise da viabilidade econômica, serão utilizados os indicadores de Valor Presente Líquido (VPL), Taxa Interna de Retorno (TIR) e *payback*. Adicionalmente, o projeto prevê a simulação de diferentes cenários para análise de viabilidade, incluindo escalas maiores de produção, cultivo alternativo do tambaqui na forma juvenil e variações nos custos e preços de venda.

Como resultados esperados, o projeto busca gerar informações técnicas da viabilidade econômica da aquaponia, relevantes tanto para o setor produtivo como para a academia. Adicionalmente, espera-se que a própria divulgação do sistema, assim como os resultados da pesquisa possam também fomentar o uso do sistema aquapônico como uma estratégia alternativa de educação ambiental e segurança alimentar no Tocantins.

Agradecimentos: Fundação de Amparo à Pesquisa do Tocantins – FAPT/ Secretaria da Agricultura, Pecuária e Aquicultura – SEAGRO /Governo do Tocantins”

AQUAPONICS: AN INNOVATIVE TECHNOLOGY FOR THE YOUTHS IN URBAN TO PERI-URBAN ENVIRONMENTS – A CASE STUDY FROM ZIMBABWE

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The world's population is an estimated 8 billion and is expected to reach 10 billion by 2050. To feed such a rapidly increasing global populace, food production must increase by 30 to 50%. This increase should not put pressure on forested land; and thanks to recent innovations, increase in food production can be done without necessarily expanding or further exploiting agricultural lands.

Aquaponics is one of the more efficient and intensive food production system that has emerged in recent years. It is efficient in terms of the amount of food produced per unit area, unit of water, units of nutrients added to the system and offers less negative environmental impacts. Hence aquaponics has become a self-supporting food production system that combines recirculating aquaculture with plant culture in the absence of soil. It provides an opportunity to utilise aquaculture effluent while growing plants with a sustainable, cost effective and non-chemical nutrient sources. Fish are reared in tanks whilst plants are grown in PVC piping channels, rafts and growbed medium like clay pebbles, rockwool, gravel etc. Mechanical and biological filters are seperate components of the aquaponics system.

Higher intial capital investment and complexity of running the system tends to provide a barrier to entry for youth wanting to venture in aquaponics. At Eden Knight Farm, we have designed a unique system that is not only affordable, but user friendly. The system suits our African conditions and is dubbed, *"Sandponics"*. The system slightly differs from most conventional aquaponics systems in that we use sand which is cheap and locally sourced as the growbed medium. The sand also acts as the mechanical and biological filter making the system easy to operate and cheaper to set up. Horticultural plants can be grown in this system whilst in combination to fish production to table size. The system uses no electricity making it adaptable both in urban and rural spaces and this guarantees food security at household level.

This case study presentation showcases the functionalities of the Sandponics system culminating from the author's experience in designing and operationalizing the system over the years.

Killian Ruzande is a passionate, innovative and regenerative farmer who has worked in the aquaculture/aquaponics sector for over 10 years. With strong hands-on experience and research capabilities, Killian has embarked on consulting and training youth organizations on aquaculture and aquaponics systems. He has recently co-founded Eden Knight Pvt Ltd based in Zimbabwe – where he operates from.

EFFECT OF TRYPTOPHAN DIETARY CONTENT ON MEAGRE, *Argyrosomus regius*, JUVENILES GROWTH, MUSCLE CELLULARITY AND BEHAVIOURAL RESPONSE

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The increasing importance of fish welfare in aquaculture is not only an ethical question but a chance to improve standards and quality of fish production technologies and aquaculture products. Fish kept under good welfare conditions have lower stress levels, are less prone to diseases, have better growth and food conversion rates (FCR) and have a better final flesh quality. Tryptophan is known to be linked to the stress response by enhancing fish brain serotonergic activity and can also inhibit endogenously derived behavioural performance, such as aggressiveness and cannibalism. In this study, three diets containing different contents of tryptophan: 0.5 (Trip1), 0.7 (Trip2) and 0.8 % (Trip3), were tested in triplicates in 112 days old meagre with an initial weight of 32.6 ± 3.4 g and 14.4 ± 0.5 cm length for 57 days. Although the results showed no significant differences for growth and FCR between treatments, there was a tendency to an increase of growth and decrease of FCR in meagre fed higher levels of tryptophan. This is supported by the results obtained in muscle cellularity where Trip3 had a higher fibre density, suggesting an increased fibre recruitment. In terms of fish behaviour, very little differences were found. In the anxiety test, fish fed the higher quantity of tryptophan showed a significantly lower number of freezing episodes compared to fish fed the lowest tryptophan amount, suggesting more ability to explore and lower levels of anxiety. These results suggest that tryptophan dietary levels can influence not only meagre growth pattern but, as well, its behavioural response.

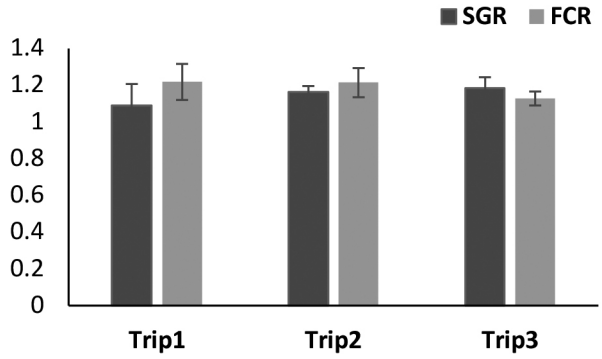

Fig. 1. Specific growth rate (SGR) and Food conversion ratio (FCR) of meagre juveniles fed a diet with 0.2 % (Trip1), 0.5 % (Trip2) and 0.9 % (Trip3) of dietary tryptophan. Values are mean and standard deviation

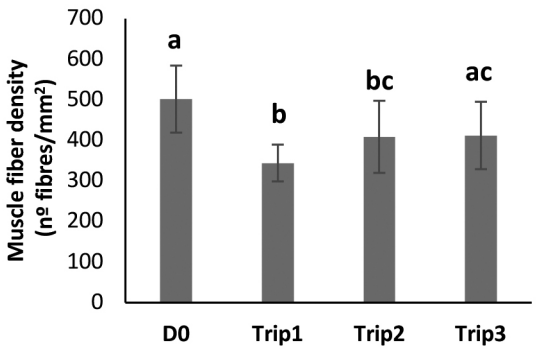

Fig. 2 . Muscle fibre density of meagre juveniles fed a diet with 0.2 % (Trip1), 0.5 % (Trip2) and 0.9 % (Trip3) of dietary tryptophan. D0- Density when the trial started. Values are mean and standard deviation

AQUACULTURE SUSTAINABILITY: BETTER FISH, BETTER ENVIRONMENT

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The role of aquaculture in the supply of fish in the future is undeniable. The consumption of fish products has several benefits for human health due to the quality of its protein, fatty acid profiles and supply of minerals and vitamins. Aquaculture is the fastest growing animal industry but because it uses natural resources, it causes environmental changes. Fish farming has evolved throughout many decades but the search for environmentally friendly and sustainable solutions are one of the current concerns. There are several paths towards sustainability either by a) feed formulation, which is important in terms of fish meal replacement and optimisation according to fish nutritional requirements, b) the adoption of environmentally friendly farming such as Integrated Multitrophic Aquaculture (IMTA) and c) increasing fish welfare and consequently reduce stress. The three paths have an important impact on both fish quality and environment, with the first path being the centre of much research and the latter still giving its first steps. This presentation will focus on the development of feed formulation, the adaptation of already existent models to embrace IMTA, leading to better fish quality and better environment and explain why we should pay more attention to fish welfare.

SCHOOL FARMING: THE ROLE OF EDUCATION IN THE FUTURE OF FOOD SECURITY

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The role of aquaculture in the supply of fish in the future is undeniable. Aquaponics is a sustainable method to rear fish (aquaculture) and plants (hydroponics). The water enriched with nutrients from fish and feed wastes are used as a natural fertilizer to plants while these purify the water that goes back to fish. It is a water cycle that results from a symbiotic ecosystem and a good example of good water use and circular economy. School farming is a project developed for schools that was launched in 2022 in Lisbon, Portugal, aiming to be a learning tool to stimulate children´s motivation and interest in nature. The project consists of building an aquaponic system which includes a fish tank, a plant growing bed and a set of filtration and pumping equipment in a classroom which all students can have access to. Each class will follow the growth of different vegetables such as lettuce, basil and peri-peri, depending on the school level as different plants require different levels of care. At the same time, they will feed the fish and observe that fish waste works as organic fertilizer for plants. At the end of the cycle, students will measure the biomass of plants they have grown and compare the results with other classes and schools through a school farming mobile digital network. The implementation of these projects in developed countries has specific goals but its application in developing countries, where food insecurity is higher, can have a major importance as it will provide children knowledge and tools that can have a higher impact not only in their own homes, by replicating small scale farms, but to their future as it can stimulate their entrepreneurship skills to reduce poverty and foster food resilience.

AN OVERVIEW OF THE AQUACULTURE INDUSTRY IN EGYPT: STATUS, CONSTRAINTS AND FUTURE PERSPECTIVES FOR SUSTAINABLE DEVELOPMENT

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Egyptian fish farms have shared 80.5% of the total fish landing, with over 1,592 thousand tons of finfish and shrimp in 2020, (99% from private farms and 1% from government farms), with a total market value of about $USD 3.8 billion (1 $USD = 16.22 Egyptian pounds) (GAFRD, 2022). The remaining of fish landing 19.5% percent are captured from the wild (Nile river, coastal and inland lakes, Mediterranean and Red sea) for a total production 418 thousand tons. In the last 10 years (2011-2020) the aquaculture activity has been tremendously increased 62.0% percent, where in 2011 aquaculture production was 986 thousand tons and became around 1,592 thousand tons in 2020 versus the fisheries which have increased only 12% percent, where in 2011 fisheries production was 375 thousand tons and became 419 thousand tons. The average yearly consumption of fish during 2011 to 2020 in Egypt has developed and increased from 16.5 kg fish/capita in 2010 to 22.7 kg fish/capita in 2020. Most of fish farms are located in Delta region, with four different Egyptian aquaculture production system types (earthen ponds, cages, paddy field and intensive tanks, producing 86.9%, 12.6%, 0.4% and 0.1% respectively). The main farmed fish species are (Tilapia, Mullet and Carp), ranking 61%, 20% and 12% respectively. The remaining species represent in total 7%, those species are catfish, marine finfish and shrimp. In 2020 the total fry finfish/shrimp seeds produced from hatcheries were 674 million and 47 million of mullet fry were collected from the wild. The total registered number of fresh and marine hatcheries have reached 103, with more than 500 tilapia hatcheries are not registered.

Different constraints and obstacles facing the Egyptian aquaculture industry (tilapia extruded feed 25% Crude Protein price has increased 55% in the last years from 660US$/ton in 2012 to 1,020US$/ton in April, 2023 due for the use of imported ingredients feed which has a very large impact on the economy of the country; scarcity of good water quality resources; shortage in marine finfish fry; the far distance between the academic research and real field problems and preventing the export of aquaculture product to the European Union due for non-completing the EU requirements.

The Egyptian aquaculture industry can develop rapidly in the coming decades if the government and NGO bodies could optimizing water productivity through multiple use of water with encouraging the Integrated Agriculture Aquaculture concepts; high quality of fry; enhancing high quality low cost formulated feed, adopting the use of renewable energy mainly solar energy; high labor skill; approved aquatic drugs; adopting of innovating modern technologies; determining the cultured fish and shrimp new candidates; following up the value production chain; support the capacity building of the aquaculture stakeholders; developing a Best Management Practices with achieving the applied scientific research; orienting the E-marketing; facilitating access to the private aquaculture farms for soft loans; enabling gender participation, facilitating the procedures for licensing aquaculture projects with all concerned authorities and provide extension services to improve the sustainability aquaculture.

AN ASSESSMENT AND ANALYTICAL STUDY FOR THE INTEGRATED AGRICULTURE AQUACULTURE (IAA) SYSTEMS IN DESERT AND ARID ZONES IN EGYPT

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An Integrated Agriculture Aquaculture - IAA research study on the Egyptian desert and arid zone was carried out by the WorldFish and conducted as part the CGIAR Initiative from Fragility to Resilience in Central and West Asia and North Africa (F2R-CWANA) during December 2022 to February 2023. The study methodology included desk review of secondary data, stockholder meeting, field visits to farmers, focus group discussions and stockholder workshop. The study identified 18 of farms adopting IAA in the following six governorates (Marssa-Matrouh, Beni-Sweif, Menia, Beheira, Alexandria and Giza). Farmed fish in IAA visited are (Go Green, Sofec, Capital, El-Janna Masr, Arzaaq, Alam El-Awel, Abdelmonem Omran, Anba Anthony Monastery, Korlos, Reda Ahmed Mohamed, Moulazem Helal Ibrahim, Saoudi Aly Mohamed, Abou Zaeid El-Sayed, El-Keram El-Alamiaa, Agromar, Kiwa, El Zeini and Nature Works Aquaponic). IAA is offering an excellent opportunity to optimizing use of water resources, increase fish production, reduce the use of chemical fertilizers in crop farming and reduce the impact of aquaculture on sour rending environment. The current assessment has provided in-depth analysis of the IAA system in Egypt (map IAA systems; identify stakeholders; knowledge gaps and opportunities for the development). A SWOT analysis conducted to identify IAA strengths, weakens, opportunities and threats. The SWOT results have concluded: IAA Strengths (the Government support to IAA in new lands by issuing laws and decrees allowing the IAA concept). IAA Weaknesses (lack of knowledge on importance of IAA systems; lack of IAA exploitation investment map; yearly seasonality of aquaculture production; limited data for aquacultural production in IAA's system; limited knowledge on best practice of IAA farms; high production cost and limited lack of access to credit).

IAA Opportunities (increasing demand for fish consumption; generate employment opportunities in rural areas; use of untapped water sources for aquaculture and increment of fresh fish to cover the need of fish processing factories). **IAA Threats** (IAA farmers needs to get permits from more than one ministry; remoteness of IAA farms from hatchery area increases cost of seed supply; high fish feed prices and high operational costs; potential negative environmental impact with excess use of water; lack of sufficient funding to support the infrastructure of aquaculture value chain and technology know-how transfer prices).

Innovation is an important approach for the sustainable development of IAA in the Egyptian ecosystem for different stakeholders. Suggested innovations are: use of Information Communication Technology – ICT; practice the Smart Sensing for Optimum use of Resources - SSOR; develop the low cost water recycling in fish farm components to address the seasonal variation crop irrigation requirements to improve water use efficiency; support the product network marketing; establish field demonstrations of IAA farms for better understanding of the systemic management and support the IAA's farmers capacity buildings in applied research/training/facilitating interactions/knowledge exchange).

