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**Title: Sustainable aquaculture development and its role
in the food security and economic growth in Eritrea:
Trends and prospects**

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1. Introduction

Chapter 1. Introduction

- ◆ The contribution of aquaculture to world food production has increased significantly over the last few decades and this sector now supplies nearly half of the total fish and shellfish used for human consumption (FAO, 2010).
 - ◆ Advances in culture techniques and the introduction of new species, have contributed to the rapid growth of the aquaculture industry.
 - ◆ The rapid growth of this sector has also brought forth the need to ensure that development is based on environmentally responsible practices, including those concerning feeds.
 - ◆ Therefore, considering its importance in the world food sector, it is widely recognized that the industry should become sustainable from every angle.
 - ◆ As the catch of wild fish declines, aquaculture is the only way to meet the increasing demand of fishery products.
 - ◆ As many scientists suggested that the future of aquaculture sector is challenged by the need to produce more fish for food security and nutrition in a further sustainable manner entailing technical feasibility, social license, environmental integrity and economic viability.
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..... Chapter 1. Introduction

- ◆ Eritrea is a small developing nation in the Horn of Africa with total area 124,320 Km² and has a population of about 6 million.
 - ◆ Eritrea is situated in a strategically important part of the Red Sea (**Map 1**).
 - ◆ Eritrea has an extensive 2,234km coastline, 1,151km of it coming from its mainland and 1,083km coming from its 356 islands on the Red Sea, which is the 6th longest coastline in Africa (**Denison and Paice, 2007**).
 - ◆ Most of the coastline is gradually sloping beaches and shallow bays with thickets of mangroves along the water's edge – and hence, a perfect environment for fish farming (**Wallace and McKeehan, 2006**).
 - ◆ Aquaculture in Eritrea, if properly developed and managed could be a reliable source of food security as is the case in many developing countries.
 - ◆ Therefore, the purpose of this paper is to review the sustainable aquaculture development in Eritrea and its role in food security and economic growth: trends and prospects.
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2. Overview of aquaculture development in Eritrea



Chapter 2. Overview of aquaculture development in Eritrea

2.1. Background

- ◆ Eritrea has the 6th longest coastline in Africa after Madagascar (4838km), Somalia (3025km), South Africa (2798km), Mozambique (2470km), and Egypt (2450km) (**Map 1**).
 - ◆ Eritrea's coastline is 2,234km, with 1,151km of it coming from its mainland and 1,083km coming from its islands on the Red Sea.
 - ◆ Eritrea has 356 islands scattered around its coastal waters, 20% of which are in the Dahalak Archipelago, with average water depth of 35 m (**Denison & Paice, 2007**).
 - ◆ The temperature at the coastline is 25-30°C between November and April, when it starts to warm up, reaching temperatures of up to 45°C in June to September. Tidal fluctuations are small, ranging between 50 and 120cm (**Denison & Paice, 2007**).
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Map 1: Map of Eritrea showing physical setting Eritrea's fisheries and coastline¹



¹Source: Adopted from **Grofit (1971)**



....Chapter 2. Overview of aquaculture development in Eritrea

2.2. Aquaculture (only marine aquaculture) trends

- ◆ With pristine waters of the Eritrean Red Sea and clean environment, aquaculture in Eritrea can have a strong competitive marketing advantage.
 - ◆ Aquaculture in Eritrea is a new form of agriculture as in many African countries.
 - ◆ An American - Japanese Expert – **Gorden H. Sato (PhD)** in the year 1987-1988, with the idea of self-reliance and food security - has initiated Manzanar project, and cultured Mullet and Milk fish species in areas under-control of EPLF in the Northern Red Sea Region.
 - ◆ Members of the EPLF navy have been engaged in the work under the supervision of **Dr. Gordon H. Sato (PhD)** and a **Chinese Aquaculture expert (Dr. Lou, PhD)**.
 - ◆ After independence, similar efforts of the Manzanar project continued in a small scale, mostly in research oriented manner in the port city of Massawa and Haleb Island.
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....Chapter 2. Overview of aquaculture development in Eritrea

2.2.1. Seawater Farms Eritrea (SFE)

- ◆ The first commercial aquaculture farm in Eritrea is Seawater Farms Eritrea (SFE).
 - ◆ SFE was established in November 1998 as a 50/50% joint venture between the Ministry of Fisheries of the state of Eritrea and a USA-based company, 10km north of Massawa.
 - ◆ With huge investment (over 20 million USD), SFE had metamorphosed from a 3.6 hectare prototype farm to about 1000 hectare Integrated Seawater Farm and supporting facilities over its 6 years active existence.
 - ◆ The farm had 153 circular concrete shrimp grow-out ponds with a total water area of 5 hectares, a Shrimp Hatchery facility, a small Pathological and Analytical laboratories, on site Feed Mill, over 140 hectare interlinked earthen lakes fin-fish culture, Canals and Constructed Wetland, about 200 hectares of developed agricultural fields for Halophyte plants, Maintenance Workshops, Offices, etc (Fig. 1-2).
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....Chapter 2. Overview of aquaculture development in Eritrea

