II INTERNATIONAL COURSE "AQUACULTURE PRODUCTION TECHNOLOGIES AND USE OF BYPRODUCTS FROM AQUACULTURE AND FISHERIES"

ONLINE EDITION

2023

Call for applications available at www.agci.cl.

Chilean Agency of International Cooperation for Development | AGCID

GENERAL INFORMATION

I. PROGRAM NAME

II International Course *"Aquaculture Production Technologies and Use of Byproducts from Aquaculture and Fisheries*", held by the Department of Aquaculture of the Marine Science Faculty of the Universidad Católica del Norte (UCN).

II. INTERNATIONAL COOPERATION CHILE – AFRICA

The second edition of the International Course is part of the international cooperation initiative promoted by Chile in Africa, whose purpose is to train the high-level human capital, through the "Nelson Mandela" scholarship program, in various subjects related to development and innovation in public policies. This initiative started in 2015, and it has endured over time with different human capital training alternatives, from short-term programs as well as master degrees financed for up to thirty months.

Aiming to promote cooperation among countries in Africa, a cooperation strategy for development has taken place in the continent, which is based in the institutional strategy and policy of the Chilean Agency of International Cooperation for Development (AGCID). In this context, African countries have shown their interest in receiving cooperation in Aquaculture, and potentially developing triangular activities with specialists from countries such as Costa Rica and South Africa as interested-parties to collaborate, promoting development and benefits for cooperating countries.

This cooperation is framed in the Chilean foreign policy, which on the one hand is "*turquoise*", pursuing to play a role in the mitigation of climate change, ocean and ecosystem protection, particularly, in moving towards a more sustainable development model. And on the other hand, "*feminist*", which shows Chilean commitment to human rights and the participation of women on equal terms, by promoting an equal selection of men and women for our human capital training programs.

The AGCID and the UCN, together have successfully developed and implemented several International Courses with countries in Latin America, The Caribbean and Africa, in Aquaculture technology, thus Chile will held this International Course, with an alliance between the AGCID and the renowned UCN, in the area of Continental and Marine Aquaculture for the interested African countries.

III. BACKGROUND

In the African coastal waters are located some of the richest fisheries in the world, with a great potential for development in aquaculture. From a geopolitical point of view, Africa is distributed in a Mediterranean area (North Africa), with a higher-level of progress supported by its proximity to Europe and Asia, as shown by the dramatic growth of aquaculture in Egypt, where production has tripled its size between 2007 and 2018. And the West African area, where around 25% of the jobs are linked to fishing. However, in sub-Saharan Africa, both fishery and aquaculture show more complex governance, associated with limited institutional capacity to support the changes needed for sustainable growth (FAO 2020a). In this regard, it is worth mentioning that improvements in infrastructure are required to develop this industrial activity and make it commercially viable (roads, warehouses, cold chains, markets). Also, it will be necessary to improve the channels for inside sales as well as the export outside the communities dedicated to culturing. Finally, more experts are needed to interact in African countries (particularly, the sub-Saharan region). Thoroughly studies are needed to know the nutritional needs of each species and, particularly, African endemic species.

The countries proposed for this second call for applications are Algeria, Ethiopia, Ghana, Kenya, Morocco, Mozambique, Namibia and Tanzania which show differences in their aquaculture status depending on the different species they culture and the industrialization developed in terms of production.

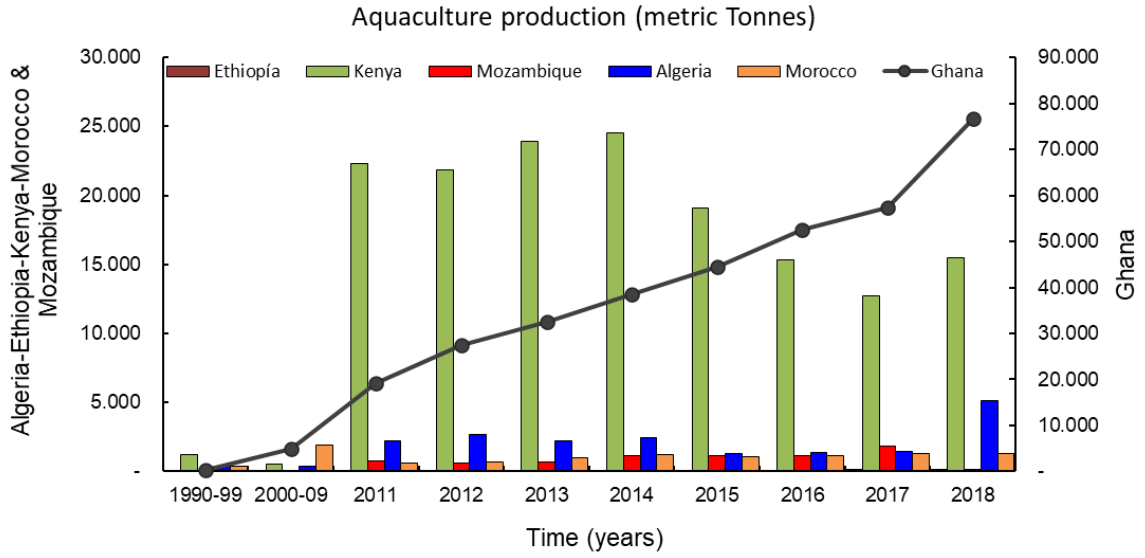

Figure 1 Aquaculture Production in the invited African countries. Information for Ghana is represented on the right axis (line) due to the larger size of its annual production (World Bank, 2021)

