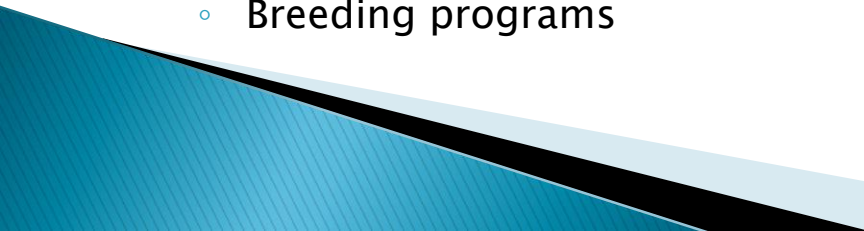


AGA 4531

Introduction to Aquaculture

Course content

- ▶ **1. Introduction**
 - Definition
 - Scope and classification of aquaculture
 - History of aquaculture
 - Current status world over and in Zambia and future perspectives
- ▶ **2. Water sources**
 - Groundwater
 - Surface water
 - Municipal water
- ▶ **3. Fish culture/Water systems**
 - Earthen ponds
 - Flowing–water systems including raceways and partitioned aquaculture systems
 - Cages and net pens
 - Recirculating systems
- ▶ **4. Site selection and facility construction**

- Siting requirements
 - Preferable characteristics
 - Fishpond design and construction
 - ▶ **6. Water quality**
 - conservative aspects of water quality including alkalinity, hardness, temperature, salinity, turbidity
 - non-conservative aspects of water quality including dissolved oxygen, pH, ammonia, nitrite nitrate
 - Influence of primary productivity on water quality
 - ▶ **7. Nutrition and feeding**
 - Biochemistry of major nutrient groups including protein, lipid, carbohydrate, minerals, and vitamins
 - Principles of diet formulation and feed ingredients
 - Feed processing methods
 - Feeding practices, strategies, and standards
 - ▶ **8. Reproduction, genetics, and breeding**
 - Reproductive physiology
 - Genetic principals applied in aquaculture
 - Induced spawning
 - Breeding programs
- 

▶ **10. Diseases and parasites**

- Major disease-causing organisms including bacteria, fungi, protozoans and viruses, Chemotherapeutic agents
- Methods of Disease Treatment

▶ **11. Handling, harvesting and processing**

- Seining, grading, and other handling procedures
- Hauling practices and considerations
- Product forms and processing procedures

▶ **12. Production Techniques; Techniques cover the following species: Tilapia, Catfishes, crayfishes, shrimp, molluscan shellfish**

▶ **Duration:** 15 weeks

▶

▶ **Contact Hours**

▶ 3 hours lectures/week

▶ 3 hours practical /week

▶

▶ **Assessment**

▶ Continuous assessment 40%

▶ Final Examination

▶ Written exam 50%

▶ Oral exam 10%

▶

▶ **Prescribed Textbook**

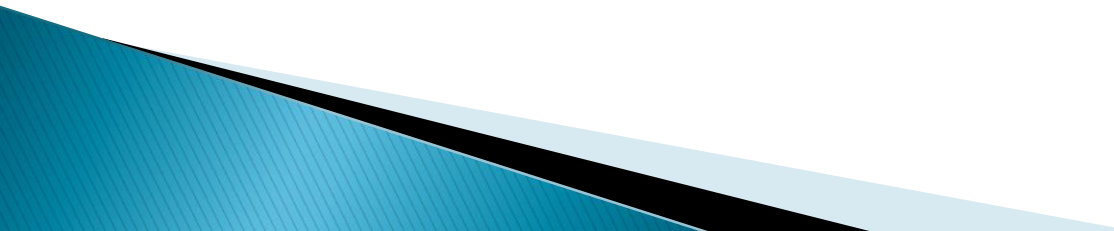
▶ Huet, M and J. A. Timmermans. 1994. ***Textbook of Fish Culture – Breeding and Cultivation of Fish***, 2nd Edition. Fishing News Books, Oxford, UK. ISBN: 0852382197, 9780852382196.

▶

▶ **Recommended Textbooks**

▶ Coche, A G, Muir J. F and T. L. Laughlin 1995. ***Simple Methods for Aquaculture; Pond Construction for Fresh Water Fish Culture***. FAO Training Series 20/1, FAO of United nations, Rome. ISBN: 9251026459, 9789251026458.

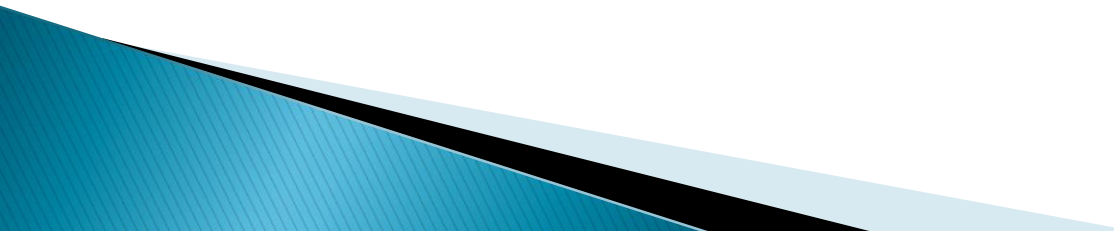
1. Definition, Scope of aquaculture

- ❖ Definition, scope, benefits, classification of systems
 - ❖ History of aquaculture and its importance to growing populations, such as Zambia.
- 

What is Aquaculture

- ❖ FAO (1990); "the farming of aquatic organisms, including fish, molluscs, crustaceans, and aquatic plants.
- ▶ Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc.
- ▶ Farming also implies individual or corporate ownership of the stock being cultivated.
- ▶ while aquatic organisms which are exploitable by the public as a common property resource, with or without appropriate licenses, are the harvest of fisheries

What is fish farming?

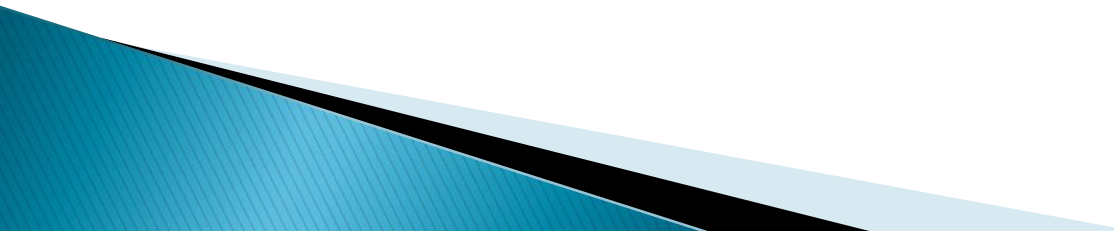
- Fish farming is the most common type of aquaculture.
 - It involves the selective breeding of fish, either in freshwater or seawater, with the purpose of producing a food source for consumption.
 - Fish farming is highly exploited as it allows for the production of a cheap source of protein.
- 

Components of Aquaculture

- ❖ Aquaculture has many components. It includes the following aspects:
 - ▶ **organism cultured**
 - ▶ **culture technique**
 - ▶ **aquatic environment**
 - ▶ **Climatic aspect**