IDENTIFICATION AND CARACTERISTICS OF MICROPLASTICS IN STOMACHS OF COMMERCIALLY IMPORTANT FISH IN TWO LAGOON SYSTEMS OF NORTHERN MEXICO

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The presence of microplastics on the planet has become a great threat to marine ecosystems and to the organisms that inhabit them. This problem covers a wide group of animals, such is the case of marine fish. The objective of this work was to evaluate the presence and types of microplastics ingested by fish of commercial importance in the Navachiste-Macapule and Topolobampo-Ohuira lagoon systems, Sinaloa, México. A total of 556 stomachs of fish sampled with a hook line were analyzed in six species of major commercial importance *Centropomus viridis*, *Cynoscion othonopterus*, *Pomadasys macracanthus*, *Diapterus peruvianus*, *Lutjanus sp,* and *Scomberomorus sierra*. Chemical techniques were used for the digestion of organic matter and microscopy for its observation. The results showed that four of the six species analyzed *C. viridis*, *C. othonopterus*, *P. macracanthus,* and *D. peruvianus* presented contamination by microplastics, in the 556 organisms, 163 have 5 different types of particles corresponding to the group of microplastics were found. Nylon (99), > Polyurethane (42), > Polyethylene (14), > Polyethylene Terephthalate (6), > Polyester fibers (2). The omnivorous species consumed 4.0 microplastics, mainly nylon, and the carnivorous species consuming 2.0 microplastics, consuming polyethylene fibers. During the spring it was the highest consumption with 4.4 polyester microplastics on average. This is the first study that reports contamination by microplastics in species of greatest consumption in two lagoon systems in northwestern México, which will be useful to generate sustainable management policies for fish species.

MICROPLASTICS IN BEACHS OF TWO RAMSAR SITIES OF NORTHERN MEXICO

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The pollution due to the presence of microplastics in marine habitats in coastal areas declared as Ramsar sites is a global concern and a trend in research due to its nature and its potential harmful impact on the marine life. In the present study, microplastics in beach sand were analyzed at eight sampling points, during an annual cycle at Ramsar sites 1826 and 2025 number on the coast of the state of Sinaloa, Northwestern Mexico. 108 sand samples were analyzed, 400 grams of each kilogram of sample were randomly selected, which was digested, filtered, separated, dried and stained to identify its characteristics, number, length, color and shape of the microplastics with the support fluorescence microscopy. A total of 2,691 microplastics were found, distributed in 6 different types. At Ramsar site 1826, 286 (Polyethylene 162, >elastic band 76, >polyethylene terephthalate 23, >High-density polyethylene 18, >nylon 7 and 2405 microplastics were found at Ramsar site 2025 (polyethylene 1206, >nylon 966, > polystyrene 193, > polyester fibers 37, > polyethylene terephthalate 3. Most of the types of plastics found are from materials found in fishing nets and disposable bags, it is suggested that there is a synergistic relationship between the generation garbage due to fishing activity and the lack of proper management of plastic waste on the region's beaches.

Palabras clave: Microplastics; Ramsar sites; Beach sand; Lagoon systems; Northwestern México.

EFFECT OF THE ADDITION OF CAROTENOIDS EXTRACTED FROM THE SHRIMP HEAD ON THE PIGMENTATION OF THE SKIN OF *Lutjanus peru* (Nichols and Murphy, 1922)

LBG. María Laura Tejeda Miramontes*, Dra. Apolinar Santamaría Miranda, Leonardo Ibarra Castro, Juan Pablo Apún-Molina

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Introduction

In Mexico, the species of the genus Lutjanus are predominantly reddish in color, due to its high demand in the market, *Lutjanus peru* promises to be a candidate for mariculture due to its flavor and high nutritional value. The natural existence of this species has been decreasing each year due to the loss of coloration when they are brought to large-scale production. On the other hand, the aquaculture input processing industry has had ecological impacts due to the amounts of shrimp by-products generated during processing, which represent around 45-50% of the catch, causing environmental contamination and disposal of waste. not regulated. There is a tendency to recover and use industrial by-products, such as shrimp, in addition to providing nutritional compounds, they contain carotenoids which have been used to make food and increase pigmentation in marine fish. Pigment cells develop from neural crest cells, and their color may be the result of absorbance or reflection of light in which physio-endocrinological mechanisms act, generated by the expression of some genes involved with pigmentation. All these processes are affected by dietary factors, so the main objective of this study is to understand the effect of carotenoids extracted from shrimp heads using them as an additive (1, 1.5, 2 g/100) in a commercial feed. skretting brand for marine fish.

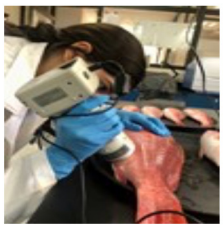
General objective

To evaluate the pigmentation in the skin of the snapper *Lutjanus peru* by including carotenoid pigments obtained from shrimp head by-products.

Methodological strategy

Shrimp head meal (HCC) was prepared by lyophilization at -86°C and by conventional drying at 75°C, carotenoids, fatty acids and bromatology analyzes were performed on the meals, as well as samples of organisms. wild as control to know the content of carotenoids in the skin, type of chromatophores and the genes involved in their pigmentation. An experiment was whispered to evaluate the pigment content in cultured organisms 1.- enhancers with commercial astaxanthin, 2.- enhancers with shrimp head by-products, 3.- enhancers with commercial formulas for marine fish. The results show that the carotenoid pigments are preserved in the oven, however, it is observed that there are more carotenoids in the freeze-drying (3.86 ± 0.59 ug equivalents / mL extract).

Regarding the analysis of fatty acids, it was observed that the HCC obtained by drying in an oven contains fatty acids such as 14:0, 17:1 (n-7), 22:1 (n-9), 20:5 (n-3) and 22:6 (n-3) and in the flour obtained by lyophilization the fatty acids are observed as 16:0, 19:0, 19:1 (n-9), 18:1 (n- 9), 18:2 (n-6), 20:4 (n-6) and 22:6 (n-3). In the bromatological analysis, the HCC shows 342.61 kilocalories vs. pelleted food with 404.89 kilocalories. In the analysis of skin color measurement of wild organisms by colorimetry L* (lightness) a* (redness) b* (yellowness) on the body (dorsal, pectoral and ventral), the dorsal part of these fish is the area where there is more pigment with an L* of 77.51±2.94, an a* of 17.17±3.97 and a b* of 11.78±2.72, finally the skin of these fish was taken to characterize the chromatophores, it was observed that *L. peru* has four types of chromatophores (melanophores, xanthophores, erythrophores and cyanophores).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USE OF MEDICINAL PLANTS IN THE TREATMENT OF TILAPIA DISEASES: USE OF *Randia echinocarpa*

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The use of medicinal plants is proposed in the treatment of diseases that impact aquaculture because they synthesize and accumulate physiologically active substances that promote pathogen inhibition (antimicrobial, antioxidants, etc.). For this reason, the goal will be to evaluate the concentration and inhibitory capacity of phytochemical compounds in plant extracts of *Randia echinocarpa* and the survival of fish infected with streptococci.

The plant was collected in the municipality of Badiraguato, Sinaloa, in the community of Rancho Viejo, and was later taken to the laboratory. Processing of plant tissues (unripe and ripe fruit, leaf, peel, fruit peel) of *R. echinocarpa* for use in tilapia feed supplementation.

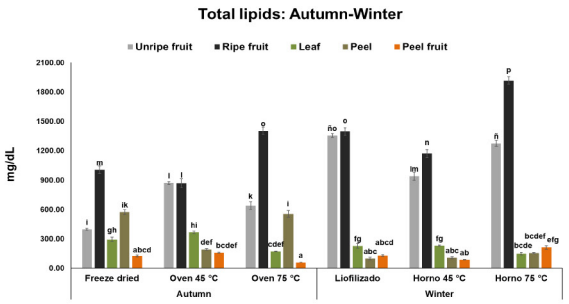
All tissues were crushed, placed in trays, and dried by freeze-drying (LABCONCO), in ovens at 45 and 75°C (Yamato IC403CW).

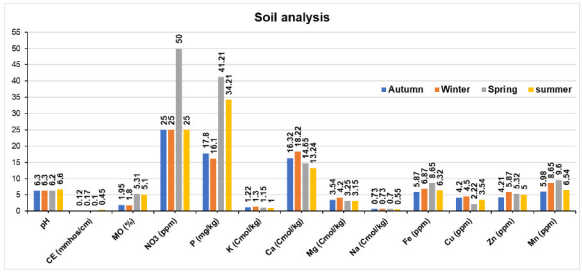
Total lipids were analyzed in five tissues of *R. echinocarpa* in two seasons of the year with three drying variations (Freeze-dried, Oven 45 and 75 °C).

A higher concentration of lipids was determined in the ripe and unripe fruit. Finding higher concentrations of lipids in ripe fruit dried at 75 °C both in autumn and winter, being significantly higher.

Likewise, the soil was analyzed in the four seasons of the year to know the properties where *R. echinocarpa* develops. An increase in phosphorus and nitrates was found in spring and phosphorus in summer.

Analysis of inhibitory capacity, phytochemical profile, and survival test of tilapia supplemented with R. *echinocarpa* and infected with streptococci will be carried out.





BIOCHEMICAL ANALYSIS OF THE BLOOD AND DETERMINATION OF THEPRESENCE OF MICROPLASTICS IN THE STOMACH OF *Mugil cephalus*

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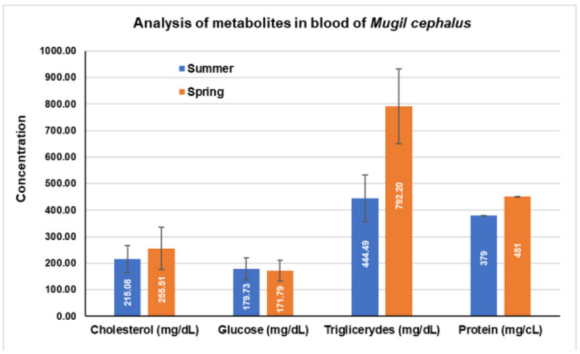
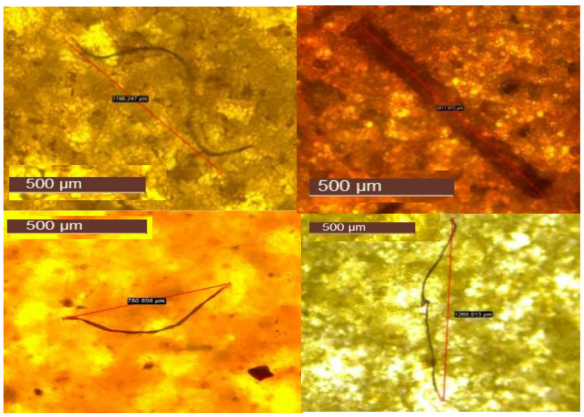
In fish, the fastest and most effectiveindicators of any physiological disturbance correspond to methods that evaluate hematological parameters and blood chemistry. Because parameters inthe blood are directly related topathologies, as well as implying the relationship of cells and metabolites withreproduction, growth, and other physiological factors. Currently, the use of plastics has caused the accumulationof fragments of these (microplastics) in various animal species, some of the mostfound in the ocean are polyethylene, polypropylene, polystyrene, polyamide,polyethylene terephthalate, and nylon, causing endocrinological problems in thespecies that present them. The objectiveof this work was to determine the health status and the presence of microplasticsin *Mugil cephalus*.

The organisms were collected atdifferent points in the coastal area of themunicipality of Ahome, Sinaloa, known as “La Robalera and Bahía del perro”, they were subsequently transported. to the laboratory for dissection and corresponding analysis. Glucose, cholesterol, triglycerides, and protein were analyzed in the blood of *M.cephalus*. Finding higher concentrations

of all the metabolites analyzed (althoughnot very significant), with respect to these same parameters reported in *Mugil curema*, it is important to carry out thesestudies in different areas and populationsof the species to establish hematological reference values.

The presence of microplastics in the stomachs of *M. cephalus* was analyzed,finding mainly nylon threads, which are commonly used in fishing gadgets such as nets, and fishing lines.





CAN RABBITFISH DIGEST SOYBEAN BASED DIETS?

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Aquaculture sustainability requires that we move from rearing only piscivorous fish to adding algaevorous marine fish to the mix of species we grow. One promising family of marine algaevores is the rabbitfishes. These are a family of Indo-Pacific fishes that feed near exclusively on algae. However, in nutrition experiments in captivity, they did not perform well when feed protein was mainly from soybeans. We performed the present work to assess whether the reason was that the fish did not have necessary enzymes to digest soy products. We evaluated digestive enzyme presence and activity in the gut of wild and aquacultured rabbitfish *Siganus rivulatus*. Wild rabbitfish were trapped off the Beirut beach and transported to the aquaculture research facility at the American University of Beirut. An initial gut sample of the fish was removed and freeze-dried within 24 hours post catch. The remainder of the fish were cultured in outdoor round tanks and their guts collected after one month and one year of being fed a commercial formulated diet. Activities of the digestive enzymes for proteins, lipids and carbohydrates were detected in wild caught rabbitfish with activity of trypsin relatively high. After feeding on a formulated diet, activities of some digestive enzymes in the various gut sections were significantly modified. Trypsin and chymotrypsin activities in fish fed the commercial diet significantly increased as compared to wild fish after one month of feeding, but amylase and lipase activity were not significantly affected even after one year of feeding. Digestive enzyme activity varied among gut sections, with trypsin and chymotrypsin being relatively high in the mid and hindgut sections and aminopeptidase higher in the foregut. Results suggest that the enzymes necessary for the digestion of soybean meal and most proteins including soy protein concentrate are present in the gut of *S. rivulatus*. Possibly, negative effects of soybean are a result of insufficient heat and pressure during manufacture of the feed.

Table 1. Digestive enzyme activity (U/mg protein) in the entire gut of *Siganus rivulatus* (W = wild fish; OM = fish offered a formulated diet for one month; OY = fish offered formulated diet for one year).

Time	**Proteases**	**Trypsin**	**Chymotrypsin**	**L-aminopeptidase**	**Lipase**	**Amylase**
W	199.1±15.9	195.8±10.5.3	195.8±105.3	254.9±53.8 [ab]	73.1±30.3	120.4±33.8
OM	164.9±11.1	379.9±213.6	224.7±10.4	324.7±18.5 [a]	63.6±72.3	87.0±62.9
OY	188.2±35	484.5±140.3	345.5±114	232.6±17.9 [b]	71.4±42	82.1±17
ANOVA (*p*)	0.3	0.2	0.2	0.0	1	0.5

AQUACULTURE NETWORK FOR AFRICA

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The establishment of a network of aquaculture policy makers in Africa, was first perceived that the *Fish for All Summit* held in Abuja, Nigeria in 2005. Among the priority actions recommended by the Summit's *Abuja Declaration on Sustainable Fisheries and Aquaculture in Africa (2005),* was the need for accelerating sustainable aquaculture development on the continent coherently and within the framework of the African Union's regional integration agenda. The need for establishing a regional network of aquaculture policy practitioners, supported by other leading government planning sectors, to accelerate the development of aquaculture development strategies and mainstreaming these into national development agenda. The Aquaculture Network for Africa (ANAF) was thus conceived benchmarking on gains for the aquaculture sector in the Asia-Pacific upon the establishment of Network of Aquaculture Centres (NACA).

