3.2.1 SUB-MODULE 1: POND FISH FARMING AND CAGE FISHING

Topic 1: Semi-intensive culture systems and management practices

This sub-module discusses semi-intensive pond-based systems comprising earthen, liner, concrete and wooden raised ponds (Figure 3.1). Semi-intensive aquaculture, particularly in the tropics, accounts for nearly 70% of the finfish production of the world. The bulk of this production is based on a handful of species, the most important being the cyprinid species, such as Chinese and Indian major carps, feeding low in the food chain. In the cultural practices the endogenous food supply is known to play a major role, and equally the exogenous food supply is very diverse; the latter often ranging from simple mixes of ingredients to pelleted feeds of various forms. In Kenya, the bulk of aquaculture production is still by small-scale pond-based culture systems and practices.

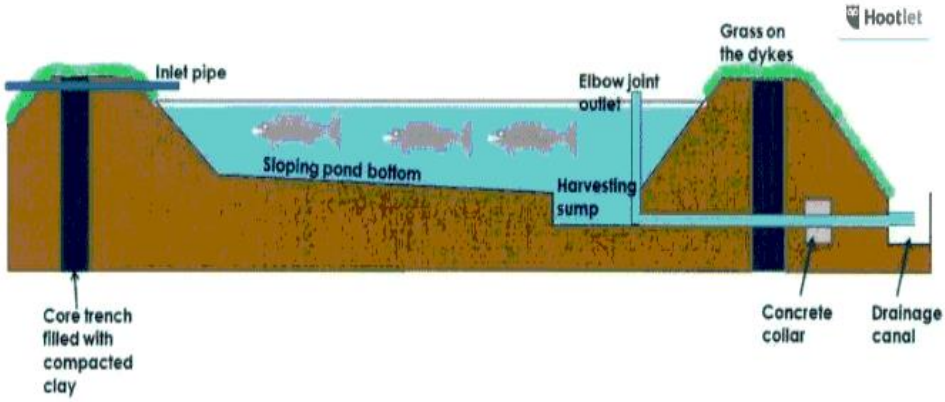


Figure 3.1. A cross-section of a complete pond showing the position of various structure

Semi-intensive culture systems depend largely on natural food produced in-situ. However, the production of natural food is enhanced by the application of organic or inorganic manure or a combination of both. At this level, the practices are known as low-cost semi-intensive system. Further intensification in these systems is attained by increasing the stocking density and application of commercially available or farm made feed or locally available agricultural by-products like bran of rice, wheat, maize etc., and various types of vegetable de-oiled cakes as supplementary feed. In semi-intensive feed and manure based freshwater carp culture, feed alone amounts to 60-70% of the total production cost. As a result, feed based culture of low valued fish species have limited acceptance among the resource poor farming communities. Low cost semi-intensive systems are followed extensively in small undrainable family ponds and relatively larger community ponds, pens erected in lakes etc. These are integrated component of the family farming system being practised. The integration becomes more visible when livestock housings are brought closer to the aquaculture facilities or the livestock animals are housed over or near the pond. The water is not only used for aquaculture but also for irrigation of crops, husbandry of livestock and other domestic purposes. Again, the wastes and by-products from crop/horticulture and excreta from livestock farming activities are efficiently recycled in the aquatic ecosystem in the form of high valued protein rich food.

Topic 2: Intensive culture systems and management practices

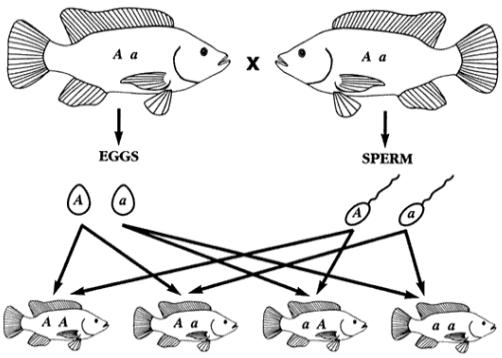
The trainees in this sub-module, will learn how to design, assemble and operate efficient, intensive culture systems such as recirculating aquaculture systems (RAS), raceway systems, cages and aquaponic systems. Intensive culture systems are high inputs - high output-based systems which require infrastructure facilities, large investment and adequate managerial skill. Such systems depend largely on complete and commercially available feed, oxygenation of the system, exchange or circulation of water etc. Intensive culture uses very high densities of culture organism (e.g., 200 000-300 000 shrimp (Postlarvae) PL/ha/crop) and is totally dependent on artificial, formulated feeds. Both systems use small pond compartments of up to one ha in size for ease of management. The topic emphasizes the design of low-cost small-scale aquaponics systems and highlights their associated challenges and lastly the use of Information and Communication Technology (ICT) in managing and operating these systems. The sub-module will further focus on Best Management Practices (BMPs) and their importance in increasing aquaculture productivity and conservation of natural ecosystems. Finally, the module addresses the key roles of fish farmers and other stakeholders in implementing BMPs.