Africa can be subdivided mainly into two areas. North and Mediterranean Africa (Algeria and Morocco), and sub-Saharan Africa (Ethiopia, Ghana, Kenya, Mozambique, Namibia and Tanzania). Among the countries invited to the call for applications, Ghana is the main producer with 76,630 MT (Figure 1). The remaining countries show annual productions below 25,000 MT (Kenya and Tanzania), down to a minimum value for Namibia, Ethiopia and Mozambique with 462, 165 and 127 MT respectively in 2018. In some sub-Saharan African countries there are at least 1.13 billion inhabitants (World Bank, 2021). With a growing population, the demand for food is expected to spike in the coming years. Mozambique and Morocco had similar productions from 2011 to 2017, however, Mozambique dropped abruptly in 2018. In some sub-Saharan African countries (Ethiopia or Lesotho) seafood consumption does not exceed 2kg per capita (FAO, 2020).

IV. PROGRAM OBJECTIVES

This second edition is addressed to investigators from universities and/or research and development centers, as well as the public officials and professionals in African countries (Algeria, Ethiopia, Ghana, Kenya, Morocco, Mozambique, Namibia and Tanzania).

In the first online edition held last October 2022, four African countries participated (Algeria, Ethiopia, Kenya and Mozambique), with a great response from the audience. Also, we saw interaction among the accepted applicants from each country, who were able to work together and share their experiences in the preparation of work. Over 94% of the participants considered the contents of the first International Course were relevant to their personal needs; 89% considered the information provided by the experts (academics) of the International Course to be very relevant; and, finally, 78% of the participants considered that the duration of the course (three weeks) was good.

The objective of this course is to acquire technological tools related to culturing of hydrobiological resources and the use of byproducts from aquaculture and fishery for aquaculture to develop in such a way that helps to minimizing hunger and poverty, making aquaculture production sustainable by providing models to manage byproducts from aquaculture and fishery in the mentioned countries and region, taking into account the Blue Circular Economy. The course is framed in the UN Sustainable Development Goals, which are: Goals 2 (Zero Hunger), 12 (Responsible Consumption and Production), 13 (Climate Action), 14 (Life Below Water), 15 (Life on Land), and 17 (Partnership for the Goals).

As in the first edition, this course shall be given through the UCN Virtual Campus, which allows remote feedback with the support of an academic team specialized in the matter.

V. EXPECTED RESULTS

The course will enable the students' development of technical and theoretical skills on aquaculture of hydrobiological resources and use of byproducts from aquaculture and fishery in the countries involved. We want to share the experience of Chile and Costa Rica, and we are working on having the collaboration of academics and/or experts from South Africa and Egypt, to know their experience sustainable aquaculture, laws and regulations, and how to give sustainability to the resources obtained according to the circular economy and the SDGs of the 2030 Agenda, creating a learning community with the beneficiary countries.

VI. MAIN REASONS TO TAKE THE COURSE

- Understand in depth the importance of new technologies for aquaculture culturing in saltwater and freshwater.
- Recognize the main challenges in the use of byproducts from aquaculture and fishery.
- Manage wastes from aquaculture and fishery in a sustainable way for the African countries.
- Know new experiences on reusing products and/or byproducts from aquaculture and fishery.
- Establish a professional network in aquaculture to exchange experiences on culturing technologies and the use of byproducts in the circular economy.

VII. PROGRAM DESCRIPTION

This is an online edition of the course. Students will access the course contents through the virtual platform (Campus Virtual UCN).

This course is divided into two modules, which are subdivided into submodules.

Each module consists of synchronous sessions with reading material and/or asynchronous sessions in video. Synchronous sessions are given by the teacher in charge of the module, whose objective is to introduce the topic, answer questions the students may have regarding the reading material (.pdf), available in the virtual platform.

CONTENTS

MODULE I: CULTURING TECHNOLOGIES:

MODULE II: USE OF BYPRODUCTS FROM AQUACULTURE AND FISHERIES

SUBMODULE 1: Circular economy for aquaculture and fishery.

- Use of wastes and byproducts from aquaculture and fishery. Technologies for re-use of byproducts from aquaculture and fishery
- Added value for hydrobiological wastes
- Biofertilizers production from fishery wastes for agriculture

SUBMODULE 2: Laws and regulations for sustainable aquaculture.

- Chilean regulations for the use of byproducts from fishery and aquaculture
- Costa Rican regulations for the use of byproducts from fishery and aquaculture
- South African regulations for the use of byproducts from fishery and aquaculture
- Health for a sustainable aquaculture

SUBMODULE 3: Financing sustainable aquaculture in circular economy.