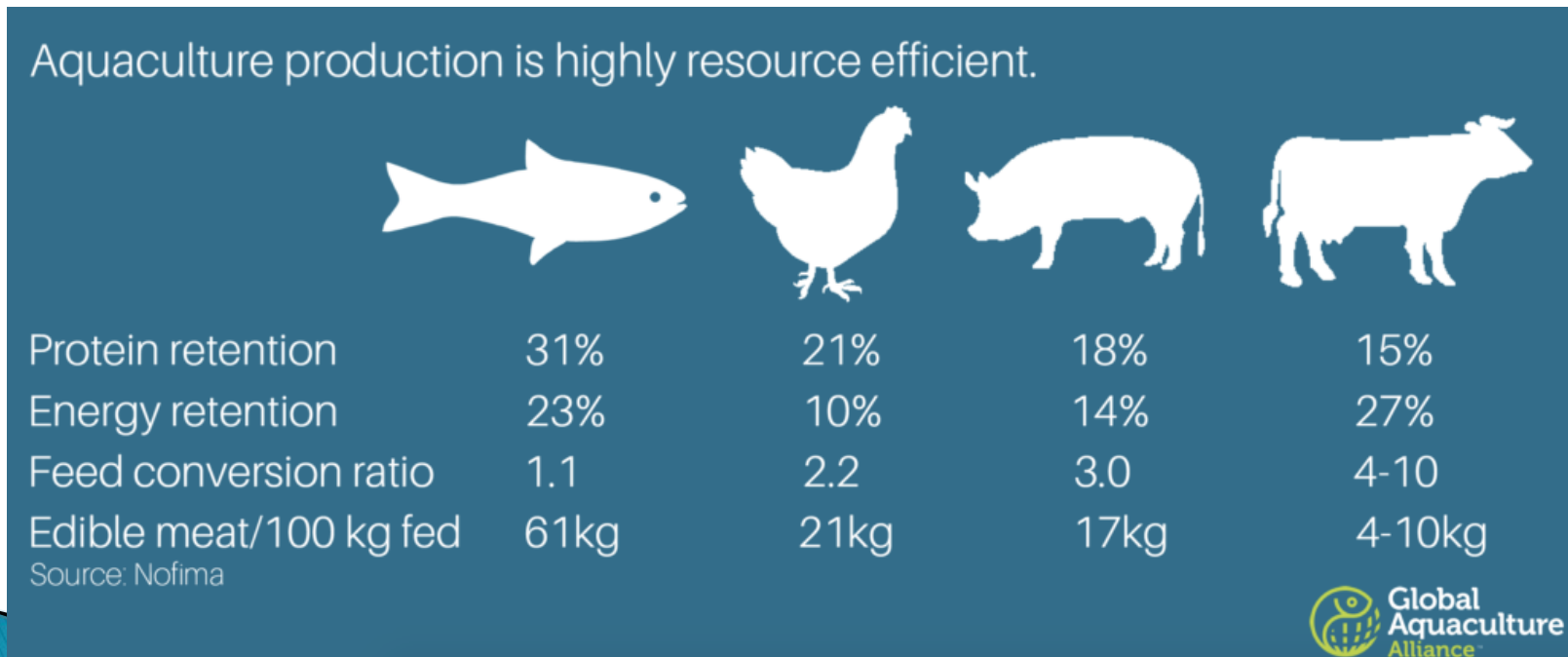


Benefits of Aquaculture

1. **Reduces pressure on capture fisheries**
 2. **Affordable source of protein compared to beef, pork and Chicken**
 3. **Integration and Recycling of agricultural waste**
 4. **Climate resilience i.e. Lower greenhouse gas emissions than other types of farming. Tilapia and catfish adapt to water and temp variations**
 5. **Rural Development; benefits of aquaculture in rural development relate to health and nutrition, employment, income, reduction of vulnerability and farm sustainability.**
- 

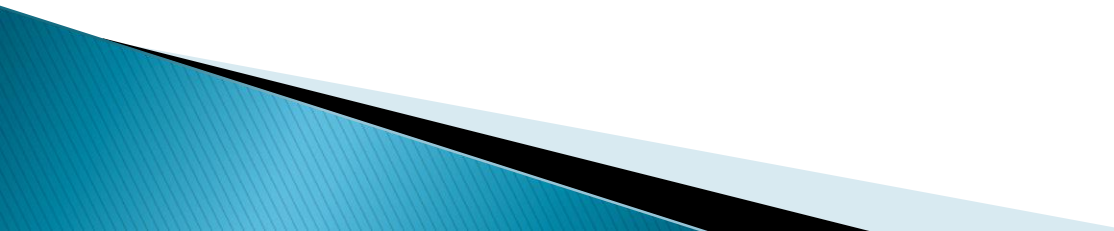
6. High productivity and Resource efficient

- Highest protein retention compared to chicken, pork and beef.
- Lowest food conversion ratio (**FCR**)
- Highest output per unit of space

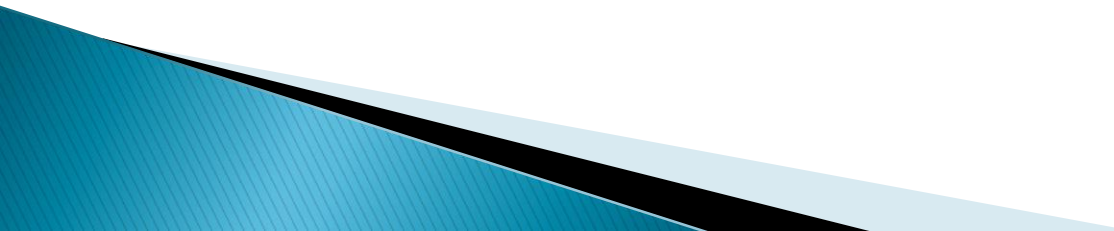


Classification of Aquaculture Production systems

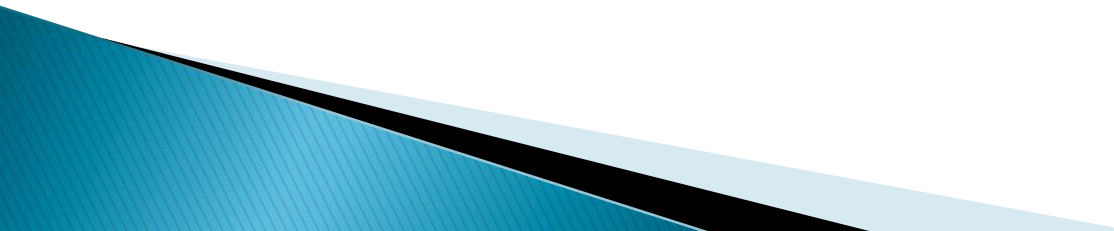
Aquaculture can be classified depending on

1. Culturable organism
 2. Hydro-biological features
 3. Intensity of production
 4. Scale of production
 5. Operational Techniques
- 

Depending on culturable organism

- ▶ Fish farming
 - ▶ Shellfish farming (Crab, Molluscs, shrimps ..)
 - ▶ Seaweed farming
 - ▶ Macro-algae farming e.g. Spirulina
 - ▶ Aquatic plants e.g. Azolla and Duckweed
- 

Depending on hydro-biological features

- Freshwater
 - Brackish water
 - Metahaline
 - Mariculture
- 

AQUACULTURE

Mariculture

(Oceans 3.5% salinity)

- Cages
- Pens
- Racks
- Poles
- Longline
- On bottom
- Nylon webbing

Metahaline

(30- 40% salinity)

- Salty ponds
(Brine shrimps)

Brackish water Culture


(Salinity more than freshwater but less than marine water)

- Cages
- Pens
- Tidal ponds
- Rafts
- Racks
- On-bottom

FRESHWATER CULTURE

- Earthen Ponds
 - Polyculture
 - Monosex culture
 - Mixed sexculture
 - Air breathing fish
- Cage culture
- Tank culture
- Recirculation system
- Biofloc systems
 - Pig-cum- fish
 - Ducks-cum-fish
 - Poultry-cum-fish
 - Cattle-cum-fish
 - Rice-cum-fish
- Ornamental fish
- Recreational fishing
- Integrated systems

Freshwater Aquaculture

- ▶ Pond culture
 - ▶ Cage culture
 - ▶ Tank culture
 - ▶ Recirculatory systems (RAS)
 - ▶ Biofloc systems
 - ▶ Aquaponics
 - ▶ Integrated systems
 - ▶ Ornamental fish culture
 - ▶ Recreational fishing
 - ▶ Culture of algae and planktons
- 

Depending on intensity of production

➤ Extensive Fish Culture

Ponds etc. are brought under this culture with little regard to raise productivity

➤ Intensive Fish Culture

Best managed form of fish farming, Pellets feed high yields (over 6000 kg/ha/year). Profitable.