Tilapia Intensive aquaculture Technology re-circulation system (Photo: aquaculture-israel.com

Topic 3: Fish breeding and genetics

This sub-module highlights the protocols to be used in fish breeding of commercially important fish species in Kenya e.g., Nile tilapia, African catfish, African carps (*Barbus* spp, *Labeo victorianus*), and ornamental fish. The faster growing tilapia strains demonstrate a continued increase in growth rate in genetic improvement programs and superior profitability for farmers in Africa and South Asia, with reduced environmental impact. New traits characterized in tilapia promise better performance and adaptation to climate change through tolerance to low dissolved oxygen conditions, resistance to tilapia lake virus (TiLV), and improved feed efficiency. In Kenya, there is a high demand for quality certified fish seed for improved aquaculture productivity. To enhance the production of quality seed, there are several documented fish breeding and genetics techniques available which include chromosomal manipulation, hybridization or cross-breeding, hormonal sex reversal, GIFT YY male technology, gene transfer and selective breeding.

Fish genetic breeding is a process that remoulds heritable traits to obtain neotype and improved varieties. For the purpose of genetic improvement, researchers can select for desirable genetic traits, integrate a suite of traits from different donors, or alter the innate genetic traits of a species. Major progress has been made in aquaculture genomics for dozens of fish and shellfish species including the development of genetic linkage maps, physical maps, microarrays, single nucleotide polymorphism (SNP) arrays, transcriptome databases and various stages of genome reference sequences. Thus, new molecular genetic tools (SNP array, reference genomes, linkage maps, genetic markers for host disease resistance) will underpin genomic selection, accelerate development of resilient fish strains and promote sustainable management of aquatic genetic resources. Genomic information provides powerful tools to enhance physiological research, the results of which may be used for optimization of husbandry practices, feeding and feed formulations, breeding technologies, or non-genetic selection or screening (e.g., epigenetics, proteomics, and metabolomics).



Fish inbreeding and brood stock management. Source: fao.org

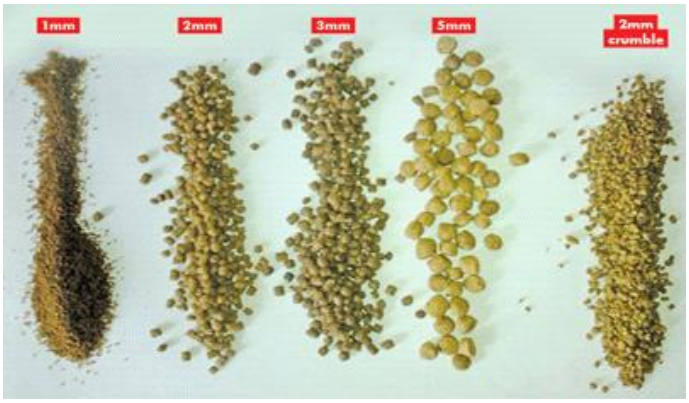
Topic 4: Fish nutrition, feed formulation and management practices

This sub-module specifies the training competencies needed to produce cost-effective cottage/supplementary and commercial pelleted fish feeds. It involves the following: sourcing of especially locally available fish feed ingredients, feeds formulations using the locally available feed ingredients, feed processing for the different fish species and growth stages, feeds conversion ratio, feeding strategies; the relationship between feeding and water quality in culture systems, and feed storage.