- International institutions for aquaculture financing (FAO)
- Circular economy in aquaculture: some examples.
- Success stories on circular economy projects in Chile

Second International Course "Aquaculture production technologies and use of byproducts from aquaculture and fisheries"

Week from 9 to 13 October

Schedule	Monday 9	Tuesday 10	Wednesday 11	Thursday 12	Friday 13
09:00 - 10:00 Time GMT-3 (CHILE) Synchronous session		Welcoming, Students introduction and working format	Fish culturing technologies in tropical water	Feeding technologies in saltwater and freshwater fish	Culturing engineering: RAS Technologies
10:00 - 11:00 Time GMT-3 (CHILE) Synchronous session		Technologies for warm water fish	Auxiliary culturing for fish and other	Bioeconomics for fish culturing	Culturing engineering and aquaponics
11:00 - 12:00 Time GMT-3 (CHILE) Asynchronous session		Saltwater fish videos	Tropical fish culturing videos	Freshwater fish culturing and use of RAS Technology	RAS videos II and aquaponics technology
Work and/or project preparation (asynchronous)		Reading and State of the art preparation - Country group	Reading and State of the art preparation - Country group	Reading and State of the art preparation - Country group	Reading and State of the art preparation - Country group

Week from 16 to 20 October

Time	Monday 16	Tuesday 17	Wednesday 18	Thursday 19	Friday 20
09:00 - 10:00 Time GMT-3 (CHILE) Synchronous session	Molluscs culturing technology (scallop - oyster)	Crustaceans culturing technology	Presentation of the state of the art of aquaculture country group 1 & 2	Microalgae culturing technologies	Laws and regulations for sustainable aquaculture
10:00 - 11:00 Time GMT-3 (CHILE) Synchronous session	Molluscs culturing technology (bivalvia)	Health considerations for culturing systems	Presentation of the state of the art of aquaculture country group 3 & 4	Macroalgae culturing technologies	Laws on mariculture in other countries
11:00 - 12:00 Time GMT-3 (CHILE) Asynchronous session	Video (pectinidae and other bivalvia)	Video: Techniques for crustaceans culturing	Presentation of the state of the art of aquaculture country group 5 & 6	Video: Techniques for macroalgae culturing	
Work and/or project preparation (asynchronous)	Reading and State of the art preparation - Country group	Reading and State of the art preparation - Country group	**Aquaculture development project preparation**	**Aquaculture development project preparation**	**Aquaculture development project preparation**

Week from 23 to 27 October

Time	Monday 23	Tuesday 24	Wednesday 25	Thursday 26	Friday 27

09:00 - 10:00 Time GMT-3 (CHILE) Synchronous session	Technologies for reusing wastes from aquaculture and fishery I	Added value for hydrobiological wastes I	Biofertilizers production for agriculture	To be confirmed	Projects final presentation country group 1 & 2
10:00 - 11:00 Time GMT-3 (CHILE) Synchronous session	Technologies for reusing wastes from aquaculture and fishery II	Added value for hydrobiological wastes II	Use of byproducts from aquaculture fishery in aquaculture	Financing of innovation technology projects	Projects final presentation country group 3 & 4
11:00 - 12:00 Time GMT-3 (CHILE) Asynchronous session	Videos: Success stories on products innovation for human consumption	Videos: Success stories on products innovation for human consumption	Videos: Reusing fishery wastes	Videos: Financing for sustainable aquaculture	Projects final presentation country group 5 & 6
Work and/or project preparation (asynchronous)	**Aquaculture development project preparation**	**Aquaculture development project preparation**	**Aquaculture development project preparation**	**Aquaculture development project preparation**	Acknowledgements and closing remarks

VIII. ACADEMIC TEAM

Academic Staff - Universidad Católica del Norte	
Toledo Agüero, Pedro	Animal Nutrition
Merino Araneda, Germán	Aquaculture engineering & RAS operation
Lira, Germán	Marine Molluscs Farming Operation
Peceño Capilla, Begoña	Circular Economy and Water Re-Use
Alvarez Vergara, Gonzalo	Microalgal Culture & Biotoxins
Tala Gonzalez, Fadia	Macroalgae Culture & Physiology
Pereira Chavez, Luis	Molluscs farming
Poblete Chávez, Rodrigo	Use of fishery and aquaculture wastes
Morales Suazo, Maria Cristina	Shrimp farming
Flores Gatica, Hector	Fish farming and aquaponics
Serrano Gutierrez, Edison	Processes and mechanisms for animal feeding
Rojas, Rodrigo	Microbiology and aquaculture
Miranda, Claudio	Antibiotics and aquaculture
Oliva Arriagada, Marcia	Larval Fish farming & Auxiliary feeds

Other lectures to be confirmed

Rhodes University (South Africa)
National University of Costa Rica (Costa Rica)
Parque Marino del Pacifico (Costa Rica)
Undersecretary Fisheries Office (Chile)
FAO representative in Chile
CORFO – Corporación de Fomento de la Producción
Chilean Agency of International Cooperation for Development (AGCID)
University of La Serena (Microbiology Department)
University of La Serena (Food Engineering Department)

IX. DURATION

The International Course is scheduled on October 10 to 27, 2023. This edition is 100% online.

The academic program requires 30 hours of theoretical work (synchronous sessions and bibliography reading and/or asynchronous videos), more than 30 hours of practical work (consisting of an application for your place of origin that is to be presented as an innovation project proposal assessed during the course).

X. METHODOLOGY

The Course is remotely conducted through Zoom and the virtual platform UCN, which is going to be the information repository. Students will be able to access the course contents in this virtual platform, such as lectures, complementary publications and videos for each topic). This course is divided into two modules, which are subdivided into several submodules. Students will dispose of an additional working time for reading the bibliography given.

Daily synchronous sessions will take place during the morning (from 09:00, Chile time GMT-3), so students are provided with enough time to connect.

Each module consists of synchronous sessions (real time) and asynchronous sessions (video), same as the workshops. Synchronous sessions are given by the teacher in charge of the respective module, whose objective is to answer questions the students may have on asynchronous sessions (video).

In order to ensure the academic learning, each student will have to attend at least 75% of the synchronous sessions and have studied the guidelines, bibliography or video sessions. Synchronous sessions will be recorded so the students are able to watch them afterwards.