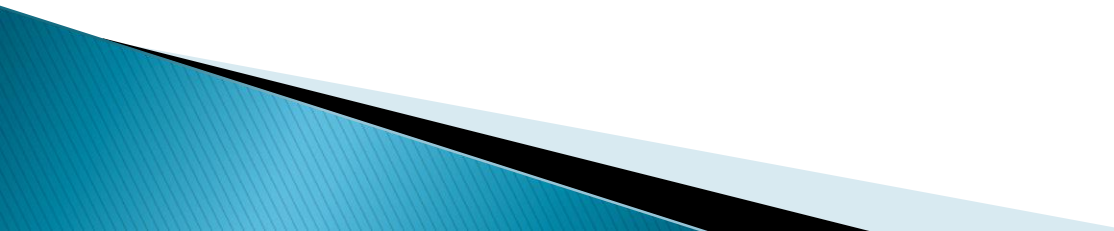
➤ Semi-Intensive Fish Culture

Certain amount of management is required and the net profit is in between the above two.

Depending on the scale of production

- **Small-scale:** aquaculture linked to agriculture/livestock; mainly on-farm resources (animal wastes, agricultural by-products, family labour) are used, extensive
- **Medium-scale:** (semi-)intensive aquaculture (SME's): more specialized aquaculture enterprises; use of artificial feed; mainly semi-intensive
- **Large-scale:** industrial aquaculture: industrial fish production; often vertical integration of fingerling and fish feed production

Depending on Operational Techniques

- Pond culture
 - Cage culture
 - Pen culture
 - tank culture
 - RAS
 - Biofloc systems etc
- 



Kafue fisheries – ponds/pigs/tilapia/cattle



Kafue fisheries – ponds/pigs/tilapia/cattle



Scadoxus fingerlings farm– Kasama



Chicoa Fish Farm - Mozambique



freshly farmed in
the clear waters of
Lake Victoria

Closed Recirculating Aquaculture System (CRAS)

HIGH TECH FISH FARM



Fish farming in tanks



History of aquaculture and its importance

Aquaculture seems like a fairly new agricultural endeavor. But actually, many ancient civilizations developed some form of aquaculture.

❖ Chinese Aquaculture

- Aquaculture in China began around 3500 B.C. with the culture of the common carp
- In 475 B.C., Fan-Li, a politician and administrator, wrote the oldest document on fish culture

❖ Egyptian Aquaculture

- ▶ For the ancient Egyptians, aquaculture seems to have evolved in tandem with the development of irrigation systems. Aquaculture in Egypt focused on tilapia
- ▶ No written documents from early Egyptian aquaculture exist, but drawings in tombs, dated about 2000 B.C., show tilapia



ACIva
(Metropolitan Museum of Art)

Pictographs from the tombs of the Pharaohs of Egypt show people fishing for tilapia in what appear to be culture ponds

❖ Roman Aquaculture

- ▶ Roman aquaculture focused on mullet and trout. Pliny the Elder (**AD 23–79**) recorded that saltwater and freshwater fish culture was practiced in Rome in the first century B.C.
- ▶ During the Middle Ages (**500 to 1500 ce**), stew ponds became important for both monks and lay people, providing a source of fresh fish.



Medieval monks were masters of self-sufficiency and irrigation, they cultivated carp fish and kept them in "stew ponds" for easy harvesting.

❖ English and European Aquaculture

- ▶ history of pond–fish culture began at the close of the eleventh century (1001 to 1100)
- ▶ **Bohemia** (a Kingdom in the Roman empire) had about 185,000 acres of ponds for carp. From spawning to marketing required four to six years.
- ▶ In 1600, John Taverner of England presented the first known comprehensive paper on the management of carp, bream, trench, and perch in ponds.

❖ Native America

By **A.D. 400**, an organized system of aquaculture existed in Hawaii. Extensive pond systems were developed, and the chiefs controlled aquaculture by leasing tracts of land to governors.

Some evidence suggests that the Maya trapped or cultured fish in ponds or canals around 500 to 800 B.C

❖ U.S. Aquaculture Development

- ▶ One of the pioneers of aquaculture in the USA Seth Green established the first public hatchery at Mumford, New York, in 1864.
- ▶ Early emphasis in Europe and the United States was on restocking depleted streams and lakes, not on the culture of food crops.
- ▶ two states dominate this area of development—Mississippi and Idaho.
- ▶ aquaculture development—catfish and trout

History of Aquaculture in Zambia

- ▶ Fish farming in Zambia dates back to the 1940s, when the Joint Fisheries Research Organization (JFRO) undertook fish farming trials.
- ▶ In the 1950s the first attempts were made to raise indigenous species of the Cichlidae family, specifically tilapias, in dams and earthen fishponds.
- ▶ By the end of 1965 there were about 1231 ponds with a total area of approximately 100 ha. Production was estimated to be 88.5 t of fresh fish.

- ▶ By 1985 pond production had increased to 750 MT of which 86 MT by small-scale rural fish farmers, 94 MT by Government fish culture stations and 570 MT (76.0%) by commercial farmers.
- ▶ 1000 MT by 1988.
- ▶ In 1972, Eastern European fish farming methods were introduced and in the early 80s, carp fish was introduced from Malawi and Czechoslovakia to Chilanga fish farms.

- ▶ In the 1970s, the Zambia Sugar Company in Mazabuka imported stocks of **Nile tilapia** (*Oreochromis niloticus*) for use in an intensive raceway system and irrigation dams from the University of Stirling in the UK.
- ▶ Nile tilapia is a historically important species in Zambia



- ▶ It was widely distributed by the Peace Corps' Rural Aquaculture Promotion (RAP) Project in the 90s in collaboration with the Department of Fisheries
- ▶ However, due to the invasive nature of this fish the DOF has in recent years withdrawn it and restricted it to Southern and Lusaka provinces
- ▶ This caused dissatisfaction among fish farmers in Northern and Luapula provinces because Nile tilapia grows faster than local species used in these areas.

- ▶ Crayfish species introduced to Zambia for aquaculture since 1979 are now established.
- ▶ deliberately introduced to a number of sites in the Zambezi and Kafue River catchments since 2001, is now widespread and highly invasive.
- ▶ Crayfish has spread rapidly across key bodies of water—particularly Lake Kariba and the Kafue floodplain—causing massive disruptions to traditional fishing patterns, practices and livelihoods.