Sub-Sahara's Directors of Aquaculture subsequently re-affirmed this recommendation in the 13th Session of CIFA in 2005. Sub-Sahara's Directors of Aquaculture subsequently re-affirmed this recommendation in the 13th Session of the FAO Committee for Inland Fisheries for Africa (CIFA) in 2005, thereafter renamed Committee for Inland Fisheries and Africa for Africa (CIFAA). ANAF's was later established based on voluntary membership among CIFAA's members to coordinate and facilitate *(i)* scientific and technical information exchange in aquaculture, *(ii)* regional and sub-regional collaborative aquaculture research, *(iii)* training of fish farmers and extension workers and *(iv)* technology transfer between countries to accelerate sustainable aquaculture development on the continent. To achieve continental ANAF's membership, in promote coherence in the implementation of the Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa (PFRS) and cognizant of AU Interafrican Bureau of Animal Resources (AU-IBAR) role mandated role in coordinating the management and utilization of all Africa's animal resources, it was later recommended the ANAF Secretariat be transferred to AU-IBAR to foster the long-term commitment of AU Member States for sustainable aquaculture development. ANAF's membership since 2018, consequently has continental coverage.

ANTIMICROBIAL RESISTANCE PROFILE OF BACTERIAL PATHOGENS IN DISEASED NILE TILAPIA IN SMALL-SCALE CAGE CULTURE FARMS ON LAKE KARIBA, SIAVONGA, ZAMBIA

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This study investigated disease outbreaks in farmed *Oreochromis niloticus* (Nile tilapia) in Siavonga among small-scale cage culture farms on Lake Kariba in order to establish bacterial etiological agents associated with fish mortality and to determine their antibiotic susceptibility. A total of 300 fish samples from 11 farms were aseptically collected and bacteria were isolated from the kidney, liver, brain, and spleen. The isolates were identified using their morphological characteristics and conventional biochemical tests. The antibiotic susceptibility of selected bacteria was determined by the Kirby–Bauer disc diffusion method. The following well-known fish pathogens were identified at a prevalence of *Aeromonas* spp. (13%), *Pseudomonas* spp. (10.3%), *Micrococcus* spp. (9.7%), *Klebsiella* spp. (8.7%), *Lactococcus* spp. (7.3%), *Streptococcus* spp. (7.0%), and *Acinetobacter* spp. (7.0%). All the isolates tested were susceptible to doxycycline, and complete resistance to ciprofloxacin, co- trimoxazole, and cephalothin was recorded in the *Bacillus* spp. The observed resistance could be attributed to bacteria from terrestrial sources as fish farmers do not administer antibiotics to fish. To our knowledge, this is the first study to establish the occurrence of several bacterial species infecting tilapia in Zambia and the first to determine the antibiotic susceptibility of fish bacteria among small- scale farms on Lake Kariba. The current study provides baseline information for future reference and fish disease management on Lake Kariba and in Zambia.

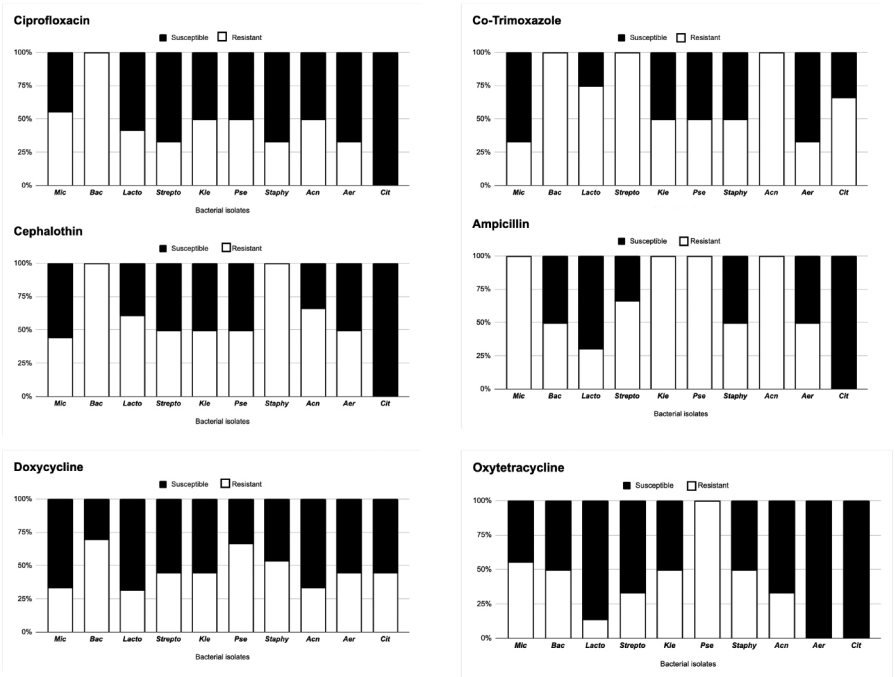

Figure 1: The results of antibiotic susceptibility tests performed on the representative isolated of diseased fish using Ciprofloxacin (30 µg/disc), Doxycycline (30µg/disc), Cephalothin (30 µg/disc), Co-Trimoxazole (25 µg/ disc), Ampicillin (25 µg/ disc), and Oxytetracycline (30 µg/disc). Mic = *Micrococcus,* Bac = *Bacillus,* Lacto = *Lactococcus spp,* Strepto = *Streptococcus sp,* Kle = *Klebsiella spp,* Pse = *Pseudomonas spp,* Staphy = *Staphylococcus spp,* Acn = *Acinetobacter,* Aer = *Aeromonas spp,* Cit = *Citrobactor spp*

ASSESSING THE FUNDING OPPORTUNTIES AND CHALLENGES FOR SMALL SCALE FISH FARMERS IN ZAMBIA: LESSONS FROM CITIZENSHIP ECOMONIC EMPOWERMENT COMMISSION (CEEC) AQUACULTURE SEED FUND

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Aquaculture is a fast-growing food production sector in Zambia and currently continues to grow. As a result, aquaculture is a promising tool to increase fish production and reduce poverty while at the same time achieve greater social equality and drive economic growth. The government of the Republic of Zambia has taken great interest and through various institutions is aimed at providing low-cost loans to small scale farmers. Citizenship Economic Empowerment Commission (CEEC) is one of the institutions that provides such a facility under the Aquaculture Seed fund which was has been rolled out across all the ten provinces in 2018.

The undertaking was done through the collection of both qualitative and quantitative data from scale farmers in the Luanshya District of the Copperbelt Province who have received funding from CEEC to cover investment, operating costs as well as other services. The study reveals that there is very high awareness of the funding opportunity by small scale farmers across the country. However framers who are selected for funding do not receive their disbursements on time which is a major constraint to the growth and development in the aquaculture and fisheries sector. The study also reveals that there is a rigid model for small scale farmers to abide by when they are selected for funding which is very impractical for many small scale fish farmers. It was also revealed that numerous loan applicants lack knowledge in fish farming and are doing it for the first time. As a result of these factors, there is very low yield attained in the production of fish contrary to the aim of the funding facility.

The study recommends that personal interviews are done before the selection of loan beneficiaries. In addition to this, systems and structures to be put in place to ensure finances are disbursed in good time and proposed. In addition, efforts of the funding initiative aimed at creating strong linkages between the small scale fish farmers funding institutions and understanding farmers' needs at different points are also given. Lastly the study recommends the creation of strong farming groups and practical training for small scale fish farmers in financial and project management.

PARTIAL REPLACEMENT OF FISH MEAL WITH GREEN PEAS (*Pisum sativum*) MEAL IN THE DIET OF TILAPIA (*Oreochromis andersonii*) JUVENILE

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A 6-weeks feeding trial was conducted to investigate the effect of green pea *Pisum sativum* as alternative protein source for fish meal on the growth performance and feed conversion ratio for tilapia *Oreochromis andersonii*. The experiment was carried out at Kapasa Makasa University, where twelve hapas (70 x70 x 70cm deep) installed in four (4) 2 x 1.2x 1m concrete ponds in a completely randomized design. All treatments were replicated three times. 120 *O. andersonii* juvenile (15-20g pooled weight and 7.5-10cm pooled standard length) were randomly allotted to four experimental diets at a stocking density of 10 juveniles per hapa (70 x70 x 70cm deep) were used for 6 weeks to stock *O. andersonii.* Four experimental diets were prepared with the increasing substitution levels of green peas (GP) for fish meal (FM) at 0% (0nly FM36%) control treatment, 20% (GP20 and FM30) treatment 2, 25% (GP25 and FM25) treatment3 and 28%(GP28 and FM20) treatment4 in a 38% crude protein. The weight gain (WG) of fish (23.52g) fed GP0% diet was comparable to fish fed GP20% diet (24.04g), fish fed GP25% diet (21.93g) and fish fed GP28% diet (20.89g) and did not differ significantly ($p > 0.05$). The feed conversion ratio of fish fed (GP20, GP25, GP28%) were comparable to the control fish and no significant different ($p>0.05$). No significant differences ($p > 0.05$) were found in the change specific growth rate and change length among the different treatments. It appears that green peas can replace fish meal at the level of 20%, 25% and 28% in diets for *O. andersonii* without adverse effects on growth, feed conversion ratio and this may also contribute to reduce feed cost to sustain aquaculture.

USE OF INNOVATIVE FISH TRAP TECHNOLOGY IMPROVES HOUSEHOLD FOOD AND NUTRITION SECURITY – LESSONS FROM MALAWI

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One of the common challenges in low-input fish farming systems in rural African aquaculture is the uncontrolled reproduction in the ponds due to the use of mixed-sex *Tilapias*. To tackle the problem, a size-selective, cheap wire mesh fish trap (material cost around 3 USD) was developed to help reduce the number of offspring through intermittent harvesting while leaving the initial fish stock (parent fish) in the pond to grow. Fish farmers using this technology are satisfied with the minimal workload required to harvest the fish, as well as amount and size of fish harvested. Furthermore, results of a comparative study revealed that fish farmers using the technology (intervention group, n=53) eat significantly more fish (3 – 4 times a week) and tend to eat more fish from their own ponds, compared to fish farmers without trap (control group 1, n=52). Additionally, households using the innovative technology had more diversified diets and were also less likely to experience food insecurity than control group 1 and control group 2 (farmers without fish pond, n=55).

The Aquaculture Value Chain for Higher Income and Food Security Project (AVCP), part of the Global Programme "Sustainable Fisheries and Aquaculture" commissioned by the German Ministry for Economic Cooperation and Development supported the development and distribution of the innovative trap technology in collaboration with the Malawi Government through the Department of Fisheries. A three-arm comparison study in the Northern Region of Malawi aimed at assessing the impact of intermittent harvesting on Household Dietary Diversity Score (HDDS), Household Food Insecurity Experience Scale (HFIES), Food Consumption Score (FCS), and fish consumption. In all four indicators, the intervention group had higher scores compared to the control groups.

Figure 1: Household Food Insecurity Experience Scale (HFIES) and acceptable Food Consumption Score (FCS) between the study groups

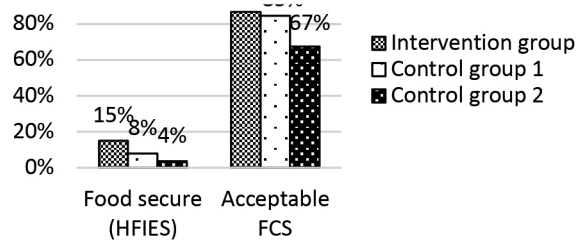
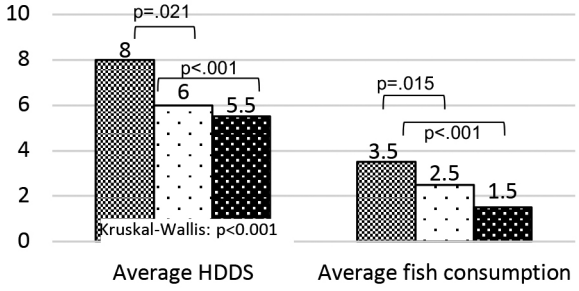


Figure 2: Household Dietary Diversity Score (HDDS) and average fish consumption between the study groups



EFFECTS OF HYPERCAPNIA ON THE METABOLISM AND PRODUCTION PERFORMANCE IN NILE TILAPIA *Oreochromis niloticus*

Peter Vilhelm Skov*, Renalda Nanziga Munubi, Muumin Iddi Hamad

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High levels of dissolved carbon dioxide (CO_2) is a daily occurring phenomenon in earthen ponds. Hypercapnic conditions lead to a respiratory acidosis, which fish buffer by an accumulation of bicarbonate. The degree of hypercapnia that fish are able to recover appears to be species specific. We investigated the effects of three levels of dissolved CO_2 (10, 30, and 60 mg L^{-1}) on the standard (SMR) and maximum metabolic rate (MMR) of Nile tilapia, following acute (1h) and prolonged (24h) exposure. Acute hypercapnic exposure resulted in significant decreases metabolic scope, that persisted for 24h for the highest exposure groups (Fig. 1).

We evaluated the effects of daily variations in dissolved CO_2 and O_2, individually and in combination, on the appetite, growth, and feed utilization in Nile tilapia using groups reared under normoxic - normocapnic conditions (control, C), diurnal hypoxia (HO), diurnal hypercapnia (HC), or combined diurnal hypoxia and hypercapnia (HO × HC) in a digestibility system. We show that hypercapnia and hypoxia exerted strong individual effects on appetite, specific growth rate, and feed conversion (Fig. 2), but also that simultaneous hypoxia and hypercapnia amplified these effects. Simultaneous exposure to hypoxia and hypercapnia resulted in a day-long loss of appetite, and reduced specific growth rates by >60%. Surprisingly, the digestibility of dry matter, protein, and lipid was either unaffected or even slightly improved in groups exposed to single or combined diurnal variation in dissolved oxygen and carbon dioxide. It is unknown whether this is the result of the change in feed intake or represents an adaptive mechanism to satisfy an increase energy demand caused by environmental stress. Overall, we conclude that although Nile tilapia is considered resilient to environmental stress, feeding and feed utilization are strongly influenced by daily fluctuations in dissolved gases, particularly CO_2.