XI. LANGUAGE

The course is going to be in Spanish (remote simultaneous translation into English), and in English.

XII. ASSESSMENT SYSTEM

The course will be assessed through two activities, whose objective is to encourage teamwork among colleagues from the same country as well as with students from other countries.

Firstly, students will be required to prepare the state of the art of aquaculture of each group/country, with at least three weeks in advance. This work is to be presented in a PowerPoint Presentation and/or share with the other students. For this assessment activity, a report linked to the PPT is required, in Word format, which is to be sent to the course management one day prior to the presentation.

Lastly, a proposal for a project to be developed by the students related to the beneficiary entity or institutions sponsoring each student. A follow–up mechanism will be established by the UCN and AGCID to verify the status of the final product (project).

In order to approve the course, the student must comply with three requirements:

a) An attendance of at least 75% to the synchronous sessions
b) Group preparation and presentation of the state of the art of aquaculture in the country of origin.
c) Preparation of a group project on one of the topics addressed during the Course, approved with a percentage higher than 60% (assessment scale is from 1 to 100%).

Students who meet all these academic requirements will obtain a course digital certificate issued by the Universidad Católica del Norte.

XIII. SCHOLARSHIP AND FINANCING

Accepted professionals from invited countries will be granted a scholarship to cover the International Course costs (enrollment fee and tuition), as well as the issuance of a digital certificate for those students who meet the approval requirements.

XIV. APPLICATION REQUIREMENTS

This course is addressed to public officials and professionals residing in Algeria, Morocco, Ghana, Ethiopia, Kenya, Mozambique, Namibia and Tanzania.

- Certificate of university professional title, bachelor's degree or other academic degree or university professional title in Aquaculture or related fields.
- Proficiency in the English language, in reading and oral skills enough to write in English and to read in English.
- Curriculum Vitae up to date (maximum two pages)
- One-year work experience, as a minimum.
- Certificate issued by the applicant's sponsoring institution from the country of origin (Ministry, University, Institution).
- Internet connection to be able to access meetings and sessions in Zoom or another platform.
- Citizenship of one of the invited countries and residency in such a country.

XV. TOTAL NUMBER OF STUDENTS

The course is designed for a total of 30 students. No established quotas per country.

XVI. APPLICATION PROCESS AND SELECTION

The invited African countries are encouraged to present applicants per country. Applicants must send to the Embassy of Chile the following documentation (review Annex IV Focal Points):

1) Application form (Annex I), stating all the required information, duly completed and signed by both the applicant and Supervisor/Chief.
2) Commitment letter (Annex II).
3) Employment letter (Annex III).
4) Professional title certificate (simple copy).

Application Schedule

Phase	Dates
Close for calls *(for applicants)*	1 September 2023
Preselection of applicants and submission to Scholarship Platform *(for Focal Points)*	8 September 2023
Selection committee	11 - 15 September 2023
Results and notice to accepted applicants	27 September 2023

XVII. CONTACTS

Departament of Aquaculture, School of Marine Science – Universidad Católica del Norte - Chile

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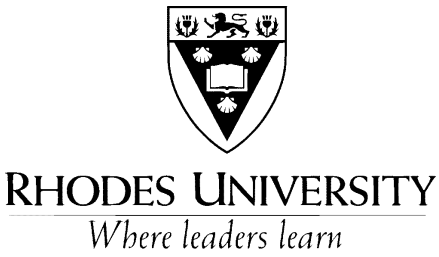
POTENTIAL COLLABORATING ENTITIES



REVIEW OF THE INVITED COUNTRIES

a) Algeria 

Aquaculture activities started at the end of the 19th century, but later disappeared due to lack of support. There are many rivers but only one coastal lagoon, which limits the potential of aquaculture in natural sites. During the 1980s, two aquaculture centers were founded and managed by the government, under the Ministry of Aquaculture: Lake Mellah fish farm (865 ha of brackish water) and the Mazafran station (Bruno, 1987).

Lake Mellah fish farm might become the first saltwater fish culture in Algeria. It has received great help from the MEDRAP (Mediterranean Regional Aquaculture Project) to develop plans on culturing (artificial production laboratory), and the sea bass fattening unit. ENAPECHE (National Fishing Company) is in control of the lake. The mollusks (oyster and mussels) are around 10 MTA of oysters and 8 MTA of mussels during 1984 (Bruno, 1987). These figures are considered to be low.

In Mazafran there is a small center for freshwater aquaculture, which is in charge of developing freshwater aquaculture, included the lakeside restocking. Between the years 1976 and 1978, Algeria established a cooperation program with China. This program included the reproduction and pre-fattening of carp with restoking purposes.

In the context of the MDRAP program, Algerian authorities projected a total fish and sea production of 175,000 MTA for the year 2000. However, statistics shown 351 MTA for the decade 2000-2009 (World Bank, 2021)

There are several aquaculture systems developing in arid systems in Algeria. In the district of Ouargla, there are four different types of farms: a) a fish farm using a flow system for intensive culturing of North African catfish (*Clarias gariepinus*) with production of 300 MTA (Corner et. al., 2020); b) an integrated agro-aquaculture farm of 20 hectare, using groundwater resources for culturing Nile tilapia (*Oreochromis niloticus*), and crops (tomatoes, cucumbers, dates and olives); c) a government aquaculture facility created thanks to the cooperation of the Korean International Cooperation Agency (KOICA) for shrimp culturing (*Penaeus vannamei*); and d) a specialized farm for *Spirulina* microalgae culturing (Corner et. al., 2020).