Procambarus clarkia



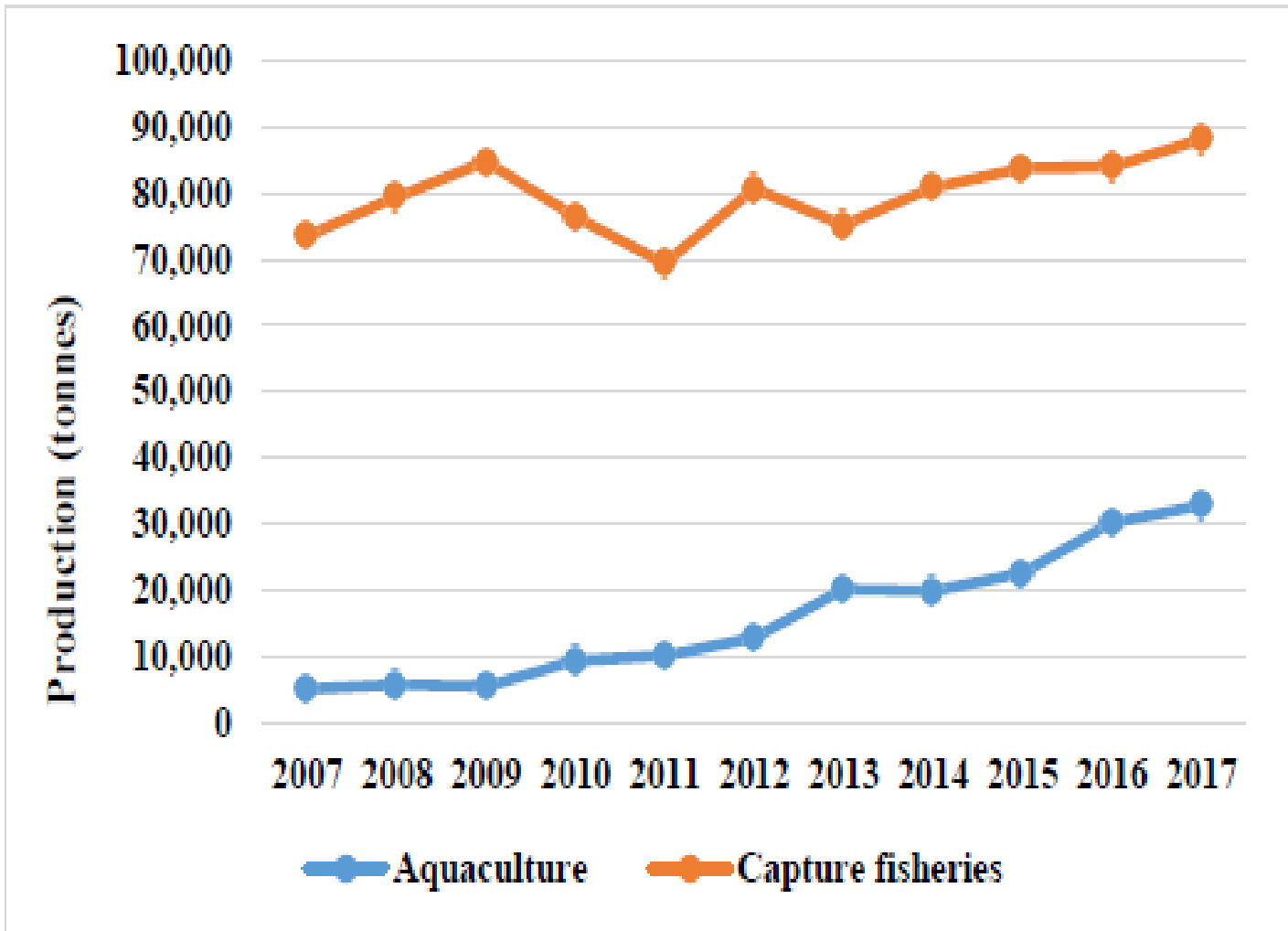
Cherax quadricarinatus

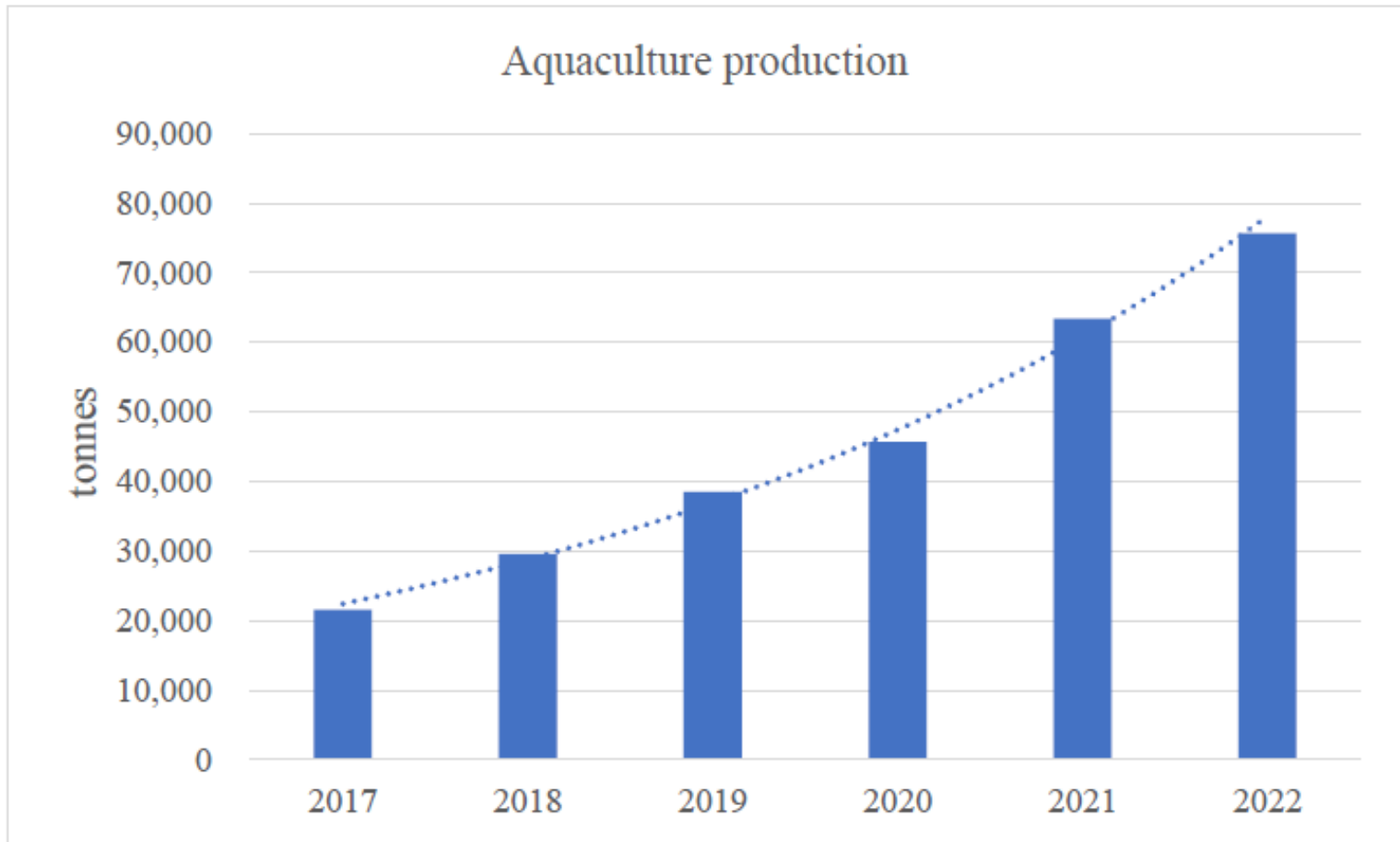
These species has implications on the future of fisheries in Zambia

- ▶ In 1981, Kafue Fisheries (Kafue Farms) began fish-farming to recycle waste by-product from its large piggery as a way to generate a new revenue stream and to minimise environmental damage from effluent.
- ▶ Over the past 10 years large aquaculture enterprises and venture capitalists have invested in cage facilities on Zambia's lakes.

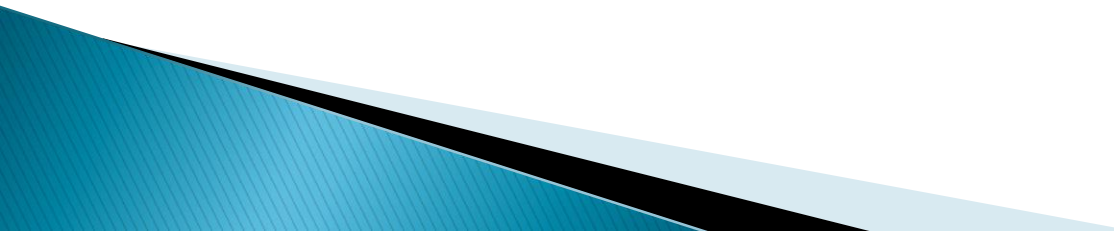
Current State of Zambian Aquaculture

- ▶ Total fish production in 2021 was estimated at **159,043 MT**
- ▶ National demand estimated about **250,000 MT**
- ▶ Capture fisheries at **95,625 mt** and Aquaculture at **63,418 MT** was not sufficient to meet the national demand.
- ▶ **SHORT FALL of 92,168 MT, which was met by imports of fish from Namibia, China, South Africa and Poland.**
- ▶ Only **6,725 mt** of fish was exported in 2021. The major export destinations were Democratic Republic of Congo, Hong Kong, United States of America and Malawi.