.....2.2.1. Seawater Farms Eritrea (SFE)

- ◆ Implementation of the integrated Seawater Farms Eritrea is shown in Fig. 1: first, seawater is channeled from the sea into shrimps and fish-farms. Rich nutrient from sea-water was used to grow salinity-tolerant, profitable species such as white-leg shrimp (*Penaeus vannamei*), Indian prawn (*Penaeus indicus*), tilapia fish and milk-fish (*chanos chanos*).
 - ◆ However, how attractive the project (SFE) on paper might have been ultimately it came to an end due to various complex reasons (see sub-section: 7.1 in this paper (What went wrong with SFE?)).
 - ◆ Nevertheless, there is no doubt that highly experienced professionals on the field were recruited, and lesson was taken especially on the merits and drawbacks of the idea of integration for future initiatives.
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....Chapter 2. Overview of aquaculture development in Eritrea



Fig.1. Seawater Farms Eritrea

....Chapter 2. Overview of aquaculture development in Eritrea



Fig.2-3. SFE activities (shrimp production, algae treatment, fishmeal processing and feed production)



....Chapter 2. Overview of aquaculture development in Eritrea

2.2.2. Integrated Farming of Fish cum Chicken (IFFC)

- ◆ Another aquaculture project was also conducted at a research level entitled Integrated Farming of Fish cum Chicken (IFFC), Ministry of Marine Resources (MMR).
 - ◆ The IFFC Project, a research based community development project was established in 2010, 12km north of Massawa, at about 5 hectares coastal area (Fig. 4).
 - ◆ IFFC was founded by local experts (**Habte-Michael Habte-Tsion (PhD) and Simon Z.-Mariam**) previously were recruited in Seawater Farms Eritrea (SFE).
 - ◆ The project was funded by the government of the State of Eritrea and the International Fund for Agricultural Development (IFAD).
 - ◆ The project, after the pilot study phase, was aimed to provide alternative livelihood or income augmenting opportunities for the coastal communities to improve their living standards.
 - ◆ This project was also aimed to enlighten its mission to be a project that **was completely committed to coastal community development with sustainability and optimal use of resources.**
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....Chapter 2. Overview of aquaculture development in Eritrea



Fig. 4 (A & B): Five hectares Integrated Fish cum Chicken Farm (IFCF) research project



....Chapter 2. Overview of aquaculture development in Eritrea

2.3. Aquaculture species in Eritrea

- ◆ Major species in the marine aquaculture of Eritrea are: White-leg shrimp (*Penaeus vannamei*), Indian prawn (*Penaeus indicus*), Tilapia, Mullet (*Mugile cephalus*), Milkfish (*Chanos chanos*), Oyster, Sea-cucumber, Lobster, Artemia, Halophyte plants (*Salicornia* and Mangrove) etc.
 - ◆ It can also be integrated with terrestrial animals such as poultry and ruminants.
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....Chapter 2. Overview of aquaculture development in Eritrea

2.4. Aquaculture production in Eritrea

- ◆ The Seawater Farms Eritrea (SFE) employed almost 800 people, shipped 1tonne of premium shrimp a week to Europe or the Middle East and cultivated over 100ha of the oil seed crop salicornia.
- ◆ The average Shrimp production in Seawater Farms Eritrea (SFE) in 2001-2003 was 14.32tonnes and 71% exported to Europe and the Middle East (Table 1).

Table 1: Shrimp aquaculture production 2001-2003 in Seawater Farms Eritrea (SFE)¹

Year	Export(t)	Local sales(t)	Total(t)
2001	9.84	1.59	11.43
2002	8.81	4.21	13.02
2003	11.50	6.73	18.23

¹Source: SFE document, Massawa, Eritrea.