In the case of mollusks, the Algerian Ministry of Fisheries and Marine Resources has designed a strategic plan for the sustainable development of marine aquaculture (MPRH 2008), which is currently being implemented. This program aims to

establish fifty six new Mediterranean mussels (*Mytilus galloprovincialis*) farms along the Algerian coast, which would lead to a production increased from around 150 MTA in 2013 to 7,600 MTA 2025 (Lourguioui et.al., 2017).

Aquaculture development with non-conventional water sources has developed slowly in Algeria since 2008. Currently, there are around 600 farmers assessing the potential for development. In general, they have small-scale operations while developing techniques and approaches for aquaculture development in arid sites; although some operations have also been developed on a larger commercial scale (Hartani, 2020). In 2017, production was estimated to 5,000 MTA, mainly tilapia, some catfish and carps integrated with more conventional agricultural crops such as date palm, cereals and garden products. Extensive and semi-intensive systems development is further hampered by poor understanding and training in production and culturing practices, although peer to peer learning is growing and some farmers have been able to benefit from trainings abroad (Hartani, 2020).

Aquaculture institutions in Algeria are:

- Ministère de la pêche et des ressources halieutiques.
- National School of Marine Science and Coastal Planning
- University of El Tarf (Marine Science and Oceanography).
- Faculté des sciences de la nature et de la vie, Université Abed ElHamid, Algérie.
- Centre national algérien de recherche et de développement de la pêche et de l'aquaculture
- Office National des Statistiques

b) **Ethiopia** 

Ethiopia has an important number of freshwater systems, including lakes, reservoir, rivers, ponds and wetlands supporting aquaculture development. This country has twelve river basins, with a total average annual flow of 122,000,000 m^3. Additionally, the country has 11 fresh and 9 salt lakes, 12 large swamps and many crater lakes (Abera, 2017). Freshwater systems support a great number of fisheries with potential nutritional and economic value. However, capture fisheries are not regulated and poorly managed, leading to overexploitation of resources, degradation of biological diversity, and reduced fish supply and income (Natea, 2019).

In Ethiopia, aquaculture was started as extensive aquaculture (Yalew et al., 2015), to restock and improve artificial lakes, reservoirs and small

water bodies. In the early 2000s, more than 2.5 million fingerlings were released, mainly Nile Tilapia (*Oreochromis niloticus*), Tilapia zilli (*Coptodon zillii*), Common Carp (*Cyprinus carpio*) and Crucian Carp (*Carassius carassius*). Semi-industrial aquaculture practices are at a very early stage of development. Candidate species for aquaculture include tilapia (*Oreochromis niloticus*) and African catfish (*Clarias spp*), while suitability for aquaculture of several other species in freshwater rivers and reservoirs is yet to be explored (Natea, 2019).

Nowadays, some inquiries to increasing fish production and integrate farmers in terrestrial areas in different parts of the country are being conducted. Several institutes such as Sebeta Fish and Aquatic Life Research Center, Batu Fishery Research Center and Bahirdar Fish and Aquatic Life Research Center are starting artificial propagation initiatives in production laboratories or hatcheries.

In general, aquaculture in Ethiopia is at a low level of development due to lack of support, outreach, human capital formation, lack of technical knowledge, lack of fingerlings, lack of funding, low research and institutional capacity (Natea, 2019).

Aquaculture institutions in Ethiopia are:

- Sebeta Fisheries and Aquatic Life Research Center
- Batu Fishery Research Center
- Bahir Dar Fisheries and other Aquatic Life Research Center
- The Addis Ababa University
- National Fish and other Aquatic Life Research Center
- Ziway Fisheries Resource Research Centre
- Ambo University.

c) **Ghana** 

Aquaculture in Ghana has shown an important growth in recent years, thanks to the fisheries program financed by the government and the World Bank through the Ministry of Fisheries and Aquaculture Development (MoFAD). National aquaculture production grew from 32,512 MTA in 2013 to 52,470.49 MTA in 2016, which represents a 61.3% increase.

There are two cage culturing companies in Ghana: Crystal Lake Fish Ltd. and Tropo Farms Ltd., both located in Lake Volta, one of the largest artificial lakes in the world (Blow and Leonard, 2008). Lake Volta, the Bosomtwi River and the Pra River,

which have also been instrumental in fish production, face their own problems, ranging from pollution due to mining to reduced water levels that compromise Fishing. On this matter, aquaculture is the best opportunity to bridge the growing gap between fish supply and demand (Rurangwa et al, 2015).

Aquaculture in Ghana consists mainly of three species: tilapia (*O. niloticus*), catfish and the African arowana (*Heterotis niloticus*). There have been attempts to introduce other species, including *Oreochromis macrochir*, the common carp (*Cyprinus carpio*) and the tiger prawn (*Penaues monodon*). Some attempts have been made in brackish water with *Penaeus monodon*, however, no efforts have been made directly in marine settings (Amenyogbe et al, 2015). As to culturing in Ghana, ponds, pens, cages or raceways are used. Cages and raceways are expensive to operate in terms of structure and feeding costs compared to pens (Blow and Leonard, 2008). However, limited knowledge on modern aquaculture techniques, inadequate supply of improved seeds, lack of continuity in policy addressing aquaculture, and inadequate funding of research have led to management and production problems in the aquaculture sector in Ghana (Amenyogbe et al. 2018). In Ghana, the private sector is leading in aquaculture. Aquaculture practice consists of more than 2,000 small-scale local fish farmers throughout the country and foreign commercial fish farmers in cages located in the southern part of Lake Volta.