Trends in fish production from aquaculture in Zambia (2017–2022).
(Source DOF, Zhang et al 2022)

- ▶ Globally per capita fish consumption in 2021 was about **20 kg/person/year**.
 - ▶ **Per Capita fish consumption in Zambia has fell from 16.5 kg in the 1970s to about 12 kg currently.**
 - ▶ This has been attributed to increases in population, decline in fish stocks in inland fisheries and reduction in incomes.
 - ▶ **However, the per capita fish consumption is slowly rising due to increase in the working middle class and availability of cheaper fish from aquaculture.**
- 

Cultured species

LOCAL SPECIES

In Zambia's aquaculture, the Cichlidae family leads the fish species used for aquaculture, with the common indigenous ones being the

- Three-spotted Tilapia (*Oreochromis andersonii*),
- Green-headed Tilapia (*Oreochromis macrochir*),
- Redbreasted Tilapia (*Coptodon rendalli*),
- Tanganyika Tilapia (*Oreochromis tanganyicae*)



Nile tilapia (*Oreochromis niloticus*)



Oreochromis andersonii (male (top) and female)



Oreochromis macrochir (Pale, Nkamba)

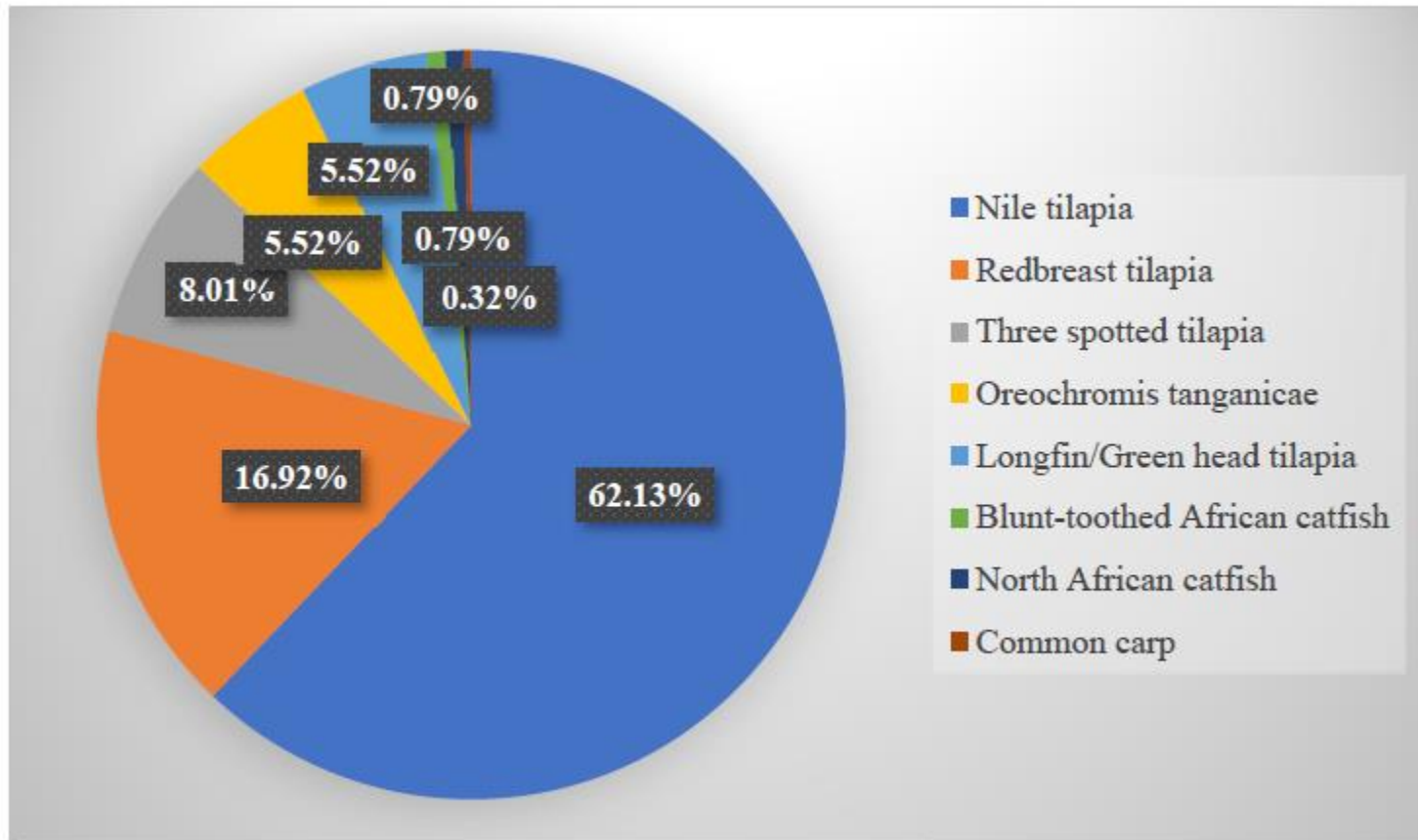


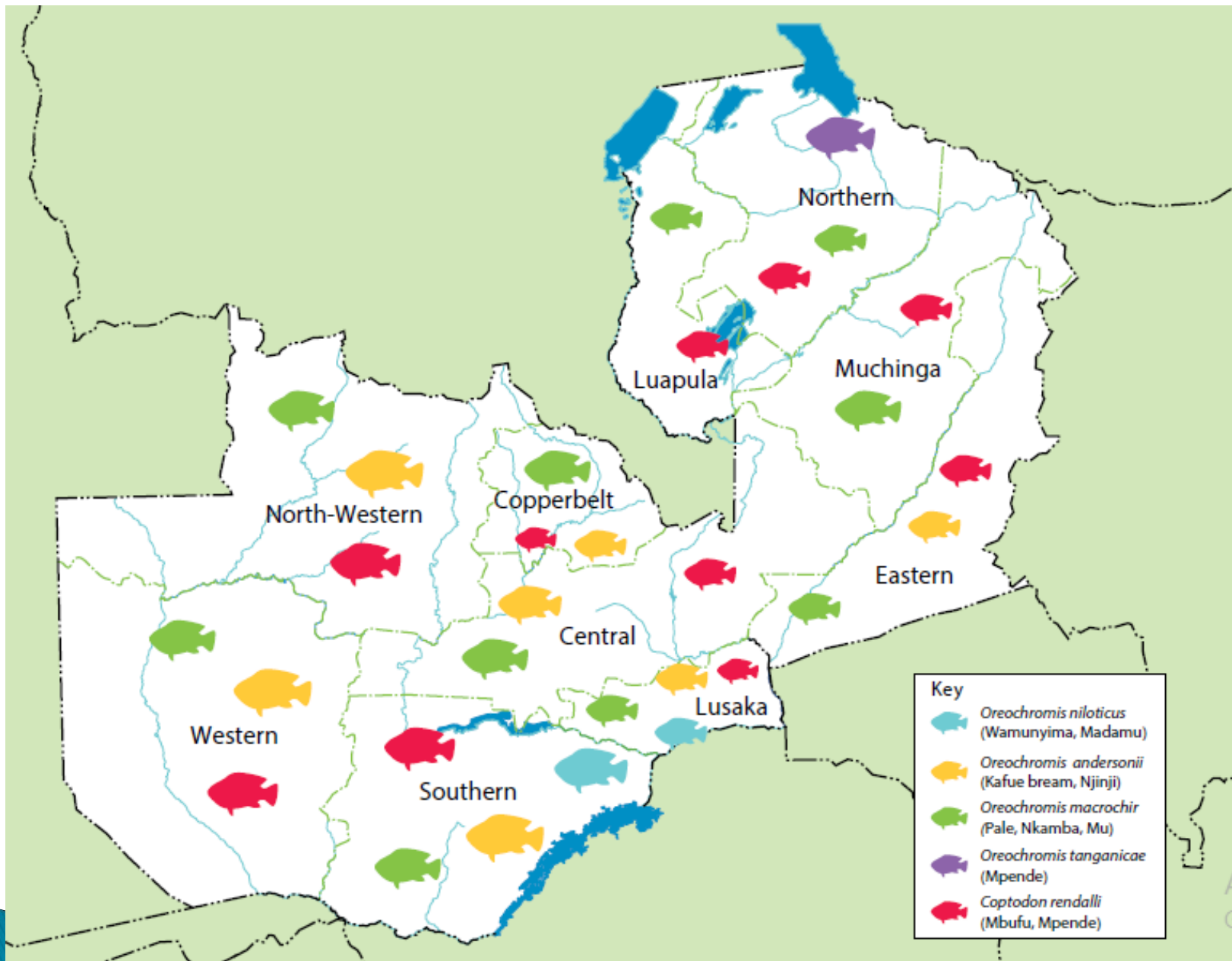
Red breasted bream (Mpende)