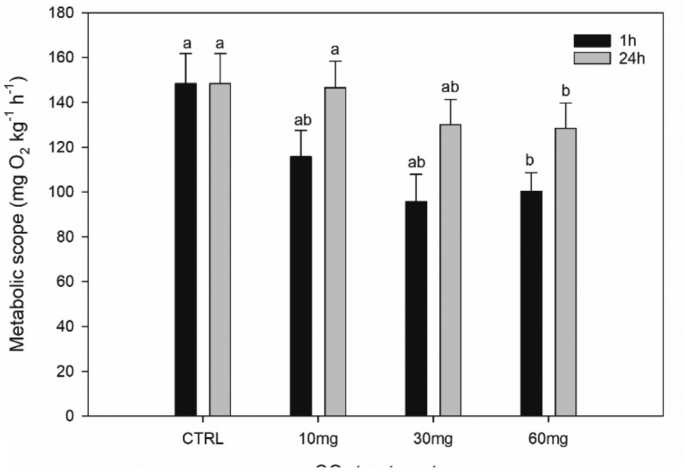

FIGURE 1. Effects of acute (1h) and prolonged (24h) hypercapnia (10, 30, or 60 mg CO_2 L^{-1}) on the metabolic scope in Nile tilapia

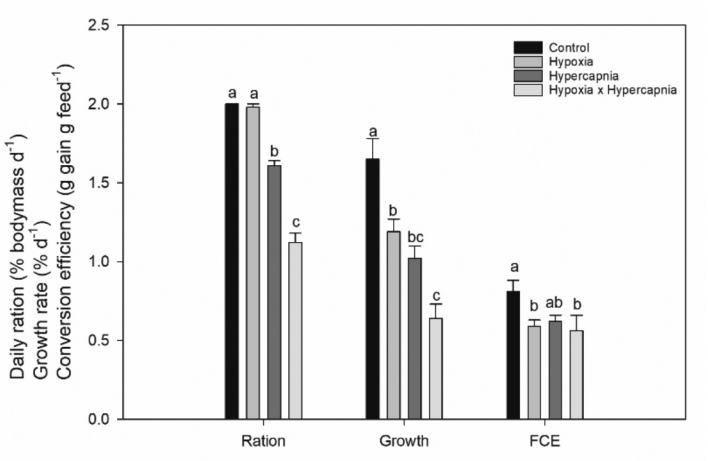

FIGURE 2. Effects of nocturnal hypercapnia (30 mg CO_2 L^{-1}) and hypoxia (10% O_2) individually and in combination, on the feed intake, growth rate and feed conversion in Nile tilapia

SOLAR DESALINATION GREENHOUSE FOR THE UTILISATION OF SALINE WATER.

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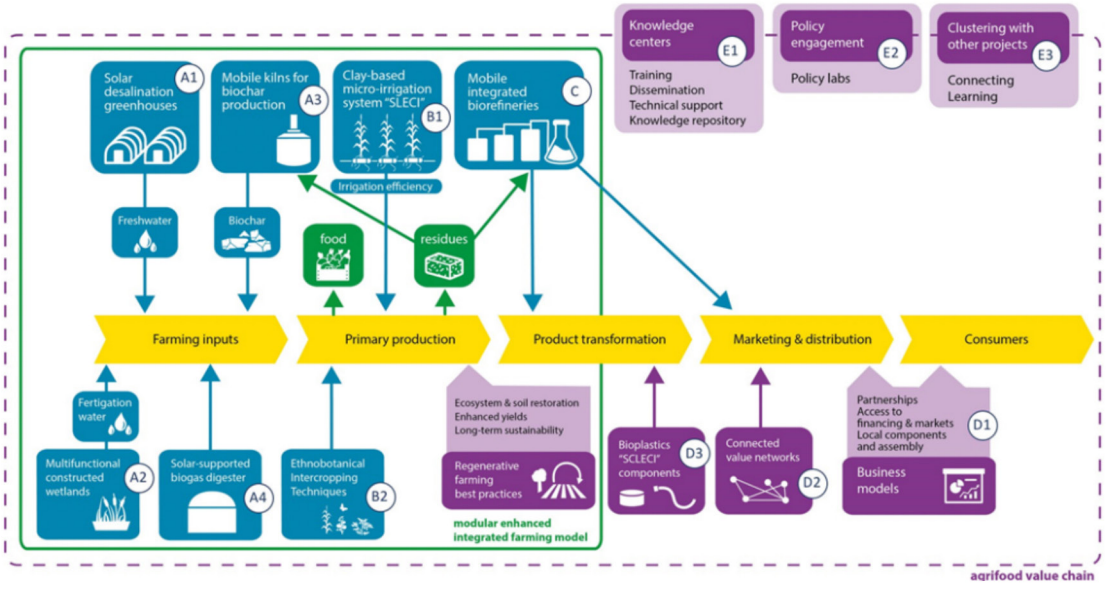
Currently, many rural economies are locked in subsistence farming and are vulnerable to food insecurity due to lack of access to water, technical know-how and feasible revenue streams, further aggravated by unsustainable farming practices and resulting in migration from rural areas to cities. Climate change negatively affects agricultural production in water-scarce regions of Africa, which makes water use efficiency one of the key factors for agricultural and rural livelihoods. Agriculture is still the most important economic sector in rural Africa and pathways of transition to a circular bioeconomy bears significant potential for socio-economic and environmental sustainability of rural communities in the long term. Revenue diversification pathways in Africa through bio-based and circular agricultural innovations (DIVAGRI) is an EU Horizon2020 funded research projects which includes 39 direct partners. The DIVAGRI consortium has identified a range of major challenges in its target regions and identified solutions to address them within the scope of the project, as summarized in the diagram below.

This presentation will deal with A1, the development of an evaporation greenhouse based on the principle of solar desalination stills. Saltwater is evaporated through open surfaces, and the evaporation increased by cultivating halophytic (salt-tolerant) plants in the desalination greenhouse. An existing conventional greenhouse was retrofitted with a desalination design. DIVAGRI tests passive surface cooling mechanisms to condensate the evaporated water, e.g., low-quality water (e.g. saline groundwater) or seawater, roof cooling mechanisms such as materials, greening of roofs (xerophytes) and shaded/ underground area. The combined cooling and humidification with the injection of CO_2 derived from the biorefinery creates optimal growing conditions inside the greenhouse, which could reduce water losses from evapotranspiration by 90% and increase yields by 10-30%. DIVAGRI also investigates cost-efficiencies of the trade-offs between surface area and energy requirement, and design considerations related to local production, operation, and maintenance.



INTEGRATED FARMING SYSTEMS FOR FOOD SECURITY AND NUTRITION

Austin Stankus

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Integrated Agriculture Aquaculture (IAA) is a sustainable farming practice that combines aquaculture with agriculture, creating a synergistic system. The integration of aquaculture and agriculture is not a recent innovation. Indeed, it is ancient, but in a context of increasing pressure on natural resources and land, aggravated by the uncertainties of climate change, it offers new opportunities to build more sustainable food systems through new practices that allow producing more, while also creating socio-economic and environmental benefits. By creating synergies, IAA not only contributes to food production, food security and nutrition, but also to the restoration of ecosystem services and biodiversity, which are essential for sustainable agriculture. It can thus play an important role in building resilience and adapting to climate change. In Africa, IAA holds great potential for addressing food security, poverty alleviation, and environmental sustainability.

One of the key advantages of IAA is its ability to maximize resource utilization. This integrated approach not only increases overall productivity but also reduces the environmental impact associated with traditional monoculture systems. IAA also provides a sustainable option for intensification, where the same amount of land and water can be used to produce both crops and fish. Furthermore, IAA allows for diversified income streams for farmers, making them less vulnerable to market fluctuations in a single sector. However, several challenges hinder the widespread adoption of IAA in Africa. Limited access to capital, technical knowledge, and suitable land for integrated systems are significant barriers. Inadequate infrastructure and market linkages also pose challenges for scaling up IAA operations.

Despite these challenges, there are notable opportunities for the growth of IAA in Africa. The continent's diverse agro-ecological zones provide a range of environments suitable for different integrated systems. Moreover, advancements in technology and innovation offer promising avenues for increasing aquaculture production. Investment in training and capacity building for farmers, as well as the development of supportive policies and regulations, can further accelerate the adoption of IAA.

ADVANCED AQUAFEED PRODUCTION USING AQUAFLEX TWIN SCREW EXTRUSION

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Currently the global aquaculture industry is challenged with increasing and highly volatile ingredient costs on one hand and decreasing farmgate price for the produce on the other. In this scenario, aquafarmers are forced to procure and use less expensive feed variants or increase the production per unit area to still remain profitable. Doing so would mean that FCR's are going to go up which would lead to more waste being accumulated in the farming system and being released into the environment which is undesired. Feedmillers on the other hand are exploring alternate ingredient sources and better extrusion technologies for feed manufacturing to reduce feed cost and to remain profitable and sustainable.

Over the last several decades, the aquaculture industry has utilized the benefits of using extrusion technology over traditional pelleting such as improved starch gelatinization, increased pellet durability, water stability and achieving floatation control by manipulating the pellet density. Having said that, most of the capacity building has been on the installation and utilization of traditional single & twin screw extrusion process. These traditional extrusion systems used in the aquafeed industry were drawn from other industries and were designed down to be just good enough for aqua feed production. The Wenger AquaFlex Extrusion system has been developed with the needs of the aquatic species in mind.

The AquaFlex system utilizes specialized screw element design to deliver higher volumetric capacity. The same screw configuration is used to produce both floating as well as sinking feeds, thereby increases uptime and optimizes production. Lower mechanical energy as well as die pressure results in smaller and finer cell structures inside the pellet resulting in more uniform pellet densities and more nutrient per pellet (20- 25%). Wenger in-house research has shown that the extruded pellets produced on the AquaFlex has the least turbidity thereby reduced nutrient leaching and water pollution making it most suitable for high density aquaculture practices.

ADVANCED AQUAFEED PRODUCTION USING AQUAFLEX TWIN SCREW EXTRUSION

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Currently the global aquaculture industry is challenged with increasing and highly volatile ingredient costs on one hand and decreasing farmgate price for the produce on the other. In this scenario, aquafarmers are forced to procure and use less expensive feed variants or increase the production per unit area to still remain profitable. Doing so would mean that FCR's are going to go up which would lead to more waste being accumulated in the farming system and being released into the environment which is undesired. Feedmillers on the other hand are exploring alternate ingredient sources and better extrusion technologies for feed manufacturing to reduce feed cost and to remain profitable and sustainable.

Over the last several decades, the aquaculture industry has utilized the benefits of using extrusion technology over traditional pelleting such as improved starch gelatinization, increased pellet durability, water stability and achieving floatation control by manipulating the pellet density. Having said that, most of the capacity building has been on the installation and utilization of traditional single & twin screw extrusion process. These traditional extrusion systems used in the aquafeed industry were drawn from other industries and were designed down to be just good enough for aqua feed production. The Wenger AquaFlex Extrusion system has been developed with the needs of the aquatic species in mind.

The AquaFlex system utilizes specialized screw element design to deliver higher volumetric capacity. The same screw configuration is used to produce both floating as well as sinking feeds, thereby increases uptime and optimizes production. Lower mechanical energy as well as die pressure results in smaller and finer cell structures inside the pellet resulting in more uniform pellet densities and more nutrient per pellet (20- 25%). Wenger in-house research has shown that the extruded pellets produced on the AquaFlex has the least turbidity thereby reduced nutrient leaching and water pollution making it most suitable for high density aquaculture practices.

IMMUNOMODULATION AND CONTROL OF INFLAMMATORY RESPONSE IN FISH USING NUTRACEUTICALS IN AQUAFEED

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Fish farming presents itself as an excellent opportunity to satisfy the growing protein demand of humanity. However, intensification systems together with the limitation of water resources hinder the growth of fish farming. Environmental stressors complicate fish performance and can interfere with the immune system leading bad productive results or even mortality due to outbreak diseases.

Substances of botanical origin such as carotenoids, phenolic, alkaloids, nitrogenous and organosulfur compounds can act satisfactorily on the immune system, the microbiota, and the intestinal integrity. The development of nutraceutical products aimed at controlling the inflammatory response and the immune system is a priority objective that can successfully contribute to improving the health conditions of fish.

The present work shows a compendium of tests carried out on tilapia (Oreochromis *niloticus)* in Nigeria, Mexico and Perú under experimental and industrial conditions. The results obtained show that it is possible to exert control on the immune and inflammatory response using botanicals incorporated in aquafeed.

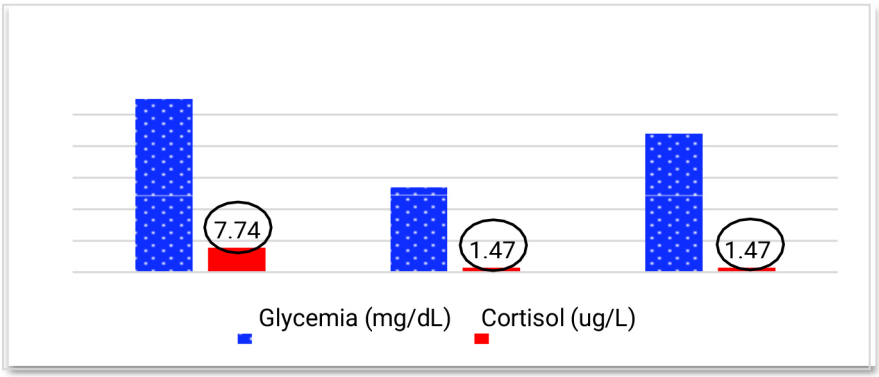
The analytical determinations made in the trials show how the use of the proposed nutraceutical exerted a favourable effect on the immune and inflammatory response. The increase in lymphocytes before and after bacterial challenge, the greater activity of endogenous enzymes (CAT; SOD and GPX), the lower levels of cortisol and glucose and the lower blood levels of liver enzymes (ALT and AST) demonstrate that it is possible to satisfactorily influence on animal health and in particular liver health which directly influences the digestive process. Therefore, Nutraceuticals applied in aquafeed are interesting tools to improve productivity in fish farms.

Baja California University. Mexico .

Nile tilapia (Oreochromis niloticus). 2022.Blood

	Control	Nutraceutical	
Leucocytes (x 10^3 mm^3)	18.90 ± 0.19 ^{a}	35.66 ± 0.38 ^{b}	0.016
Total protein (g dL^{-1})	3.86 ± 0.08 $^{a, b}$	3.91 ± 0.04 ^{b}	0.034
Albumin (g dL^{1})	1.32 ± 0.04 $^{a, b}$	1.36 ± 0.02 ^{a}	0.039
Glucose (mg dL^{-1})	95.63 ± 3.31 ^{a}	65.44 ± 3.19^{b}	<0.001
Cholesterol (mg dL^{-1})	117.4 ± 2.76 $^{a, b}$	140.33 ± 7.85 ^{b}	<0.001
Triglycerides (mg dL^{-1})	146.57± 6.88 ^{a,}	253.88± 37.41 ^{a}	0.075

Industrial Assay
Peru 2023. Nile tilapia.
Blood analyses
Glycemia-Cortisol



FINANCING AFRICAN AQUACULTURE: MIXED FINANCING AND PUBLIC-PRIVATE-PARTNERSHIPS

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African aquaculture, although still minor compared to the rest of the world, proven to have a significant potential for expansion and development. African geographies where aquaculture has developed and is developing consist of complex value chains, where majority of actors are small and marginalised. One of the significant characteristics of the smallholder-based aquaculture in Sub-Saharan Africa is the low productivity. Drawing investments into marginalised value chains for improving productivity and efficiency has great promise – in fact, the greatest promise – for better livelihoods, healthy and nutritious foods, women's empowerment, and climate resilience at large scale. This is not an easy task given much traditional thinking that smallholders are "difficult" or "too fragmented" or "remote." If we perceive smallholders as a market severely constrained in resource access, we must redefine them as a colossal untapped potential. Both public and private investors should diligently explore this vast potential, adopting a proactive yet patient stance. There is much insight, data, technologies, and business solutions that can effectively mitigate risks for businesses with a vision to empower smallholders and marginalised communities. Collaborative private-public partnerships can bring transformative change, placing a strong emphasis on uplifting smallholders. Neglecting them could lead to a highly unequal food system, causing missed opportunities in the blue foods sector.