Aquaculture institutions in Ghana are:

- WARFP (West African Regional Fisheries Programme)
- MoFAD (Ministry of Fisheries and Aquaculture Development)
- Kwame Nkrumah University of Science and Technology
- University of Ghana
- University of Cape Coast
- Kwadaso Agricultural Institute

d) **Kenya** 

Kenya, in sub-Saharan Africa, has a vast network of water resources including freshwater lakes and rivers and a wide base of ocean resources. Inland waters cover an area of 18,029 km^2, the surface of marine waters (including the EEZ) is 142,400 $km^{2,}$ and it has a continental coastline of 640 km that supports a diverse fishery production (KMFRI, 2017). In the last decade, aquaculture has grown, playing an important role in the national food basket. Freshwater fish account for about 98% of Kenya's aquaculture production, showing.

a production growth of 4,218 MTA in 2006 up to 24,096 MTA in 2014, representing 15% of the total national fishing production. As a consequence of this fast growth, Kenya is the fourth largest aquaculture producer in Africa. This growth is mainly associated with government intervention through the cross-sector Economic Stimulus Program (ESP) in 2009, which allocated 22 billion Kenyan shillings (approximately US$283 million) to aquaculture in key sectors, between 2009 and 2012 (KMFRI, 2017). However, the freshwater aquaculture sub-sector for the second year in a row, show a decrease in total fish production falling by 24.8%, from 18.70 MTA in 2015 to 14.95 MTA in 2016. However, Kenya has a much larger capacity for fish farming with more than 1.14 million ha potentially available to enable a production capacity of more than 11 million MTA (KMFRI, 2017).

The main species cultured in freshwater are Nile tilapia, which accounts for around 80% of the production, followed by African catfish, which contributes around 14% of the aquaculture production.

In marine aquaculture, the most commercially cultured fish species is milkfish (*Chanos chanos*), which represents 90% of the production, followed by mullet (*Mugil cephalus*), which contributes 10% of the aquaculture production. Shellfish culturing in Kenya has been primarily the culturing of crustaceans (Crab; *Scylla serrata*), shrimp (*Penaeus monodon*), and Artemia sp. Experimental oyster culturing took place in Gazi and Funzi bays on the South Coast but was not sustainable due to lack of market links, despite the success of the culturing.

Aquaculture institutions in Kenya are:

- KMFRI (Kenya Marine and Fisheries Research Institute)
- NARDTC (National Aquaculture Research Development and Training Center)
- KWSTI (Kenya Wildlife Service Training Institute).

e) **Morocco** 

In Morocco, the history of aquaculture dates back to the 1950s, with the beginning of oyster culturing in the Oualidia lagoon. Intensive farms were also born in 1985 on the Mediterranean coast in the Nador lagoon, and later in the M'diq bay. Production was mainly focused on sea bass, sea bream and oysters.

Ten years later, pen culturing was introduced at the mouth of the Moulouya with the production of prawns. From 2011, a new impetus was given to the aquaculture sector

with the founding of the National Agency for the Development of Aquaculture within the framework of the Halieutis plan.

In Morocco, marine aquaculture production is distributed as follows: molluscs (75%), algae (21.5%) and fish culturing (3.5%). The most important species are:

a) Molluscs: Oysters (*Crassostrea gigas*), clams (*Ruditapes decussatus*), mussels (*Mytilus galloprovincialis* and *Perna perna*), scallops (*Pecten maximus* and *Pecten jacobeus*) and abalone (*Haliotis tuberculata*).

b) Fish culturing: Sea bass (*Dicentrarchus labrax*), sea bream (*Sparus aurata*), corvina (*Argyrosomus regius*), and turbot (*Psetta maxima*).

c) Algae: *Gracilaria* sp.

Aquaculture in Morocco shows potential but is under-exploited compared to other countries in the North African region. By 2016, there were 21 aquaculture firms with a total of 470 tons of production (289 MTA of oysters and 181 MTA of fish). Early in 2000, a shellfish farm was opened in Dakhla Bay, for bivalvia molluscs culturing.

In 2019, aquaculture production in Morocco reached 895 MTA, while the estimated potential is 380,000 MTA, thanks to the 1,700 km of coastline and 13,385 Ha available for development. The strategy for the development of the aquaculture sector points to a production of 200,000 MTA by 2020 (Estrada, 2021).

Aquaculture institutions in Marocco are:

- ANDA (Agence Nationale pour le Développement de l'Aquaculture)
- INRH (Institut National de Recherche Halieutique)
- ONSSA (Office National de Sécurité Sanitaire des Produits Alimentaires)
- DPM (Département de la Pêche Maritime)
- CNHP (Centre National d'Hydrobiologie et de Pisciculture)

f) Mozambique 

Mozambique's population is over 28 million inhabitants, a coastline of 6,942 km and an exclusive economic zone of 493,672 km2. Two thirds of Mozambique's population live on the coast. Most of the fish is processed using traditional techniques (salting/drying), although part of the catch is also sold fresh, on ice or frozen (Tembe, 2014).

By 2018, it had a total production of 352,100 MTA. However, 99% was of fisheries and only 1% to aquaculture production (Globefish, 2021). Of Mozambique's fishery, 93% is fish, 6%

are crustaceans (mainly shrimp), and 1% is molluscs. In 2018, the main aquaculture production was penaeid shrimp with 10,570 MTA and Tilapia fish with 2,654 MTA. (Globefish, 2021).