Oreochromis tanganicae

Cultured species % distribution



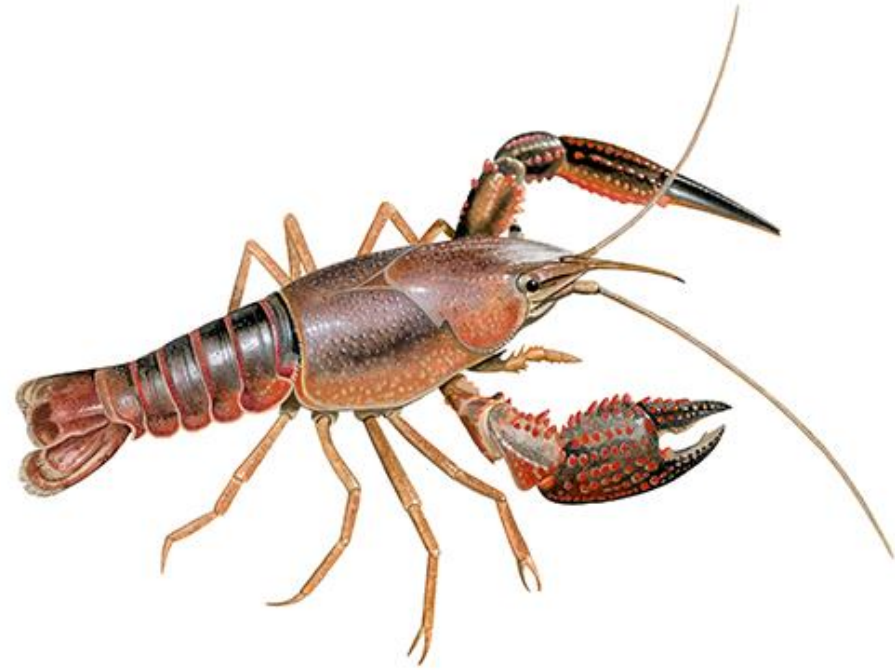


EXOTIC SPECIES

- Nile Tilapia (*Oreochromis niloticus*)
- Common carp (*Cyprinus carpio*),
- Red swamp crayfish (*Procambarus larkia*)
- ▶ Amongst all these species, the exotic Nile Tilapia has been the main cultured species
- ▶ by commercial aquaculture producers in some parts of the country, and it is allowed by the government