DIGITALIZATION OF MONITORING SYSTEM: A LEARNING EXPERIENCE

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In the ever-evolving sector of freshwater aquaculture, the need for precise, relevant, and accessible information has become increasingly vital for farmers, their institutions and government departments. Digitalization is being considered as the major component to achieving this target. Although digitalization has made great progress the communication between farmers and their organizations is still based on word-of-mouth, recalling memories, WhatsApp messages, phone calls, or sometimes sporadic member surveys. The "QR Code Based Monitoring System," addresses this communication challenge for areas with high smartphone accessibility. With the support of this tool, farmers and farmer institutions have an easy way to exchange information to provide technical support and to manage community-based institutions for aquaculture. The tool is operational in 25+ farmers institutions having around 200 to 300 farmer members each.

Traditionally, accurate and up-to-date information is the limiting factor for farmer institutions to estimate input needs and production, which then limits their ability to optimize services for their members. This hampers the growth of the sector and makes it difficult to make informed decisions, for the farmer as well as for the farmer institutions.

In India, farmer institutions confirmed several constraints while using modern smartphone-based apps such as often the target users for these apps are individual farmers and not institutions, barriers in customization options, free version limitations, business model of those apps such as recurring cost in paid version, data privacy, security and so on. The profit sense is often lost when considering customized digital solutions that attract huge investments, recurring costs, and other issues.

The "QR Code Based Farmer Monitoring System" tool attempts to respond to the above problem via open-source frameworks. By using the tool, communication between farmers and their institutions is improved to monitor fish growth, estimate production, and access curated benefits tailored to farmers' needs by the farmer institution. In addition, the tool could also allow enrollment of members of the farmer institution to various government programs, improving access to financial services and insurance facilities.

IgM QUANTIFICATION OF ORAL ADMINISTRATION OF PROBIOTICS *(Bacillus subtilis and Lactobacillus plantarum)* IN NILE TILAPIA *(Oreochromis niloticus)* VACCINATED AND CHALLENGED WITH *Streptococcus agalactiae*

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Maria José Tavares Ranzani-Paiva; Patricia Bianca Clissa; Daniele Pereira Orefice; Danielle De Carla Dias;
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The pathogenic bacterium *Streptococcus agalactiae* is one of the main obstacles in tilapia farming worldwide. This project aimed to evaluate the immunoglobulin-IgM of Nile tilapia fed with AQUA-PHOTO® probiotic (composed of *Bacillus subtilis* and *Lactobacillus plantarum*) and vaccinated against *Streptococcus agalactiae*.

The experimental design was completely randomized, with five treatments (CON – control; ADJ - only adjuvant injected, without probiotic feeding; PRO - with probiotic and without the vaccine; VAC - without probiotic and with the vaccine; PRO+VAC - with probiotic and with the vaccine) and five replicates, for 63 days. The fish was fed with ration + probiotic for 21 days (PRO and PRO+VAC). The fish was vaccinated at 21th day and revaccinated (booster) at 35th day of experiment. The fish blood (n=10 per treatment) was collected after anesthesia with eugenol (0.02 mg.L-1) at day 21 (phase I), 35 (phase II), 49 (phase III) and 63 (phase IV) of experiment. The IgM antibodies detection was performed in tilapia serum by indirect ELISA with *S. agalactiae* bacterin, Nile tilapia anti-IgM polyclonal antibody produced in rabbit, anti-rabbit IgG, peroxidase-conjugated and, the colorimetric substrate tetramethylbenzidine (TMB). The reaction was read at spectrophotometer (450 nm).

In phase III, the fish IgM quantification of PRO+VAC was higher than other treatments ($P<0.001$) and VAC values was higher than CON, ADJ and PRO, but only lower concentration than PRO+VAC ($P<0,05$).

We conclude that PRO+VAC and VAC at phase III, provide good production of IgM of Nile tilapia after infection with *S. agalactiaea* and probable will protect against *S. agalactiae* infection.

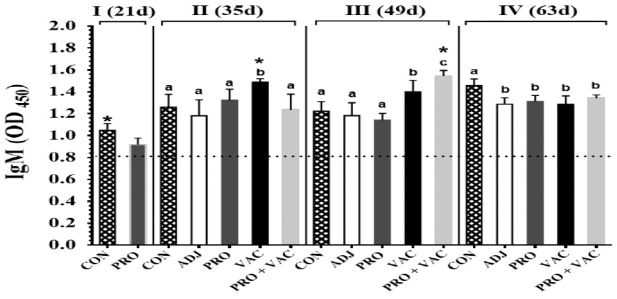

Figure. IgM Nile tilapia serum quantification by ELISA, pahses: [I] probiotic diet feeding, [II] vaccination, [III] revaccination (booster) and [IV] survivors post-infection with *S. agalactiae* seroty serotype Ib. Statistical differences between control and treated groups ($P<0.05$). (CON: control; ADJ: adjuvant; PRO: probiotics; VAC: vaccinated; PRO+VAC: probiotics + vaccine). * Significant difference by Kruskall Wallis ($P<0.001$). ^{abc} Significant difference in Dun test between groups within each period. OD_{450}: Optical Density at 450nm.

EFFECTS OF REPLACEMENT OF FISH MEAL WITH A MIXTURE OF COWPEAS AND AMARANTH (*Amaranthus cruentus*) IN LABEO VICTORIA (*Labeo victorianus*) CULTURE

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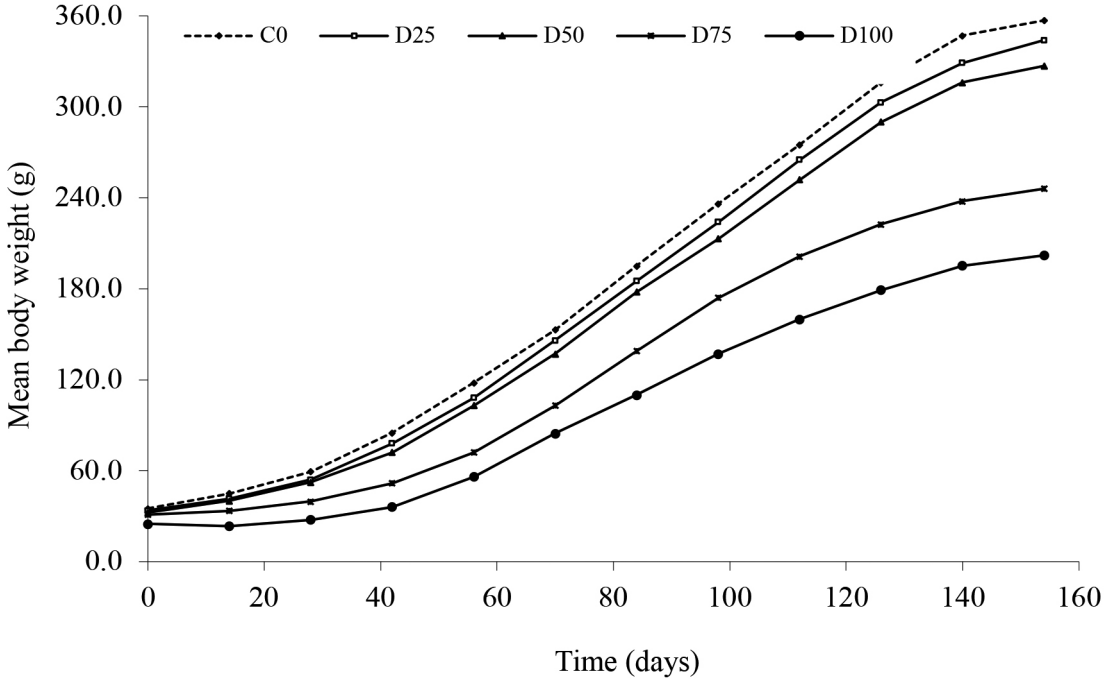
The study evaluated the suitability of replacing fish meal with a mixture of two plant proteins: cowpeas (*Vigna unguiculata*) and *Amaranthus cruentus* as a protein source in the diet of three weeks old *Labeo victorianus* on growth performance, nutrient utilization and carcass proximate composition. Fishmeal was replaced with the mixed vegetables at a ratio of 25%, 50%, 75% and 100% and the substitution effects compared with control diet containing fish meal as the sole protein source. The five dietary treatments were tested in triplicate in static flow through tanks for 90 days. The fish were fed four times a day at 4% body weight. After 160 days of feeding, growth, nutrient utilization and FCR in fish fed at 25% and 50% *Vigna unguiculata*) and *Amaranthus cruentus* were better than those fed 75% and 100% *Vigna unguiculata*) and *Amaranthus cruentus* but not significantly different from those fed with fish meals diets alone ($F = 17.002$, $P = 0.002$). Growth reduction, increased FCR and reduced nutrient utilization occurred with increasing plant inclusion in the diet beyond 50% inclusion levels. Thus it is possible to replace up to 50% of fish meal with a mixture of *V.unguiculata* and *Amaranthus cruentus in* the diets of *L. victorianus*. This will reduce the cost of production as fish meal is increasingly becoming expensive as its demand outweighs its supply.

This finding lends credence in the continued research into areas of utilization of alternative plant proteins sources in place of fishmeal based feeds as protein sources in improving aquaculture.



HELP MY FISH ARE FLOATING: WHAT TO DO IN THE EVENT OF A MASS MORBIDITY OR MORTALITY

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Mass morbidity and mortality events are par-for-the- course in intensive aquaculture production systems, due to the often-dynamic nature of the aquatic environment, multiple stressors, and sensitivity of aquatic species to change and environmental impact. In addition, pressure upon natural eco-systems and poor biosecurity measures are playing a growing role in mass mortality events and disease outbreaks in open systems like Africa's inland lakes and dams, with devastating impact on production, natural populations, food security and Africa's economies. We can take the *Infectious Spleen and Kidney Necrosis Virus* (ISKNV) outbreak on Lake Volta, Ghana in 2018/2019, and the multiple *Tilapia Lake Virus* (TiLV) outbreaks as good examples in Africa.

Dealing with these events rapidly is of paramount importance in mitigating the impact on a farm or within an eco-system. However, with Africa's significant gaps in supporting diagnostic and veterinary skill and capacity, the onus often falls upon the farmer to take immediate action to facilitate a diagnosis and action remedial biosecurity and intervention measures.

Most farmers and extension services are poorly equipped in terms of knowing what to do, who to contact and actions to take. This presentation highlights a simple step- by- step action plan supporting the farmer- veterinary health team, that can serve as a basis for on-farm preparedness and early disaster mitigation.

THE HOST: PATHOGEN: ENVIRONMENT TRIAD IN FISH HEALTH MANAGEMENT: THERE'S ALWAYS MORE THAN ONE PROBLEM IN THE MIX

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Aquatic health is a fundamental aspect of the aquaculture sector that cannot afford to be underestimated or ignored. And it all begins with the basics.

In a farmer-motivated study surveying health and husbandry of 19 tilapia (*Oreochromis* spp.) systems in the Northern provinces of South Africa, it became surprisingly apparent that the biggest health- related threats to the outputs and production potential of farms, were not so much large- scale losses from economically serious diseases like Tilapia Lake Virus or *Streptococcus* septicemias, but rather the little underlying factors compromising growth, fecundity and causing ongoing chronic small- scale losses. And most farmers were unaware of these.

Obvious widespread poor understanding and implementation of good biosecurity practices, in turn, is a ticking time-bomb for both the aquaculture sector and environment, where our many of Africa's seemingly healthy protected and biodiverse aquatic populations can easily be compromised by disease introduction and a potential future market leverage for healthy fingerlings lost. Consider the impact of other disease outbreaks like Avian influenza and Foot and Mouth disease on national and regional economies.

In a sector with increased focus on intensive production and involving high capital outlay and day- to- day running costs, and where fish time in system is money lost, creating farmer and veterinary awareness, and supporting farmers in addressing these underlying factors is essential to optimize sector potential, create cash- positivity, contribute to GDP, create jobs and improve livelihoods- all focal goals of the global aquaculture sector.

If we are to strengthen aquatic health within the African aquaculture sector, the basics cannot be ignored. A multi-pronged strategy is needed where improved aquatic diagnostic and veterinary capacity and research are built upon sound farmer-level basics and the "little -big" factors are not ignored.

THE UNIVERSITY OF PRETORIA, FACULTY OF VETERINARY SCIENCE, AQUATIC VETERINARY HEALTH UNIT: GROWING AFRICAN VETERINARY AND PARA-VETERINARY CAPACITY ONE STEP AT A TIME

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A significant gap currently exists in Africa: in Aquatic veterinary and para-veterinary capacity, supporting aquatic diagnostic infrastructure, aquatic-focused research, and training and skills development. Global aquaculture production is growing exponentially, yet African aquaculture is struggling to follow suit. One of the key reasons for this is the impact of aquatic disease. To speak into these challenges, the Aquatic Veterinary Health Unit at the Faculty of Veterinary Science, University of Pretoria, was established.

Building on the veterinary faculty's history of over 100 years of significant input into veterinary education and support within the animal health sector and industry, a well- established infrastructure, and global accreditation, the aquatic unit has been well positioned to address some of the identified gaps. A phased development strategy was implemented with the three fundamental pillars of aquatic veterinary and para-veterinary education, practical industry- relevant research outputs, and meaningful service and support to industry. Initial focus was on equipping interested undergraduate Veterinary and Veterinary Nurse students with the necessary skills to ensure day- one competency in Aquatic Veterinary Medicine, providing a platform and resources for both under and post-graduate level aquatic research, development of and accessibility to relevant aquatic diagnostic tools to support the sector, and fostering interaction and connection between various academic institutions, government and industry. This has been strengthened through inclusion of a collaborative aquatic training course with Michigan State University, development of the first African one-year Aquatic Internship Program with Ushaka Marine World and African Aquatic Veterinary Services, hosting and skil- sharing in aquaculture farmer workshops and wet-labs at Onderstepoort, and a soon-to-be-released online aquatic seminar series. Our hope is that the unit will provide a platform for the development and growth of aquatic veterinary medicine in Africa, where Vets and Paravets, at both under and post-graduate level, farmers and industry players can learn, undertake research and connect, and in so doing, add to a healthy African aquatic veterinary workforce.

AQUATIC DIAGNOSTICS: THE ROLE OF HISTOPATHOLOGY

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Veterinary diagnostics plays a central role, guiding the application of treatment and control measures in any veterinary field. The approach to problem solving in the veterinary field starts with identifying the most appropriate and economical method/s to reach an accurate diagnosis from which every action there-after emanates. The explosion of available information on the web has turned every person into instant diagnosticians which has had a significant impact on navigating a minefield of diagnostic approaches, some of which are simply nonsensical and leads many scientists and veterinarians to bark up the wrong trees. In the world of intensive farming, no matter the species, disease status of a population is measured by production output. Whether poor production is the result of poor fertility, poor growth or high mortality rate, all these entities require a diagnostic investigation to start somewhere.