In Mozambique, aquaculture began in the 1950s, whose growth has been important for the development of the country. In the late 20th century, an aquaculture program for local communities helped Mozambique to develop freshwater fish culturing. (Boane et.al., 2008). The government built three research and demonstration centers in the early 1960s. However, not all of these centers are working now (Chirindza, 2010). In 2008, as part of a strategy for the development of aquaculture, the National Institute for the Development of Aquaculture was created. The institute is responsible for preparing technical legislation, aquaculture development policies, extension, management and collection of statistics. (Moyo y Rapatsa, 2021).

From a coastal point of view, the Northern Mozambique Channel is a treasure of unique oceanography, rich coral reefs, migrating tuna, and whales, bounded by the Comoros, France, Madagascar, Mozambique, Seychelles, and Tanzania. Its living resources are relatively intact and of great importance for food security and livelihood security and the developing economies of its surrounding countries. (Obura et al., 2019). The Mozambique Channel contains extensive habitats typical of shallow tropical seas, such as coral reefs, mangrove forests and seagrass beds, and a highly dynamic pelagic zone.

Aquaculture is underdeveloped even in the Northern Mozambique Channel region and is greater in Madagascar. In some areas, a low-population density model is applied with 5-10 shrimp per m^2 (Obura et.al., 2019). The most developed fish groups are *Oreochromis mossambicus* (the main species of tilapia cultured in Mozambique) and the common carp *Cyprinus carpio*. There is some Nile tilapia *Oreochromis niloticus* culturing (exotic to Southern Africa), showing a faster growth rate compared to *Oreochromis mossambicus*. Regulations of most Southern countries in Africa forbids culturing *O. niloticus*, because it is a highly invasive species. The introduction of *O. niloticus* to Lake Chikamba in Mozambique showed a fast colonization of the ecosystem and now it is the dominant fish species. Currently, populations of *Oreochromis niloticus* are well established in Zambia, Botswana, Zimbabwe, Mozambique, and South Africa (Picker and Griffiths, 2011; Moyo and Rapatsa, 2021).

According to the FAO (2008), it is estimated that 50% of the population animal protein intake is directly from fish and fishery products. and aquaculture programs contribute significantly to food security and to improve the living conditions. (Boane et.al., 2008).

In the last years, macroalgae culturing has been very important. Recently, countries such as Kenya, Morocco and Mozambique are beginning to produce macroalgae, considering that there are still low productions (<2%) compared to Tanzania that exceeds 92% of the production of the African continent (Msuya et.al., 2022).

Aquaculture institutions in Mozambique are:

- Ministère de la mer, des eaux intérieures et de la pêche du Mozambique
- Institute Nacional de Desenvolvimento de Aquacultura (INAQUA)
- Eduardo Mondlane University.
- Institut Supérieur Polytechnique de Gaza

g) TANZANIA 

Freshwater aquaculture in Tanzania dates back to 1949, when rainbow trout (*Onchorynchus mykiss*) was introduced into the mountainous regions of the north and south of the country (Rukanga, 2018; Mmanda et al 2020). Due to poor cultivation methods and technologies, growth of the aquaculture sector was slow until the late 1980s (Mallya, 2007). However, the number of fish farms then grew significantly, from 14,100 earthen fish ponds in 2004 to 26,445 in 2019, producing a total of about 18,018.6 MTPA (URT, 2019). It should be noted that 90 per cent of the sector is concentrated in earthen fish ponds and there is considerable potential for investment in other technologies, such as cages, because of the country's availability of marine and freshwater resources, amounting to 64,000 km² and 64,300 km², respectively. Furthermore, there are 8,000 seaweed farmers with a production of 1,000 tonnes per year (Rukanga, 2018).

Aquaculture activities in Tanzania are regulated by the Fisheries Act, 2003, which was followed by the Fisheries Regulations, 2009, and the development of the National Fisheries Policy of 2015. The director of the Aquaculture Development Division of the Ministry of Agriculture, Livestock and Fisheries is the competent authority for aquaculture in Tanzania, together with the minister and the permanent secretary. Each plays a role in ensuring aquaculture activities are carried out in a respectful and sustainable manner (Rukanga, 2018).

The most commonly farmed species is Nile tilapia (*Oreochromis niloticus*), followed by African catfish (*Clarias gariepinus*) (Mallya, 2007; Chenyambuga et al., 2014). However, for decades, tilapia farming in Tanzania, as in other sub-Saharan countries, has grown very slowly due to a lack of skilled labour, feed supply, and quality seed (=fingerlings) production (Mmanda et al 2020).

Meanwhile, mariculture in Tanzania had its start with Prof. Keto Mshigeni, who promoted and introduced seaweed farming to the country in the 1970s (Msuya et al., 2007). As of 2015, there are about 8,000 seaweed farmers in the country, 90 per cent of whom are women. Cultivated seaweed species include *Eucheuma denticulatum* (*E. spinosum*) and *Kappaphycus alvarezii* (*E. cottonii*). Seaweed farming is an important industry for coastal women and also provides an alternative means of livelihood to the overexploited local fish stocks. In 2015, Tanzania exported about 1,170 tonnes of dried raw seaweed to Spain, the United States, India and China (Rukanga, 2018).