African catfish

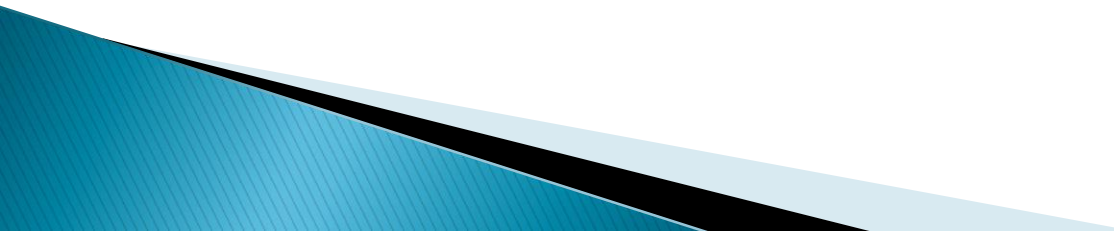


Crayfish

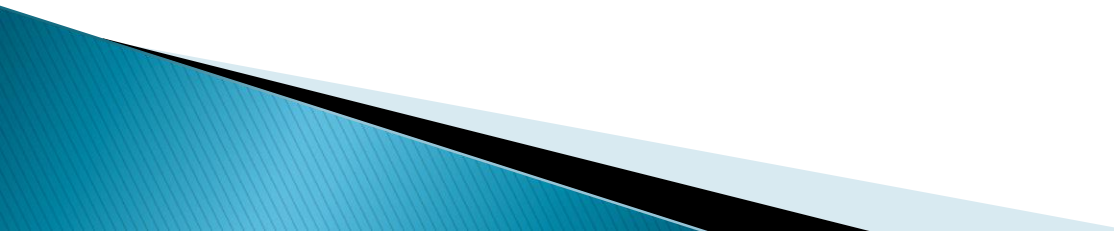


Carp

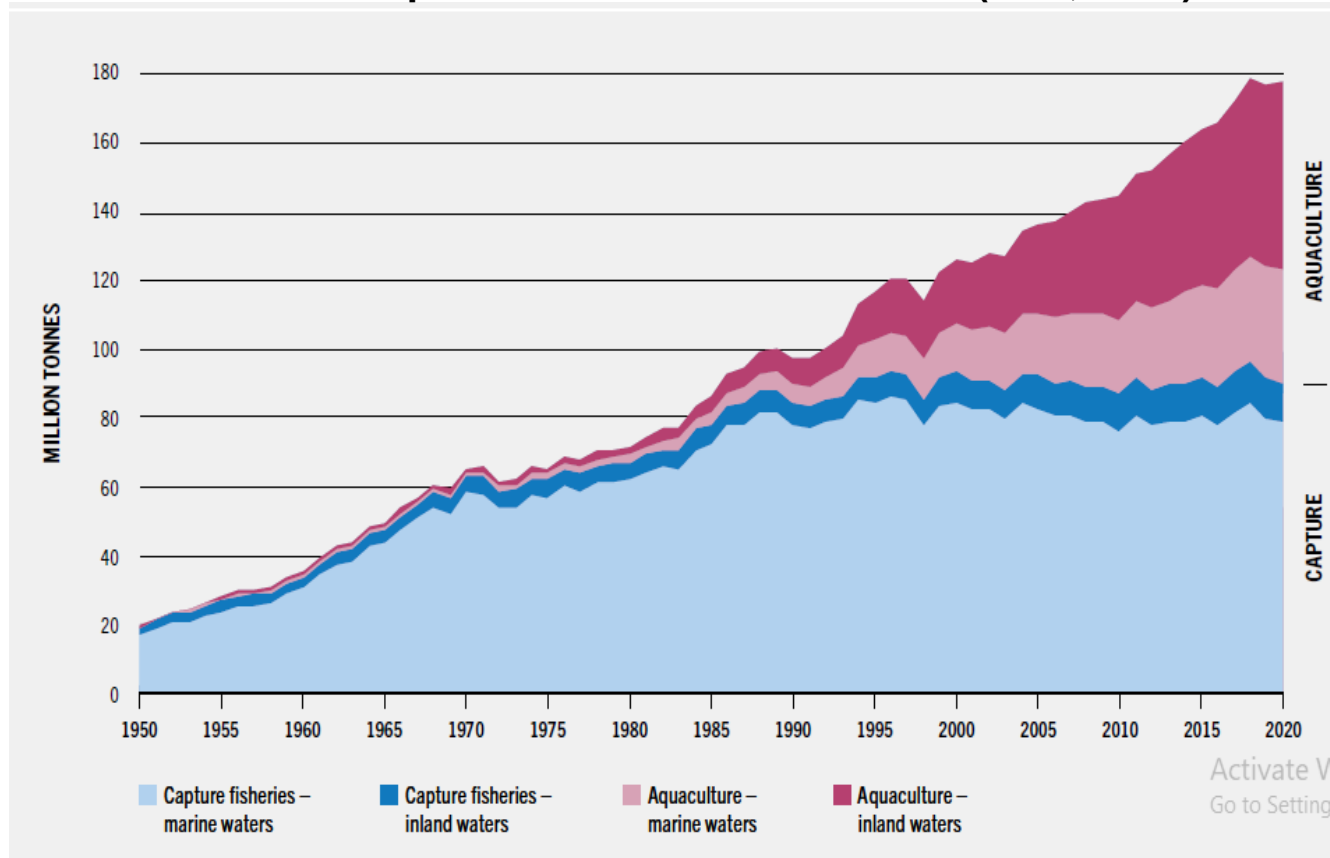
Challenges of Aquaculture in Zambia

- ▶ Fish Seed Diversity and Quality
 - ▶ Fish Feed Accessibility and Affordability
 - ▶ Financial assistance to farmers
 - ▶ No formal marketing structures for farmers
 - ▶ Post-Harvest Financials
 - ▶ Policy inconsistency
 - ▶ Fish smuggling
- 

STATE OF WORLD AQUACULTURE AND ITS IMPORTANCE TO GROWING WORLD POPULATION

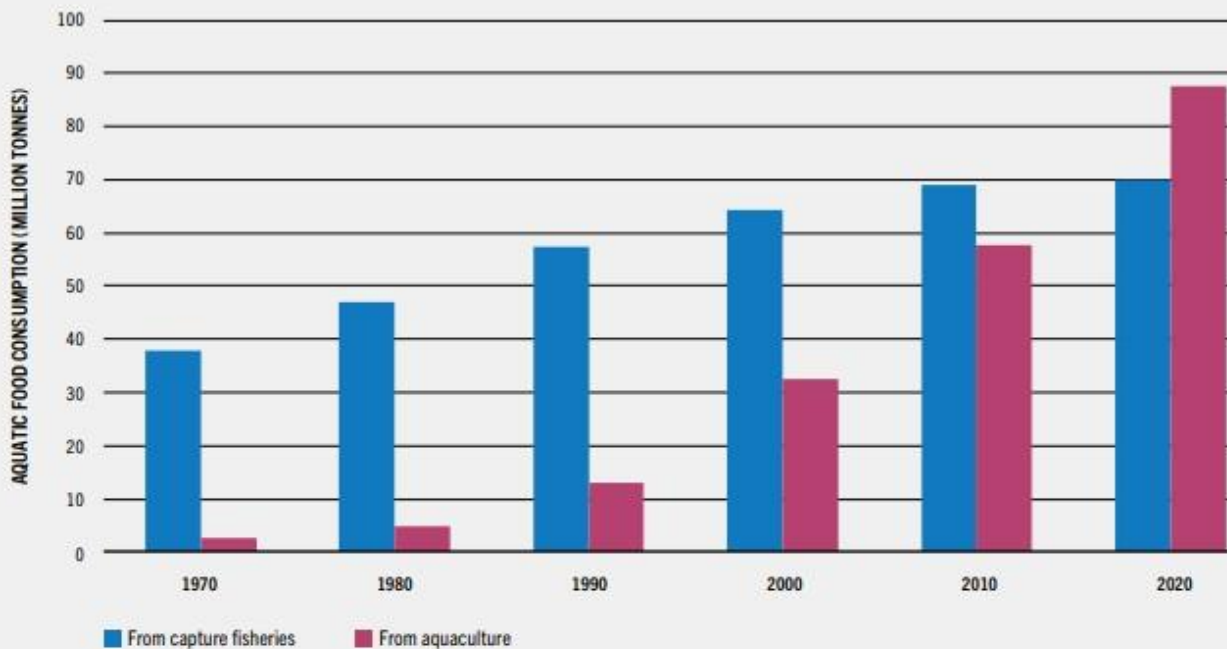
- ▶ Global fisheries and aquaculture production is at a record high and the sector will play an increasingly important role in providing food and nutrition in the future.
 - ▶ Total fisheries and aquaculture production reached a record 214 million tonnes in 2020, comprising 178 million tonnes of aquatic animals and 36 million tonnes of algae, largely due to the growth of aquaculture, particularly in Asia.
- 

World seafood production from 1950 to 2020 (FAO, 2022)



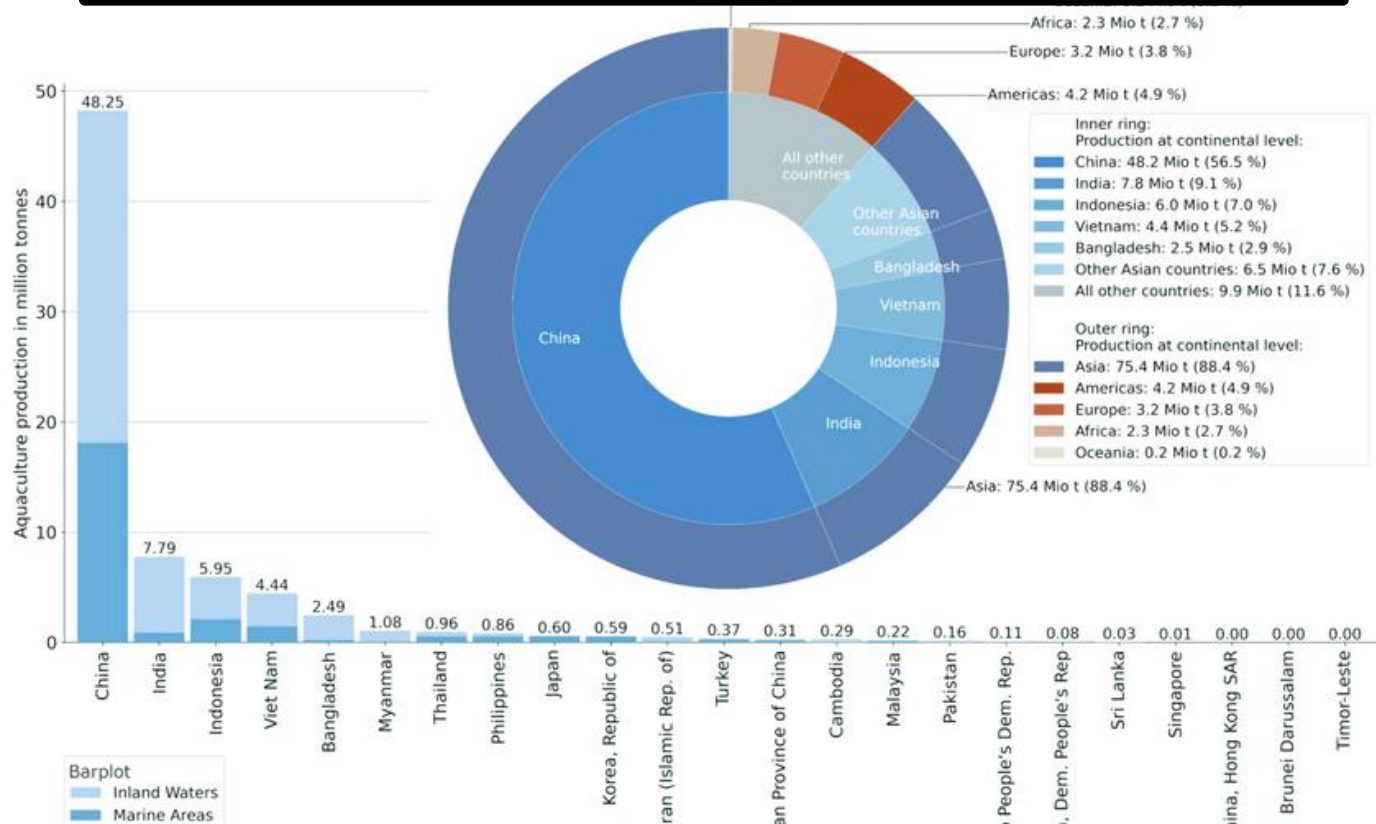
- ▶ Aquaculture has great potential to feed and nourish the world's growing population. **But growth must be sustainable.**
- ▶ The world's consumption of aquatic foods has increased significantly in recent years and will continue to rise.
- ▶ Fishery resources continue to decline due to **overfishing, pollution**, poor management and other factors, but the number of landings from biologically sustainable stocks is on the rise.
- ▶ Aquatic animal production is forecast to grow another 14 percent by 2030.
- ▶ It is vital this growth goes hand in hand with safeguarding **ecosystems, reducing pollution, protecting biodiversity and ensuring social equity.**