On-farm clinical and macroscopic post mortal investigation in association with submitting specimens from mortalities or electively culled individuals is the sensible approach. In events where the condition being investigated is unclear, full sets of tissues for histopathological examination should be the first line of diagnostics, since this method is not specific and casts the net the widest of all tests. The result is often diagnostic, but when inconclusive will at the very least provide direction for further diagnostic tests. Not only does this cut costs tremendously but also provide a sound foundation for subsequent decisions to move in a sensible diagnostic direction.

THE WORLD AQUATIC VETERINARY MEDICAL ASSOCIATION (WAVMA): A GLOBAL RESOURCE FOR AQUATIC VETERINARIANS

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WAVMA was formed in 2006 as a not-for-profit Professional Association to serve the rapidly expanding discipline of aquatic veterinary medicine throughout the world. The mission of the Association is to serve the discipline of aquatic veterinary medicine in enhancing aquatic animal health and welfare, public health, and seafood safety in support of the veterinary profession, aquatic animal owners and industries, and other stakeholders. To fulfill this mission the World Aquatic Veterinary Medical Association has established the following objectives**:**

1. To serve aquatic veterinary medicine practitioners of many disciplines and backgrounds by developing programs to support and sustain members, and the aquatic species industries that they serve.
2. To identify, foster and strengthen professional interactions among aquatic medical practitioners and other organizations around the world.
3. To be an advocate for, develop guidance on, and promote the advancement of the science, ethics, and professional aspects of aquatic animal medicine within the veterinary profession and a wider audience.
4. To optimally position and advance the discipline of aquatic veterinary medicine, and support the practice of aquatic veterinary medicine in all countries.

WAVMA is dedicated to providing continuing education & professional development (CEPD) and life-long learning opportunities in aquatic veterinary medicine for its members and others. This is currently met through a number of world-renowned educational programs like the WAVMA Certified Aquatic Veterinarian (CertAqV) and WAVMA Certified Aquatic Veterinary Nurse/ Technician (CertAqVNT), the WAVMA WebCEPD program, and the Pitts Education awards program. A significant focus of WAVMA is global veterinary and para-veterinary student education through efforts of the Education and Student Committee, and establishment of student chapters around the world. WAVMA has been privileged to host Dr Gillian Taylor (South Africa) as President 2022, and Dr Nelly Isyagi (Uganda) as current Regional Director for Africa. This has encouraged the association to expand its focus into Africa and the hope is that this influence will continue to grow and expand with time.

BIOSECURITY CERTIFICATION FOR DEVELOPING REGIONS: A COLLABORATIVE VETERINARY- INDUSTRY APPROACH TO SUPPORTING A HEALTHY SOUTH AFRICAN TILAPIA AQUACULTURE SECTOR

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Disease outbreaks in aquaculture systems can be devastating, especially for those who are not equipped to deal with them. Small aquaculture enterprises in Africa don't have the resources to address biosecurity like their large global counterparts, with high level technology, biosecurity plans and large- scale disease surveillance. Lack of veterinary and diagnostic capacity in Africa further exacerbates the situation. A need exists for a health and biosecurity plan that fits the realities of African aquaculture and the farmer's pocket. To this end, in collaboration with the Tilapia Aquaculture Association of South Africa, a tiered farm flagging biosecurity plan was designed by Dr Gillian Taylor of African Aquatic Veterinary Services. This plan not only minimizes disease introduction risk and outbreaks, but also helps farmers increase their profit margins and the marketability of their products, by identifying underlying stressors that impact productivity, growth and health. With stress and subclinical disease found to play a significant role in farm outputs in South Africa, the biosecurity plan focuses strongly on identifying farming and husbandry practices affecting health like water quality, system design and filtration, nutritional impact, disease management and lack of biosecurity. In addition to biosecurity and disease surveillance, strong emphasis is placed on training and developing the farm team to better understand and manage health and biosecurity on the unit.

To provide accessibility to small scale farmers, the plan provides three farm flag status awards, each with varying levels of input and cost, but with the goal to allow affordable entry and development of start- up farmers. All three levels build upon each another, increasing in difficulty and qualifying requirements – such as training and rigorous screening – moving from Yellow Flag to Green Flag and, finally, at the highest level, Blue Flag farms.

This certification system now serves as an industry standard for the tilapia sector in South Africa and has achieved global recognition as a novel certification standard.

AN ASSESSMENT OF THE POTENTIAL OF SMALLHOLDER FRESHWATER TILAPIA CULTURE ON NATIONAL FOOD SECURITY AND ERADICATION OF UNDERNOURISHMENT. A CASE OF ZIMBABWE

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Food security is a predominant challenge in many parts of the African continent, Zimbabwe of which is not left out. This study aims to address on smallholder inland freshwater fish farming, in particular, tilapia culture, its impact on enhancing food security at the household level and its potential to get rid of the hunger burden in Zimbabwe. Fish is unquestionably a good source of nutrients that are needed for human health and it is a part of the answer to building concrete food systems and sustainable excellent food regimes. Although still in its embryonic stages, Zimbabwe's aquaculture industry has the potential to develop and subsidize much to the improvement of the country's nutritional needs. In the same vein, smallholder freshwater tilapia culture has the potential to improve food security and thus reduce the occurrence of malnutrition, especially in the rural areas of Zimbabwe, where the mainstream of the poor live. However, there is a need to ease the regulatory burden for small holder farmers potentially for household consumption. The government of Zimbabwe still has a long way to go to fully exploit the potential of inland smallholder freshwater tilapia culture in the country. Among others, there is a need to invent legislation and policies governing aquaculture, encourage and support aquaculture education, proffer technical knowledge and support, financial support, policy reviews and inter-sectoral collaborations with sister sectors such as Ministry of Lands, Agriculture, Fisheries and Rural Development; Zimbabwe Parks and Wildlife Authority and Environmental Management Agency.

DEVELOPMENT OF A COMMERCIAL TRAINING PROGRAM WITHIN THE PRIVATE SECTOR FOR EMERGING AQUACULTURE INDUSTRIES IN WESTERN SUB-SAHARN AFRICA

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Fish products are an important source of food for the people of sub-Saharan Africa, traditionally from wild catch from both marine and freshwater sources. The growing number of people on the sub-continent now located in urban areas along with the decline in available wild catch has created both an economic opportunity and environmental need for the expansion of responsible and sustainable aquaculture production to sustain and improve livelihoods. A trained labor force is needed to advance the commercial aquaculture sector in Western Africa. There is currently a deep divide in the needs of the commercial sector and the services provided by the local universities and federal government ministries. The general lack of practical farm knowledge and experience in the training of students and government personnel often hampers commercial sector growth and advancement, and the lack of sound best aquaculture practices on the commercial farms have resulted in severe economic losses at all levels of the aquaculture supply chain. The World Initiative for Soy in Human Health (WISHH) is developing a training program within the private sector for a training program designed to create a high-level internship training program on a commercial farm where students would be held to a higher level of responsibility to address multiple issues and basic management practices on fish (e.g. husbandry, feed management, spawning, fry cultures, transportation, water quality, and overall fish health management) through a well-structured internship and practical training approach. Through funding by the US Soybean Board Checkoff Program, 17 individuals have gone through this intensive training program at Flosell Farms, Ltd. in Ghana over the last year through three of these programs. Job placement and program impacts are being monitored for improvements in economic sustainability.

DEVELOPMENT OF A GIS SITE SUITABILITY MODEL TO MAP MOZAMBIQUE TILAPIA (*Oreochromis mossambicus)* POND AQUACULTURE SITE SUITABILITY FOR THE LIMPOPO PROVINCE – SOUTH AFRICA

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The aim of this study was to produce a Mozambique tilapia *(Oreochromis mossambicus)* pond aquaculture Site Suitability Model in a Geographic Information System (GIS) environment and to use this model to create a Mozambique tilapia pond aquaculture site suitability map for the entire surface area of the Limpopo Province. This model was designed for easy duplication and expandability to other South African provinces and as well as other countries. The suitability map was used to score and rank specific existing aquaculture farmers based on their current GPS locations on the Mozambique tilapia pond aquaculture site suitability map.

The suitability model was designed in a Multi-Creteria Evaluation (MCE) model in a Geographic Information System (GIS) environment using the Analytical Hierarchy Process (AHP) to rank the four sub-models. These four sub-models comprised of financial as well as physical variables which determine the suitability for specifically the indigenous Mozambique tilapia in pond aquaculture. In figure 1, the product of the model is a suitability map created by the Weighted Overlay (WO) methodology in the GIS.

In Figure 2, Forty-eight existing aquaculture farmers were scored and ranked according to the suitability of their positions on the suitability map. This could facilitate the determination of priority where to allocate fiscal and other support optimally to farmers in better positions.

The suitability maps produced by this research could be used to guide decision makers in identifying the most suitable areas for optimal allocation of funds to support existing aquaculture farmers that are in the more suitable locations or to develop new Mozambique tilapia pond aquaculture farming sites in the Limpopo province.

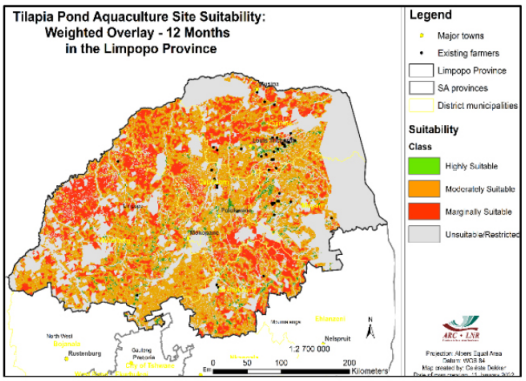

Figure 1: Weighted Overlay Pond Aquaculture Site Suitability Map for Limpopo.

Farm ID	Distance to wetland (m)	Restricted 1 = No 0 = Yes	WS	WS - RU	WO
7	280	0	3,5522	4	4
29	0	0	3,4579	4	4
28	448	0	3,4202	4	3
10	1592	1	3,3847	4	4
25	1262	0	3,3795	4	4
18	1187	1	3,3624	4	3
22	5534	0	3,3093	4	4
30	3405	0	3,2691	4	4
31	166	0	3,2118	4	3
27	404	0	3,1920	4	3
9	2125	0	3,1143	4	3
32	600	1	3,1018	4	3
3	1677	1	2,9985	3	3
8	9440	1	2,9489	3	3
24	3892	0	2,9455	3	3
21	427	0	2,8909	3	3
23	5009	1	2,8863	3	3
5	232	0	2,8645	3	3
33	6205	1	2,8355	3	3
14	1659	0	2,8321	3	3
4	4187	0	2,8314	3	3
34	1790	1	2,7814	3	3
26	2108	1	2,7697	3	3
19	1085	0	2,7345	3	3
20	1100	0	2,7345	3	3
2	2430	1	2,7156	3	3
11	2530	1	2,6998	3	3
1	954	1	2,6602	3	3
35	4168	1	2,6418	3	3
17	3579	0	2,6211	3	3
15	4735	1	2,6055	3	3
36	2932	0	2,6022	3	3
39	728	1	2,5857	3	3
37	595	1	2,4090	3	2
38	407	0	2,3925	3	3
16	4544	1	2,3780	3	3
40	3093	1	2,3359	3	3
13	891	1	2,3333	3	2
41	1297	1	2,2989	3	3
42	4839	1	2,2956	3	2
12	2929	0	2,2738	3	2

Figure 2: A top section of the scoring and ranking table of existing farmers according to the suitability map.

UNLOCKING NILE TILAPIA *Oreochromis niloticus*, (LINN. 1758) SELECTIVE BREEDING PROGRAMS IN UGANDA THROUGH GEOGRAPHICAL GENETIC STRUCTURE MAPPING

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Nile tilapia (*Oreochromis niloticus*), native to Africa and the Levant, is an important species for both aquaculture and capture fisheries. Despite these attributes, Nile tilapia has been negatively impacted by anthropogenic activities ranging from overfishing, and habitat destruction to translocations. These human-mediated activities have threatened the genetic evolutionary integrity of Nile tilapia and its congeneric species through admixture, demographic bottleneck, and introgressive hybridization. In this context, the genetic contrast between farmed/bred strains and or natural Nile tilapia populations in the L. Victoria basin remains confounding. Therefore, understanding the genetic structure reference maps of Nile tilapia populations in the basin is key as may lessen the risks that result from aquaculture maladaptation, unfold ideal strains for selective breeding, help in the conservation & management of stocks, and enhance fish productivity in the region. We sampled 756 Nile tilapia individuals in the major water bodies of Uganda (Lake Victoria basin), and genotyped them using a panel of 34 microsatellite loci based on the Microsatellite Genotyping-By-Sequencing (SSR-GBS) technique. The samples were sequenced using Next Generation Sequencing (NGS) platform. The results indicate three discrete genetic clusters of, the Edward-George system; Albert, Kyoga, Kyoga-Nile; and Kyoga-Nakuwa. We also report that Nile tilapia in Lakes Victoria, Kyoga-Kwania, and the fish farm at ARDCK lie intermediary between other populations which may be an indicator of admixture. Evidence of the historical fish translocations was noted through a number of migration rates as a proxy to gene flow. Importantly, we observed some genetically distant populations coupled with high genetic diversity which can be ideal sources for future selective breeding programmes aimed at elevating aquaculture production in the region.

A BASELINE STUDY ON THE ASSESSMENT OF THE BIODIVERSITY OF BENTHIC MACROINVERBRATES AT KELP BLUE CULTIVATION SITE, SHEARWATER BAY, LÜDERITZ

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Shearwater Bay mariculture in Lüderitz cultivates seaweed *Macrocystis pyrifera* of three populations namely, California, Cape Town and Falklands Island. This baseline study aims to assess the initial state of benthic macroinvertebrate communities within kelp mariculture project (Shearwater Bay site) in contrast to a non-cultivated site (Grossebucht) and adjacent sandy shores. A systematic field sampling of transects will be done, using a Van Veen grab for offshore sediment collection and quadrat sampling using core for intertidal sandy shores sediment collection. This is done to examine the composition, abundance and biomass macroinvertebrates. Physiological parameters (temperature, dissolved oxygen, pH and water depth) will be measured. To ground truth manual identification, DNA based analysis will be carried out for species identification at all sites. Sediment grain analysis will be carried out as recommend by studies that kelp cultivation could possibly influence sediment and organic matter at cultivation sites. The data collected will be tested for normality using the Shapiro Wilk Test at alpha level 0.05. The Shannon Wiener Diversity Index and the Evenness Index will be used to examine the distribution of taxa and species abundance (individuals). Multiple regression analysis will be used for normally distributed and DIVERSE and PRIMER V6 will be used to evaluate ecological parameters. If the distribution of the data set is not normal the Kruskal Wallis (non-parametric) test will be used. The results of this research may aid future studies that aim to compare and understand the impacts of kelp cultivation on the explored population as a way to mitigate possible impacts.