However, Tanzanian seaweed farming has recently stagnated due to different issues, including water quality and seedling shortages (The FishSite: https://seafood.media/Fis/Worldnews/search_brief.asp?l=s&id=108616&ndb=1). On the other hand, by 2015, milkfish (*Chanos chanos*), pearl oyster and prawn farming along the country's Indian Ocean coastline was producing around 300 tonnes per year (Rukanga, 2018).

A 2017 survey on rural aquaculture indicated that fish farming contributed 13 per cent on average to household incomes and explained 5 per cent of the variation in the same, while 84 per cent of the variation was due to non-fish sources. The majority of fish farmers surveyed (79 per cent) wanted to continue to practice fish farming, while 9 per cent had decided to abandon it and 12 per cent had yet to decide if they would continue (Mulozoki et al 2020). According to Msuya et al. (2022), Tanzania is by far the leading producer of macro seaweed, accounting for 92 per cent of production on the African continent.

Institutions associated with aquaculture include:

- Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania
- Department of Aquatic Sciences and Fisheries, University of Dar es Salaam, Dar es Salaam, Tanzania.
- Ministry of Agriculture, Livestock and Fisheries, Aquaculture Division, Dodoma, Tanzania.
- Kigoma Centre, Tanzania Fisheries Research Institute, Kigoma, Tanzania.
- Tanzania Fisheries Research Institute (TAFIRI).
- St. Augustine University Of Tanzania.
- Mzumbe University.
- St John's University of Tanzania.
- St. Joseph University in Tanzania.

h) NAMIBIA 

Namibia has a total land area of 823,290 km² and 1,500 km of coastline. This mostly arid country has extremely scarce inland water resources and regularly experiences prolonged periods of drought. Namibia is divided into 14 administrative regions and is one of the least densely populated countries of Africa. The population is estimated at 1.9 million, of whom 32 per cent live in urban areas.

Namibia has a thriving fishing industry thanks to the rich fishing grounds supported by the Benguela Current, one of four upwelling systems that forms the eastern boundary current of the Southern Atlantic Ocean, which is home to abundant stocks of pelagic and demersal fish. The commercial biomass of Namibia's 200-nautical mile Exclusive Economic Zone contains about 20 different species, consisting mainly of small pelagic fish (sardine, anchovy, horse mackerel, mackerel) and lobster that are found along the shallow coastal waters of the continental shelf, as well as large pelagic species that include adult mackerel, demersal hake and other deep-sea species. However, fish populations on the Namibian coast are prone to sharp natural fluctuations due to both the overall instability of the oceanographic and biological environment as well as to climate change. Some fish populations can even disappear completely for a period of time, and changes in the composition of species can also occur (ATFALCO, 2012).

Namibia has no significant natural freshwater bodies suitable for commercial exploitation. It does share some border rivers with Angola, Zambia, Zimbabwe and Botswana in the Caprivi and Okavango regions, which can provide more than 1 million hectares of river-floodplains with a fishing potential that varies seasonally but ranges between 6,000 and 8,000 tonnes annually, mainly of tilapia. Namibia has no major lakes; its only permanent inland water bodies are man-made reservoirs. Freshwater aquaculture is therefore a challenge (MFMR, 2017).

Inland fisheries yield an estimated 2,000 tonnes annually, of which between 800 and 1,000 tonnes originate at Caprivi. The species caught are mainly catfish, sea bream and tiger fish. Freshwater fish are exported to Botswana, Democratic Republic of the Congo, Malawi, Tanzania and Zambia. The volume of this trade is very low, just 247 tonnes (ATLAFCO, 2012).

The number of licenses for inland aquaculture and mariculture increased to 21 in 2010 and were granted for the cultivation of the following species: abalone, oyster, Pacific oyster, clam, seaweed, crocodile, tilapia and catfish (ATLAFCO, 2012).

Commercial marine aquaculture is dominated by oyster and abalone production at Walvis Bay, Swakopmund and Lüderitz. Both Pacific oysters (*Crassostrea gigas*) and European oysters (*Ostrea edulis*) are cultivated. Cultivation methods include the use of baskets

suspended from rafts, longlines and onshore raceways, in open ocean and in ponds. South African abalone (*Haliotis midae*) is raised at Lüderitz using onshore flow-through tank systems.

Oyster production levels reached approximately 3,500 MTPA in 2016, while mussel production was slightly less than 14 MTPA that same year. In 2016, the markets for Namibia's farmed oysters consisted of several Asian countries (43 per cent), South Africa (40 per cent) and the domestic market (17 per cent) (Murta y Kibria, 2022).

Despite the abundance of marine fishery resources in Namibia, the country has one of the lowest rates of fish consumption in Africa, an estimated 13.3 kg per capita annually (FAO, 2020). Fish is not part of the traditional diet. On another note, the lack of capacities in the public and private sectors has been identified as one of the main obstacles to the sustainable development of aquaculture in Namibia (ATLAFCO, 2012).

Although the Namibian aquaculture industry remains small, there is potential for it to be a driver of both food security and economic growth in the country. Current governance regulates matters such as public health, environmental protection, animal health and diseases. The strict regulatory requirements for the import of new species limit the growth opportunities that could be achieved with fast-growing non-indigenous species (Angala et al 2022).

Institutions associated with aquaculture include:

- National Marine Information and Research Centre (NatMIRC).
- Ministry of Fisheries and Marine Resources of Namibia.
- Kamutjonga Inland Fisheries Institute (KIFI).
- Department of Agriculture and Natural Resource Sciences, Namibia University of Science and Technology (NUST).
- University of Namibia.

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