Contribution of capture fisheries and aquaculture to human consumption. (FAO, 2022)



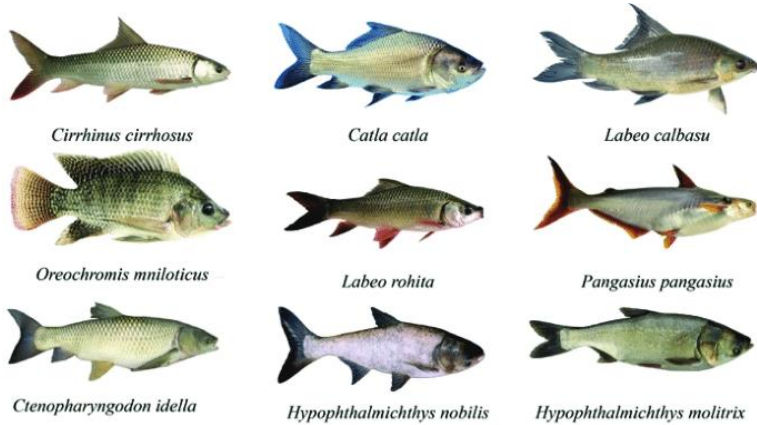
- By 2020 Aquaculture had passed capture fisheries in terms of contribution to human consumption
- Aquaculture production will increase further with population and **several challenges may arise with intensification aquaculture production**
- For the sustainable development of aquaculture, **integrated approach** to overcome the challenges facing aquaculture development is essential

Aquaculture Production in Asia



Bar chart: Aquaculture production in inland waters and marine areas among Asian countries in 2019; Donut chart: Share of aquaculture production among continents and the top 5 global producers in 2019: (Ottinger et al 2021)

Common cultured species in Asia



Giri et al
2019



Catla Fish



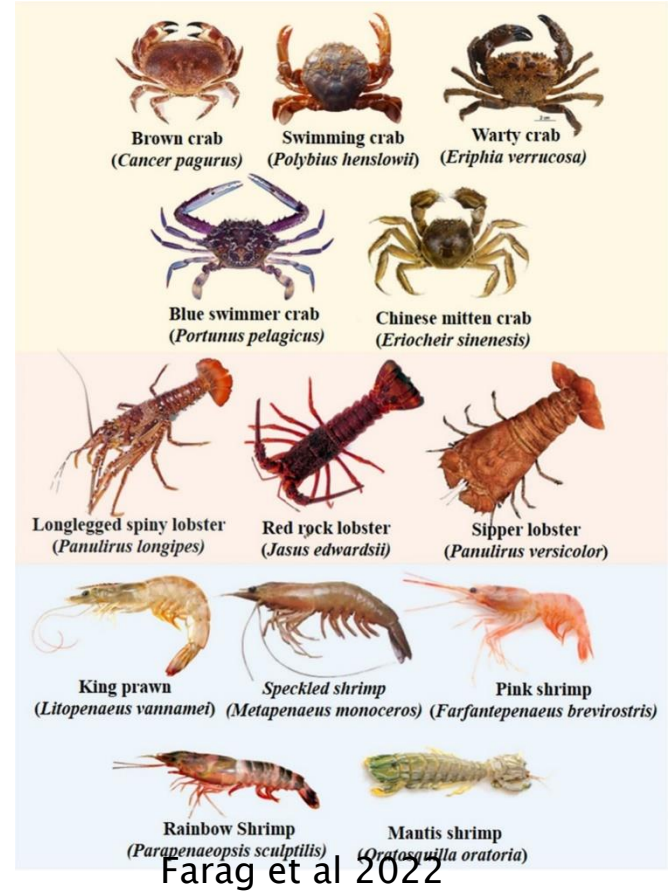
Rohu Fish



Common Carp

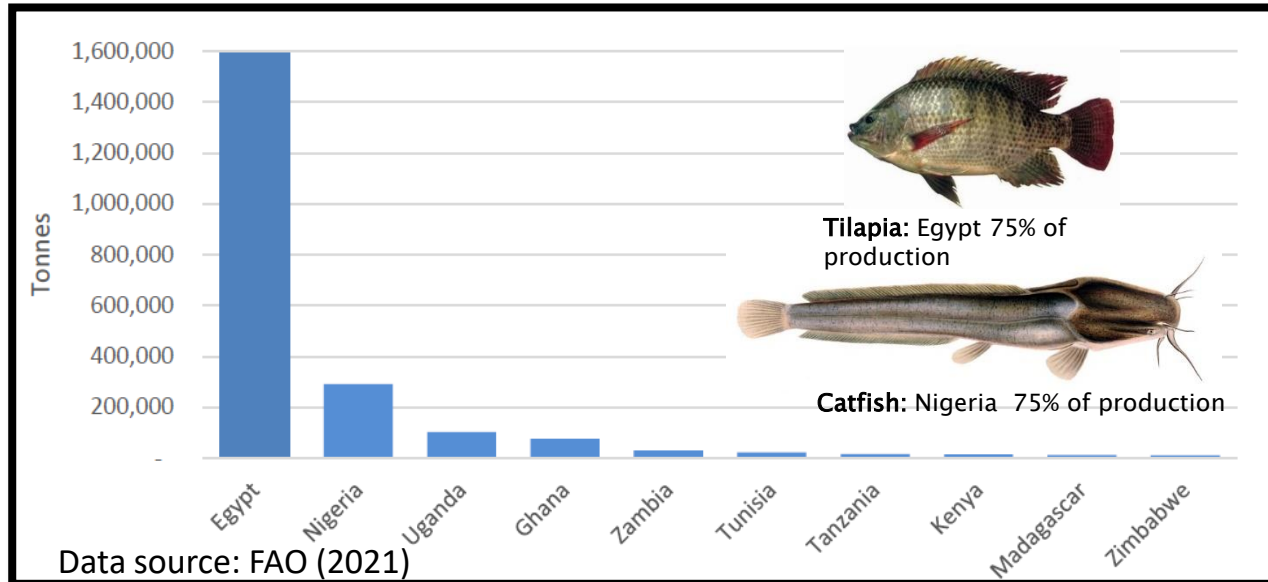


Mrigal Fish



Farag et al 2022

AFRICA : Production volume by country



Very low contribution of marine aquaculture output across Africa, despite an abundance of marine resources

The total aquaculture production volume in Egypt alone (1.6 million tonnes for 2018) was more than twice the total production of all the remaining African countries (652,217 tonnes for 2018)

- Egyptian production is made up of tilapia
- Nigeria (291,323t for 2018), consisting mainly of catfish
- Uganda (103,737t for 2018), consisting mainly of tilapia

Why high production in Egypt?

Aquaculture production is high in Egypt due to several factors such as

- ▶ favorable climate conditions,
 - ▶ availability of water resources (such as the Nile River)
 - ▶ Government support
 - ▶ Investment in the aquaculture sector
 - ▶ Increasing demand for fish products both domestically and internationally.
- 