3. Fish consumption level and consumption preferences in Eritrea



Chapter 3. Fish consumption level and consumption preferences in Eritrea

3.1. Marine aquaculture fish

- ◆ Seawater Farms Eritrea (SFE) has been able to market fresh iced and frozen shrimp to EU (France, Greece), Saudi Arabia, United Arab Emirates (UAE), and Egypt.
 - ◆ SFE's shrimp has received excellent acceptance including in the countries like France, which has very demanding quality requirements.
 - ◆ SFE was not able to exploit this high demand mainly because of limited production.
 - ◆ Almost all of the buyers contacted look for consistency of both quality and supply of the product, which SFE was unable to respond to the latter.
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....Chapter 3. Fish consumption level and consumption preferences in Eritrea

3.2. Progress in fish consumption level

- ◆ Currently, the Ministry of Marine Resources as an agency of the government with stakeholders in the fish supply chain channel is working based on the following factors:
 - (1) creating fish consumption awareness among the public through the mass media; and
 - (2) providing local distribution net works for easy access to consumers at affordable price.
 - ◆ The ministry with stakeholders has established many new distribution sites mainly in the cities and towns; likewise, to fulfill consumers demand, the **Massawa Eri-Fish Processing Plant** and **Asmara Eritrean Marine products Companies (EMPC)** have been distributing fresh fish using cold storage equipped vehicles throughout the country.
 - ◆ As a result the consumption level for marine fish is increasing from time to time.
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4. Fish processing status in Eritrea

Chapter 4. Fish processing status in Eritrea

- ◆ **Eri-fish Processing Plant** was established in 1995 in Massawa, it has processing capacity of 15tonnes of fish and 4tonnes of shrimps per day. It currently sells fresh and frozen fish products in the regional and local markets.
 - ◆ **Eritrean Marine products Companies (EMPC)** of Asmara and Assab branches that were established in 1995 and 1998 respectively have also been processing and distributing fresh fish to local markets and for export.
 - ◆ **The EMPC Asmara** is a processing and marketing company, operating a processing plant with a capacity of 10tonnes of fish per day.
 - ◆ Established in 2011, fish processing and depot plants in **Gelalo, Tio and Eddi** have been playing essential role in collecting fish harvested through artisanal fishing practices.
 - ◆ The facilities of the EMPC and Eri-fish Processing Plant have been recognized as meeting the standards required for eligibility to export to the EU market (**MMR, 2011**).
 - ◆ These processing plants are also expected to play a vital role in aquaculture development.
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5. Key institutions for aquaculture development in Eritrea



Chapter 5. Key institutions for aquaculture development in Eritrea

5.1. Ministry of Marine Resources (MMR)

- ◆ The MMR has overall responsibility for the management and development of the fisheries resources (including aquaculture) of Eritrea within the legal framework provided by the Fisheries Proclamation (No.104/1998).
 - ◆ The Ministry has two operational departments: the Fisheries Resources Development Department (FRDD), and Fisheries Regulatory Services Department (FRSD); and two Divisions: Training and Human Resources Development; and Administration and Finance.
 - ◆ The operations of the Ministry are decentralized into two regional branches, Northern and Southern Red Sea Regions.
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....Chapter 5. Key institutions for aquaculture development in Eritrea

5.2. College of Marine Science and Technology (COMSAT)

- ◆ The COMSAT was established in June 2005 under the auspices of the Ministry of Marine Resources and Ministry of Education to fulfill the following objectives:
 - (1) to produce graduates that will participate in the exploitation, management and conservation of living marine and coastal resources,
 - (2) to train seafarers that can serve in the maritime industry as engineers and to train technical personnel that can install, maintain and repair engines and cooling equipment, and
 - (3) to generate and disseminate knowledge on the marine and maritime resources of the Eritrean coast through research and publications.
 - ◆ The college is currently offering four degree and five diploma programs in four academic departments: **Department of Aquaculture**; Department of Applied Marine and Fisheries Science; Department of Marine Biotechnology; and Department of Marine Engineering (IFAD, 2010).
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6. Policy for short and long term aquaculture development plan in Eritrea

Chapter 6. Policy for short and long term aquaculture development plan in Eritrea

- ◆ The Eritrean Constitution and macro-economic policies provide the wider policy and legal context for the development of the fisheries sector, including aquaculture.
 - ◆ The policy goal is the long-term sustainable utilization of fisheries resources for the benefit of Eritrea and its people.
 - ◆ The objectives are: (1) The provision of employment opportunities for the coastal population; (2) Improvement of the livelihoods of artisanal fishers; (3) Enhancement of food security; (4) Increase in foreign exchange earnings through exportation of high value fish and fish products, principally to the regional and European markets; and (5) Sustainable and balanced use of fisheries resources, including aquaculture.
 - ◆ According to the report in the Symposium of the Ministry of Marine Resources in May, 2011; taking into account the given potentials and opportunities, a five-year plan has been charted out to introduce **community-based aquaculture** in seawaters (Kesete, 2011).
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7. Constraints in the Eritrea's aquaculture development



Chapter 7. Constraints in the Eritrea's aquaculture development

- ◆ Against the above opportunities for aquaculture development in Eritrea must be set multiple constraints to their realization.
- ◆ These bear on critical areas of general levels of capitalization, production, aquaculture-related infrastructures and services, marketing, policy, etc.