INTRODUCING THE AQUACULTURE GOVERNANCE INDICATORS (AGIs)

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Governments, industry and civil society groups have developed a range of tools and mechanisms to guide and steer the sustainability of the rapidly expanding aquaculture sector. Many of these state and private mechanisms have focus on farm performance and legal/standard compliance, and set out technical criteria for improvement. While these components are important in understanding how aquaculture practices can be improved, there are limited insights in the ways in which collaborations between, and adaptive capacity of, both private and public actors affect the sustainability of the sector, and how these (inter-) actions impact regulatory and formal processes. We have developed the Aquaculture Governance Indicators (AGIs) to help identify potential gaps in existing governance systems and to provide guidance to the various state, industry and civil society actors. Together, the 26 AGIs form an integrated framework for assessing governance performance in any given country, based on four governance dimensions and three governance principles. The four governance dimensions (Legislation; Voluntary Codes and Standards; Collaborative Arrangements; and Governance Capabilities) allow for a systematic mapping of the governance landscape. The governance principles (Legitimacy; Effectuation; and Coordination) structure the analysis of the way roles and responsibilities are organized, how enforcement, monitoring and learning is effectuated, and the extent to which activities are aligned. The AGIs thus serve as a diagnostic and analytic tool, showing governance is both a context and a means for improvement. Actionable insights from the AGIs can help to identify strengths and weaknesses in aquaculture governance of a given country, and thereby provide input for a conversation about gaps and improvement. We have finalized and published ten country assessments (see our website: www.aquaculturegovernance.org), capturing salmon producing countries, shrimp production in South-East Asia and aquaculture governance in China. Recently, we moved focus to Africa and currently conducting assessments in Uganda, Nigeria and Senegal.

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STUDY ON THE INFECTION AND EFFECT OF SAUDAU (*Azadirachta indica*) EXTRACTION ON FISH LICE (*Caligus* spp) PARASITICS ON RABBIT FISH (*Siganus guttatus*)

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The research was conducted to identify the infection level of fish-lice (*Caligus* spp) on Rabbitfish (*Siganus guttatus*) which cultures in Thua Thien Hue province, and to clarify the effect of extraction from Saudau (*Azadirachta indica*) plant on the fish lice. The total of rabbit fish that were used for experiments is 120 fish, and fish were collected in 6 months at two different sites. The extraction of the Saudau plant was collected from leaf, and seed and then concentrated for experiments at ppm (0; 10; 50; 100; 500; and 1000) to evaluate the effect of extraction on fish lice. The results showed that the infection rate of fish lice on rabbit fish is 62,5% and infection intensity averaged at 19,2 lice/fish. Based on the collection data, it was clearly shown that in January, February, and March, fish lice were found much more than in other months ($p<00.05$). After fish lice were treated with the extraction from leaf and seed for 30 hours, we found that the half effective concentration (EC50), and 90% effective concentration (EC90) of leaf extraction are 148ppm and 928ppm, respectively. The EC50 and EC90 of seed extraction are 62ppm and 397ppm, respectively. The results from our research frankly show the potential of using extraction from Saudau leaf and seed to treat the parasite disease caused by fish lice on Rabbitfish.

POTENTIALS OF NON-PATHOGENIC *Escherichia coli* METABOLITES BASED-DIETS ON THE GROWTH AND GUT HEALTH OF AFRICAN CATFISH

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Inclusion of metabolites extract (ME) of non-pathogenic *Escherichia coli* in fish feeds could enhance fish growth and gut health, resulting in high yield. However, there is scanty information on its utilization particularly in aquaculture feeds. Therefore, this study investigated the growth and gut health potentials of non-pathogenic *E. coli* metabolites in the diets of African catfish (*Clarias gariepinus*).

Fish (8.80±0.36g; n = 255) were randomly assigned into 15 tanks in a completely randomized design and fed non-pathogenic *Escherichia coli* metabolites diets of 40% crude protein containing 0.0g/kg (ME_0), 5.0g/kg (ME_1), 10.0g/kg (ME_2), 15.0g/kg (ME_3), and 20.0g/kg (ME_4) at 3% body weight for 12 weeks to determine the weight gain (WG, g), specific growth rate (SGR, %g/day) and feed conversion ratio (FCR). Gut morphometric characteristics and microbial loads were assessed. Blood was sampled to determine pack cell volume (PCV, %), white blood cells (WBC, 10^6/µL), alanine transaminase (ALT, IU/L). Economic values (EVs) were also estimated, and all data analyzed using ANOVA at $\alpha_{0.05}$.

Highest WG (55.7±0.5), SGR (2.3±0.0), and least FCR (1.3±0.0) occurred in ME_2 fed *Clarias gariepinus* Villi height and width ranged from ME_2 (3336.95±12.88) to ME_1 (1340.00±277) and ME_2 (442.60±109.60) to ME_1 (189.60±62.00) respectively. TVC ranged from ME_0 (45.3±16.5) to ME_4 (16.6±1.5). *Escherichia coli* (14.00±7.94) and *Vibrio species* (28.00±12.82) were highest in ME_0 and least in ME_2 (2.6±4.6 and 7.8±7.7, respectively). The PCV was highest in ME_2 (31.0±2.8), WBC (24.0±38.5) highest in ME_1, and ALT highest in ME_3 (21.9±0.7). The EVs ranged from ME_2 (1.19) to ME_0 (0.00). Therefore, this implies that 1.0% ME per kg diet inclusion had better yield performance.

In conclusion, diets containing 1.0% ME per kg inclusion enhanced growth, morphometric indices (villi height and width), and also improved economic values.

ILLUMINATING HIDDEN PRODUCTION: STATUS OF CATFISH PRODUCTION IN NIGERIA

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With over 223 million people, Nigeria is Africa's most populous nation. It is also the world's largest producer of African catfish. Annual production was estimated at around 1 million tons in 2021 based on preliminary results in a study conducted by FISH4ACP and the Federal Ministry of Agriculture and Rural Development. The research took place in an environment where information, such as the number of aquaculture producers and their output, is not known. FISH4ACP collected data in 2021, used an extensive WorldFish dataset, and came to its estimates following triangulation, discussions with key informants, and comparisons. Based on this analysis, Nigeria has about 285 000 producers of which small-scale farmers represent an estimated 60%, while the catfish value chain offers employment to about 1 million people. However, years of annual growth between 2005 and 2015 ended when catfish production started declining in 2016. According to the study, increased production costs and a drop in demand fueled by inflation and devaluation of the national currency are behind this. In response, FISH4ACP sees opportunities in efficiency gains, aimed at reducing production costs and bringing catfish prices down to a more affordable level in order to meet the strong market demand. These opportunities include improved practices in feed, fingerling and fish production, management and distribution. With the bulk of fish farming undertaken in clusters of earthen ponds, strengthening these clusters and improving good production practices are a key priority. Ultimately, the aim is to make this massive and vital value chain more resilient and efficient in providing affordable food to the Nigerian people, creating jobs and business opportunities, while reducing harm to human health and lessening the burden on the environment.

INVESTING IN AQUACULTURE VALUE CHAINS: FISH4ACP

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A value chain (VC) development approach is a holistic method, which examines all the elements, the players, their complex interlinked behaviour, and their technical, economic, social and environmental performance to devise an upgrading strategy that will improve the chain's sustainability and resilience to shocks.

The FISH4ACP VC development approach is highly participatory in nature and stakeholders driven. The primary aim is to provide a VC development plan on which all stakeholders agree as they will need to commit resources to the upgrading of the VC throughout and beyond the lifetime of the FISH4ACP initiative. Each VC supported by FISH4ACP has a ten-year upgrading strategy, resulting in an overall action and investment/financing plan for improving the VC with aeras of intervention which should eventually remove the main constraints on the development of the CV. FISH4ACP oversees and supports the implementation of the upgrade strategy up to 2025. In this process, FAO is a neutral facilitator and catalytic coordinator in the project's analysis and development activities.

The three fish farming VCs supported by the project (farmed tilapia VCs in Côte d'Ivoire and Zimbabwe and catfish VCs in Nigeria) have activities in their upgrading strategy to promote investment and foster access to finance for VC operators, including: linking financial institutions with VC stakeholders, building their capacities, enabling financial institutions to develop suitable products and operators to improve their access to financial services.

INSECTS IN AQUAFEEDS: INNOVATION OR IDEOLOGY?

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In recent years, there has been a significant increase in attention towards the utilization of insect-based products as potential alternatives for key nutrients in aquafeeds. This presentation offers a comprehensive review of the studies conducted by Stellenbosch University and Nutritionhub on the incorporation of insect-derived products into aquafeeds. This presentation will focus on the functional benefits associated with the integration of insect-derived products into production procedures, with particular emphasis on their impacts on production efficiency, meat characteristics, and consumer health.

The research findings pertain to the efficient usage of insect products as a protein source and feasible substitute for fish meal in catfish, tilapia, and abalone diets. Insect meal was successfully included at 30 and 10% in catfish and tilapia diets respectively, whilst complete fish meal substitution was achieved in abalone diets, at 14% dietary inclusion. The replacement of fish oil with insect oil resulted in a notable alteration in the fatty acid (FA) profile, leading to an increase in the concentration of lauric acid in catfish and trout fillets by roughly 4% and 6% respectively. The present discourse examines the application of dietary chitinase as a potential strategy for augmenting the usage of insect-derived products. Additionally, the adverse effects of dietary chitinase on the water stability of feeds intended for slow-feeding animals, including abalone, are explored. There is a great body of research presented that explores the application of insect protein hydrolysates as a viable and value-added alternative to traditional fish meal and insect meal.

Furthermore, this study also addresses practical concerns pertaining to the inclusion of insect products in formulations, taking into account the many potential limitations and constraints. Moreover, the cost aspects associated with incorporating insect products as functional ingredients and fish meal alternatives are also examined and analysed. This study considers the impact of rearing substrate and harvesting age on the variability of nutrient content in insect products. Additionally, it examines the challenges faced in the market when incorporating insect meal into aquafeeds, with a specific emphasis on constant supply, regulatory constraints and the cost-effectiveness of aquafeeds derived from insects. Lastly, current research methodology is discussed, with a key focus on shortcomings and considerations when interpreting study results for practical application.

SAMAKI POA: EMPOWERING AQUACULTURE GROWTH BY BRIDGING CAPACITY GAPS ACROSS 25 SUB-SAHARAN COUNTRIES WITH FREE DIGITAL TRAINING

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With 18 free courses (Table 1) and over 150 tailor-made training videos on Nile tilapia and African catfish, howtodoaquaculture.com is a groundbreaking digital learning platform developed to transform the aquaculture industry in sub-Saharan Africa. This platform makes learning about aquaculture accessible and effective in East Africa and beyond. In combination with internship and vocational training programs offered at the Aquaculture Academy, no effort is spared by the Samaki Poa project to tackle one of the principal challenges facing the industry: access to practical aquaculture knowledge tailored to the specific context of sub-Saharan Africa.

East Africa is undergoing an economic and demographic transformation. These factors have been driving up total fish demand and imports of fish in the region. However, due to limited technical performance and challenging financial positions of fish farmers in East Africa, productivity and sustainability remain sub-optimal. It is difficult to find well-trained fish farm staff with practical knowledge, hindering the success of fish farms in the regions. Grossly underfunded, most education institutes lack the financials or structures to provide practical education to students. Quality internships and other practical learning environments are hard to find. As a result, many graduates lack sufficient practical expertise direly needed to take the sector to the next level.

To close this knowledge gap, local and global aquaculture experts joined hands under the name 'Samaki Poa', a 4-year project funded by Norad. The platform combines local solutions and international best practices, using footage recorded at fish farms throughout East Africa. In animations of 2-3 minutes, users learn about all key aspects of fish farming and take tests to assess understanding and enhance active learning. They are then awarded certificates as evidence of their efforts and competence. To ensure continuous access to relevant information, the platform also includes a comprehensive *knowledge base* where users can conveniently revisit information related to specific sub-topics when navigating through the different phases of production.

The digital and vocational training programs encompass not only the technical aspects of fish farming but also focuses on the business side of aquaculture where one learns the essential skills required to operate profitably and sustainably.

Anyone with a phone and internet connection can learn about aquaculture at their own pace. Within one year, over 2,500 individuals from 25 African countries have already registered and used the platform, demonstrating the significant demand and expansive potential of free, digital capacity building, far beyond East Africa.

TABLE 1: Available courses: Nile tilapia (9) and African catfish (9)

Courses	Video's
- Farm management & planning	28
- Farming systems	13
- Production	36
- Feed management	31
- Genetics & reproduction	18
- Health management	28
- Water quality	9
- Pond construction and use	10
- Sustainability	9

DOUBLE-USE OF WATER IN THE SAHEL: FISH BEFORE IRRIGATION (FBI) BY WOMEN'S GARDEN GROUPS IN SENEGAL

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Andando is an NGO based in Oregon that works with women's cooperative gardens in Senegal since 2008. Groups consist of about 100-150 women who share plots on 1 hectare of land. Each garden has a hand dug or borehole well and solar pump that fills a 5000L reservoir during the day which distributes water to 6 basins throughout the garden. The women fill their watering cans at these basins and water their small vegetable plots by hand daily. Fish are a vital component of the Senegalese diet both nutritionally and culturally, but access to fresh fish in inland areas is limited and often prohibitively expensive for smallholder farmers. In the hopes of improving access to fish in the area, in 2020, Andando's local leadership along with women from 4 cooperative gardens in Andando's Keur Soce region of operation came up with a plan to try adding fish production tanks upstream of the existing watering basins. In this system water already destined for irrigation purposes can pass through fish holding tanks before flowing to watering basins, thereby facilitating fish production and increasing vegetable outputs due to increased nutrients in the water, allowing for a double use of water. The fish holding tank is larger than the watering basins so that only half of the water is removed daily and replenished by the solar pump each afternoon. The fish tanks are each plumbed to two watering basins with water coming from the bottom of the tank to facilitate the evacuation of nutrient rich fish waste.

Thanks to a small grant from the Tankersley Endowment managed by Auburn University, two such fish tanks per garden were installed in each of 4 gardens. For the first trial, one tank was stocked with mixed sex tilapia and the other with clarias fingerlings. The women were guided closely during the first trial by the garden technicians, who were also learning about fish. Mistakes were made before the group and garden technicians could receive in-person training towards the end of the first cycle. This prompted the women to ask very good questions when they finally did get the training. funded by ASA/ WISHH. After learning some about the feeding habits of the fish, and with their experience in trying to attain fingerlings, they decided to raise only tilapia for the next production cycles, mainly because they could produce their own fingerlings, the tilapia were easier to feed if they could not get pellets, and the growth rates were acceptable. Three more cycles have now been completed.

The "fish water" allowed the women to increase production of fast-growing high value crops such as lettuce, and mint, the latter of which was able to produce 3 cuttings per month compared to 2 cuttings previously. Other crops such as aubergine, tomatoes, and cabbage also showed faster growth and overall healthier plants. Women who had previously quit the group now wanted to re-join. All of the fish are sold to women within the groups. The intent is to sell at a favorable price that still allows the group to purchase inputs for the next cycle. The improved garden yields provide the most benefit, so even if the women only break even on the fish, they have access to fresh fish for their families and their garden production has benefited. Two fish crops per year produce 20 to 25 kg of market size tilapia per crop in each of the 5 cubic meter tanks and usually enough fingerlings to re-stock. Fish tanks have been constructed at Andando's new Keur Soce High School garden, which will start production in October, making this the first High School in all of Senegal with an aquaculture program.