7.1. What went wrong with Seawater Farms Eritrea (SFE)?

- ◆ SFE has failed as a business venture because it failed to generate sustainable economic profit, which is the main measure of success of a commercial venture.
 - Although each unit has been projected to generate revenue and even profit the system as a whole has generated little income that eventually led to the failure and cessation to operate and manage the farm, as envisioned in its onset and development, as integrated farm.
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....Chapter 7. Constraints in the Eritrea's aquaculture development

.....7.1. What went wrong with Seawater Farms Eritrea (SFE)?

Some of the drawbacks, mistakes and failure factors of SFE are listed below:

- ◆ *Lack of clear and binding national laws and regulations* on aquaculture development in Eritrea at the time of inception of SFE.
 - ◆ Although the theoretical project concept was well developed and attractive on paper it was *not successfully implemented on ground*. No thorough, truthful and professional techno-economic feasibility study was conducted.
 - ◆ *Poor job on site survey, analysis and selection.*
 - ◆ *Arguable production strategy:* Extensive, semi intensive, intensive and super-intensive farming systems are all being utilized in aquaculture industry today.
 - SFE employed super-intensive culture system that is at the peak of all culture systems that demands the highest cost of development, operation, skill and technology, with a high risk.
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....Chapter 7. Constraints in the Eritrea's aquaculture development

.....7.1. What went wrong with Seawater Farms Eritrea (SFE)?

- Super-intensive culture systems may be appropriate in the highly developed countries where land is very expensive and technological advancement is at its crest.
 - Therefore, no thorough professional considerations were taken on the production strategy in relation to cost of development, operation, return, risk, management, Eritrea's climate, economic, technological advancement, etc.
 - ◆ *Lack of responsible aquaculture practices:*
 - especially associated with the protocols of live animal importation, quarantine and bio-security measures etc.
 - As a consequences disease introduced from abroad.
 - ◆ *Poor business management:*
 - SFE cannot just be regarded as an aquaculture facility.
 - It is rather seawater based integrated farm that integrates shrimp, fin-fish and cultivation of halophyte plants, and constructed wetland all functioning in a coordinated interdependent integrated fashion.
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8. Rationale and recommendations for sustainable aquaculture development in Eritrea




Chapter 8. Rationale and recommendations for sustainable aquaculture development in Eritrea

8.1. Recommendations for sustainable aquaculture development in Eritrea

For the development of a successful sustainable aquaculture industry in Eritrea and aquaculture industry to reach its full potential, a number of critical success factors must be addressed and resolved.

1. The government should incorporate and endorse aquaculture into national development plans and strategies and provide commitment to its development as one sector of the Eritrean National Development Strategy to contribute its share in Eritrea's foreign exchange earnings, food security and direct and indirect employment generation (e.g. China).
 - Given the availability of extensive coastal plains, unpolluted water, existing road infrastructures along the coast, relatively inexpensive labor, and some local aquaculture operation experience, aquaculture has a bright future and good potential of economic contribution.
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....Chapter 8. Rationale and recommendations for sustainable aquaculture development in Eritrea

.....8.1. Recommendations for sustainable aquaculture development in Eritrea

2. The government needs to put a great deal of effort to lay the necessary all round basic foundation for the development of sustainable aquaculture in Eritrea in terms of policy and regulations, establishing administrative procedures for evaluation and approval of projects, developing Code(s) of Best Practice etc, by promoting increased dialogue and communication between all stakeholders including with due consultation of scientists (local and foreign aquaculture experts) and the experience of Seawater Farms Eritrea.
 3. The government needs to allocate resources for sustainable aquaculture development, strengthen aquaculture related institutions including research center, monitoring, regulatory systems, etc.
 4. Identify appropriate funding sources (grants) and technology for sustainable aquaculture development (e.g. China).
 5. Seawater farms Eritrea should only be taken as a learning experience and not as a reference of aquaculture prospect in Eritrea.
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Summary

- ◆ All in all aquaculture in Eritrea, if properly developed and managed could play key roles in food security and economic growth as the case in many developing countries, **including China**.
 - ◆ Eritrea is found at the very important strategic economic zone for **China's new initiative Maritime Silk Road (MSR) and South-South cooperation plans**.
 - ◆ Indeed, aquaculture at Eritrea's coastline is one of the potential industries to be developed under this initiative.
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Academic awards & rewards

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 4. **Certificate of Honor** entitled “Excellent International Student” from College of International Education, Nanjing Agricultural University in January 2016.
 5. **Certificate of Honor** entitled “Outstanding Graduate Student in the Mid-term Evaluation” from College of Graduate Students, Nanjing Agricultural University in June 2015.
 6. **Certificate of Honor** entitled “Excellent International Student” from College of International Education, Nanjing Agricultural University in June 2015.
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