GENETIC ENHANCEMENT OF MOZAMBIQUE TILAPIA *Oreochromis mossambicus* AT THE AQUACULTURE RESEARCH CENTER (CEPAQ) – MOZAMBIQUE

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This study reports the results of an ongoing genetic enhancement program for Mozambique Tilapia (*Oreochromis mossambicus*) that has been in progress since 2016. Given this Tilapia species' ability to tolerate a wide range of salinity, withstand stress, and adapt to extreme environments, along with its popularity in local cuisine, the Mozambican government selected it as a preferred choice for genetic improvement. Furthermore, Mozambique boasts an extensive coastline with ideal conditions for brackish water aquaculture development, making Mozambique Tilapia a valuable alternative. To initiate the program, reproductively sized specimens of *O. mossambicus* were collected from lakes and rivers in the southern and central regions of Mozambique between October 2016 and May 2017. They were divided into five groups based on the collection area and carefully transported to the Aquaculture Research Center in 500-liter tanks containing pure oxygen. Upon arrival, the fish were acclimated in concrete tanks with slightly saline groundwater and continuous aeration, allowing for adaptation and transition to an artificial feed diet over 7 to 10 days. Once acclimated, the fish were transferred to hapas in excavated tanks, where they were segregated by sex and size. Out of the 2,055 collected and acclimated fish, 921 were randomly selected from the five groups and marked with PIT-tags to become breeding candidates. The program's goal is to develop a commercially attractive Mozambique Tilapia lineage suitable for brackish water cultivation. In generation 1, Mendelian crosses were employed, while in subsequent generations, crosses were based on genetic values for weight gain. Thus far, CEPAQ has produced six generations of Mozambique Tilapia, and the results demonstrate significant improvements in terms of weight gain and salinity resistance. The population maintains a high level of genetic variability, suggesting considerable potential for genetic gains in the forthcoming generations.

PREVALENCE AND INTENSIT Y OF ECTOPARASITES IN NILE TILAPIA HATCHERIES IN HOMABAY COUNTY, KENYA

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Nile tilapia remains to be one of the most preferred fish for rearing and human consumption in Africa. Despite being a prolific breeder, the demand for tilapia seeds remains high, and hatcheries have been established to meet this demand . However, hatcheries face significant challenges with high costs associated with feed, electricity, and also with fish diseases. An often overlooked challenge in the hatcheries is the presence of ectoparasites which pose a high potential risk to fish health. The combination of high stocking densities in most hatcheries and frequent handling of the fish, increases the susceptibility of the fish to ectoparasites infestation.

A study was conducted in two hatcheries in Homabay County, Kenya in the months of March and April, in a bid to establish the prevalence and intensity of different ectoparasites in these facilities.

Samples were collected from all age groups in the two hatcheries and examined *in-situ*. Twenty (20) scoops each for eggs, fry and larvae were sampled, while for broodstock and fingerlings 40 samples each were taken, totaling to 140 samples. The eggs , larvae and fry were examined wholly under the microscope, while for fingerlings and brooders, skin scrapes, fin clips and gill clips were examined. The total parasitic prevalence was 66% (92/140) and prevalence was highest in broodstock fish at 80% (32/40) while it was lowest in larvae at 10% (2/20).

Five ectoparasite genera were recovered, with *Gyrodactylus* spp. being found in all age groups at an overall prevalence of 35% (49/140).The others included the genera *Dactylogyrus* spp.12% (19/140), *Trichodina* spp. 11% (16/140), *Epistylis* spp. 4% (6/140) and *Argulus* spp.0.7% (1/140) (Table:1). The highest mean intensity was observed in the ciliate, *Epistylis* spp., at 30.8.

The findings show that ectoparasites can be found in all the age groups in the hatchery, and being most prevalent in brooders, they can spread to other age groups. Hatchery owners should implement strict biosecurity measures in order to avoid the spread of ectoparasites within the hatcheries and grower ponds.

Table 1: *Prevalence of ectoparasites in the hatcheries*

***Gyrodactylus* spp.**	***Dactylogyrus* spp.**	***Trichodina* spp.**	***Epistylis* spp.**	***Argulus* spp.**
35% (49/140/)	**12% (19/140)**	**11% (16/140)**	**4.3% (6/140)**	**0.7% (1/140)**

IMPLEMENTING ZONAL AQUACULTURE INNOVATION PLATFORMS IN UGANDA: KEY LESSONS LEARNED

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Uganda's aquaculture sub-sector is rapidly developing, currently contributing up to 22% of all the fish produced in the country. However, the sub-sector is still faced with challenges related to limited access to extension services, production inputs, post-harvest handling facilities, limited value addition skills, disease incidences, and weak market linkages. These challenges hinder productivity and profitability of the aquaculture value-chain with a knockdown effect on rural employment, food security and national export revenue. Although there have been isolated interventions at different aquaculture value-chain nodes, the registered challenges continue recurring. Therefore, there is a need for coordinated interventions to enhance access to production technologies, innovations, knowledge, and skill transfer in order to promote gender-centred aquaculture development. Innovation platforms have been seen to stimulate development in several agricultural sectors in Uganda, where coordination is weak, and a similar approach was adopted for the challenged aquaculture sub-sector. To address the prioritized issues in Uganda's aquaculture sub-sector, nine zonal aquaculture innovation platforms were established based on Uganda's nine agro-ecological zones. These platforms brought together different stakeholders to identify solutions to common problems in each aquaculture value-chain node. Each innovation platform consisted of fish farmers, hatchery operators, traders, extension workers, researchers, input suppliers, local leaders, and financial institutions. During a series of zonal workshops, participants identified constraints to the aquaculture sector in their respective agro-ecological zones. For each of the selected constraint, possible strategies, and solutions, mostly within reach of zone were formulated. It is anticipated that the zonal innovation platform approach will be an effective route of linking different value-chain actors, particularly youth and women to business opportunities in the aquaculture value-chain.

CO-OCCURRENCE OF EMERGING PATHOGENS ISOLATED FROM INFECTED FARMED TILAPIA IN THE LAKE VICTORIA REGION, UGANDA: *Aeromonas sp, Edwardsiella sp and Francisella sp*

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Tilapia production from aquaculture is growing fast in Uganda to meet the increasing demand for fish. Farm yields and profits are increasingly reduced by periodic disease outbreaks in land and water-based systems. High mortalities experienced within hatcheries and cage systems with infected fish presenting signs of lethargy, exophthalmia, granulomatous spleen, fin rot, ulcerations and haemorrhages. Histopathological reports showed gill hyperplasia with epitheliocystis, and granulomatous head-kidney, spleen, liver with melanomacrophages. However, asymptomatic fish samples showed recovery stages of populations as exhibited in granulomas spleen and kidney. Molecular identification revealed unique strains of *Aeromonas veronii*, *A. hydrophila* of *Edwarsiella ictaluri, E. anguillarum, Francisella philomiragia, F. noatunensis and F. tularensis* from infected farmed tilapia in Uganda. These were resistant to Ampicilin and Amoxicillin, erythromycin and sulphamethoxazole trimethoprim, respectively. Identification of co-occurrence of these emerging pathogens presents strategies to reduce further economic losses in the tilapia industry.

NATURAL DIET AND FEEDING HABITS OF FRESH/BRACKISH WATER PRAWNS GENUS MACROBRACHIUM (FAMILY PALAEMONIDAE) IN KENYA

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Introduction

The fresh water prawns of the genus Macrobrachium comprises 243 globally[1] but in Kenya it comprises of M. rude, M. dolichodactylus, M. equidens,,M. lepidactylus and M. niloticus species. The macrobrachium species is well known for its ecological role and for human consumption. However, there is limited information on their natural diet and feeding habits in Kenya limiting the aquaculture potential of some of these prawns.

Materials and methods

Field sampling of prawns data was carried out in 7 selected sites along mid and downstream coastal estuaries/deltas of rivers Tana, Athi, Ramisi, Umba and Mkurumuji in both midstream and during the wet season/long rains (March-May 2021) and dry season (June-September 2021) in Kenya. Laboratory Microscopic work on stomach content analysis was carried out at both Kenya Marine Fisheries and Research Institute laboratory at Gazi-Bay station and National Museums of Kenya and stomach content data was analyzed using the percent frequency of occurrence of food items., using IBM SPSS 20software.

Results

A total of 343 specimen samples consisting of M. rude(220; 64.4%), M. lepidactylus (77; 21.9%) and M. dolichodactylus (46; 13.7%) per different sexes and size groups ranging from 20 to 231mm were analyzed. 80 different types of food items were identified. In terms of stomach fullness index, 70.2% of M. rude recorded ¼ full index while 29.4% of M. dolichodactylus and 33.3% of M.lepidactylus recorded full stomach indexes.The resultsrevealed significant differences in frequency occurrence of food items between different Macrobrachium species, sites, seasons, size lengths, sexes and stomach fullness index ($P<0.05$). The most dominant food items were sand particles (16%), unidentified plant materials (9.5%), animal materials (6.8%) and microplastics (4.3%) Figure 2). Combined algal species food items were the most frequent e,g. Ankistrodesmus sp (6%).

Discussions and Conclusions

The results of this study suggest that the three Macrobrachium spp are omnivorous in nature with a preference of algal species. This euryphagous feeding habit is important in the culture of these species. The presence of microplastics in the diet of most prawns suggest the dangers paused by these materials to both prawns health and human beings consuming them that need to be controlled. The nutritional information generated from this study on the prawns diet will allow formulating recommendations for artificial feeding of Macrobrachium spp. for the mass production in aquaculture to secure sustainable fishing and the success of aquaculture initiatives.

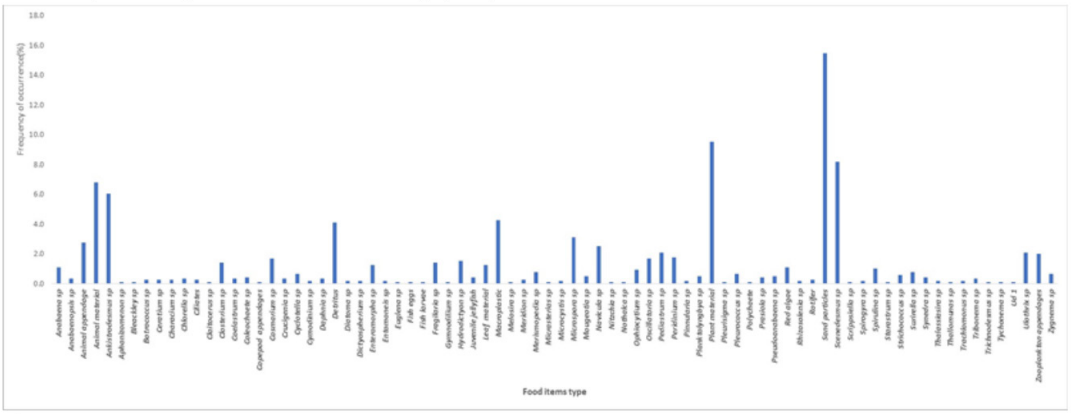

Figure 1

FROM CRISIS TO CONSERVATION: SAFEGUARDING AQUATIC HEALTH AND WELFARE FOR SUSTAINABLE BLUE FOOD SYSTEMS IN AFRICA

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The aquaculture industry in Africa is facing unprecedented challenges posed by environmental and climate change impacts. As we strive towards sustainable blue food system development, it is crucial to prioritise the strengthening of aquatic animal health, welfare, and ecosystem health.

With a focus on Africa, this paper/poster will delve into the unique challenges faced by the region and highlight success stories and best practices from across the continent. We will examine the interconnections between environmental and climate change impacts, aquatic animal health and welfare, and overall ecosystem health. By fostering knowledge exchange and collaboration during the conference, we aim to develop practical and effective measures to ensure the sustainability of our marine resources.

The paper and or poster will explore the latest advancements in aquaculture research, technological innovations, and policy frameworks that promote the well-being of aquatic animals, enhance ecosystem resilience, and support the development of sustainable blue food systems. Together, we can create a future where Africa's marine resources thrive amidst environmental challenges, ensuring food security, economic growth, and ecological sustainability.

CONTRIBUTION OF AQUAPONICS TO SUSTAINABLE RURAL HOUSEHOLDS' FOOD SYSTEM. A CASE IN VHEMBE DISTRICT, LIMPOPO SOUTH AFRICA

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Aquaponics is an intensive fish and vegetable production system operating within the food-water nexus and recycle water at a rate up to 95 to 99%. The system produces fish and crustaceans in fishponds with water from the ponds used to irrigate the vegetables that will be cultivated in a medium other than the soil. Aquaponics production system not only contributes to solving climate change challenges but also produces fish and vegetables using less land and water. The production system gives households control over some components of their food systems as they decide what to produce and how it will be produced. Aquaponics system is believed to be important to nutrition security that has been a challenge to Africa where more than half of the population cannot afford a healthy diet (WWF, 2019). This technology is handy as part of the continent's strategy to produce 50% more food by 2050 to meet its food and nutrition needs (WWF, 2019). Researchers concur that aquaponics is a candidate food production strategy that can contribute to production of enough food and improve the livelihoods and wellbeing of the population through the sale of excess fish and vegetables. This can be part of the answers to persistent climate change and variability challenges which are constraining the existing food systems, limited capacity of land due to degradation and high cost of inputs. There is growing evidence showing that existing fish and vegetable production systems cannot meet the demand of which climate change and variability is further complicating the fish and vegetable production capacities. As was also noted by Swap et al, (2002) in South Africa there is a near collapse of freshwater fish production due to harsh environmental conditions. Interestingly in the whole of South Africa, Limpopo ranks number one in terms of potential for aquaponics production nationally but is only contributing 1% of aquaponics national outputs (DTI 2020). Globally the demand for fish is rising and aquaponics is expected to meet 60% of the demand (DTI 2020). South Africa has witnessed a steady annual growth of 8.6% of the aquaponics outputs between 2006 and 2016 (DTI 2020). This paper presents the findings from a study undertaken with households participating in aquaponics projects that were implemented with selected households in Vhembe District Municipality of Limpopo Province in South Africa between 2017 and 2022. The specific objective of the paper was to analyse the contribution of the aquaculture to participating households' food systems. The data was collected in a survey where a structured questionnaire was administered to 30 participating households and 30 households who were not participating in aquaculture production. The quantitative data was analysed using a one-way Analysis of Variance. The results show that that adoption of aquaponics technology result in remarkable improvements in households food systems. It was concluded that aquaponics adoption and wider uptake may go a long way in contributing to the country's achievement of selected SDGs. As was also noted by Love et al. (2015) aquaponics farmers have a guaranteed ready market for the fish and vegetables hence can be a viable strategy to also improve incomes of smallholder farmers. By and large the technology is pro poor hence a sustainable way to reduce poverty an unsustainable food system among the rural resource poor farmers. Its adoption is therefore being recommended to reduce expenditure by households on food basket which cost more than 65% of the household income of which the savings could be invested into other household needs as was also suggested by Ronquest-Ross et al. (2015).