Proper nutrition for fish is dependent on the quality of the ingredients used to make their feed, how it is formulated (recipe), the techniques and equipment used in producing it, care taken during storage and the feeding technique applied. The following criteria need to be taken into account in selecting ingredients for fish feed: 1. Nutritional value (protein, fat, carbohydrates and fibre); 2. Availability (seasonal or annual); 3. Price and cost to transport; and 4. Any pre-treatment needed to make the ingredient more digestible. The ingredients must be kept in a dry place that is protected from sunlight and rodents, in order to maintain them fresh. Ideally, ingredients should be purchased within a week prior to producing the feed. All ingredients selected must be dry. Any ingredients purchased fresh – such as brewer's spent

grain – must first be dried (pre-treated). Each ingredient is then ground to obtain a fine meal (≤ 800 μm is optimal) to facilitate mixing with other ingredients. Each ingredient must be ground separately to avoid any contamination or undesirable mixing. The milling machine must be cleaned carefully between ingredients. Once each ingredient has been ground, sifting is recommended (ensuring that the sieving mesh size is ≤800 μm) to eliminate any coarse particles and obtain a homogeneous powder. Once the ingredients are ready, a recipe is prepared based on the nutritional requirements of each species of fish targeted (tilapia, African catfish, common carp, etc.) and their respective stage of development (larvae, starter, grower and finisher). A specific recipe must be produced for each species of fish and each stage of development. Good recipe combines several ingredients to provide the necessary nutrients to provide balanced nutrition for proper growth and development of the fish.

Fish should be fed at least twice a day (at 9.00 and 15.00) or three times a day (at 9.00, 12.00 and 16.00). Fry or fingerlings, however, need to be fed at least five times a day (at 8.00, 10.00, 12.00, 14.00 and 16.00) as their stomachs are still very small. Feeding rates diminish as the fish grow. Fish may be fed 8% of their weight per day at the starter stage, declining gradually to 3% at the grower stage and 2% at the finisher stage. Pellet size, however, increases as the fish grow larger. It is recommended that fish be fed when the weather is fine and not when it is raining. During the feeding process, fish should be visually checked to see whether they are eating and active. If they are not eating, feeding should be stopped and the water quality verified.



Tilapia Feed Formulation and Feeding Technique. Source: Fish-feed-extrude.com

Topic 5: fish health management and biosecurity

The sub-module on fish health management and biosecurity specifies the training competencies required for fish health and biosecurity. Fish health management is a term used in aquaculture to describe management practices which are designed to prevent fish disease. It includes the practices, procedures and policies used to prevent the introduction of disease-causing organisms. The occurrence of disease outbreaks in fish farming may be due to poor husbandry practices since the disease- causing organisms are always in the environment. Diseases cause problems until the fish become stressed through inadequate dietary or environmental conditions. Since fish consumers would want to have an assurance that fish products are safe to eat, retailers have a responsibility of ensuring the quality and safety of fish for human consumption. The farm management needs to ensure that biosecurity

principles are observed in all farm operations.

Once fish get sick it can be difficult to salvage them. Successful fish health management therefore begins with prevention of disease rather than treatment. Prevention of fish disease is accomplished through good water quality management, nutrition and sanitation. Without this foundation it is impossible to prevent outbreaks of opportunistic diseases. The fish is constantly bathed in potential pathogens, including bacteria, fungi, and parasites. Even use of sterilisation technology (i.e., ultraviolet sterilisers, ozonation) does not eliminate all potential pathogens from the environment. Sub-optimal water quality, poor nutrition or immune system suppression generally associated with stressful conditions allow these potential pathogens to cause disease. Medications used to treat these diseases provide a means of buying time for fish and enabling them to overcome opportunistic infections, but are no substitute for proper animal husbandry.

Topic 6: Fish post-harvest technologies and value addition

This sub-module will train on specific competencies required for fish post- harvest and value addition. These two aspects (post-harvest and value addition) comprise several processes, including transportation and handling fish hygienically; processing fish using different value enhancing techniques; preparation of fish using different recipes; maintenance of good quality fish products; packaging, branding and certifying fish and fish products and preparation and storage of fish safely for longer shelf life.

Post-harvest operations are comparatively less labour intensive than the food production operations. The introduction and uptake of improved technology can help enhance product quality and safety, reduce food loss and waste, achieve environmental benefits, operate costs and time savings, and improve working conditions. Women – who often dominate the fish post-harvest sector – are highly reliant on technology, particularly in relation to fish processing by drying, salting and smoking. Processing is particularly necessary when there are inefficiencies or lack of a cold chain. The processing extends shelf life (by up to several months) and makes fish transportable over long distances.

Value addition is seizing opportunities offered by markets. It involves the process of adding value to products (starting from raw materials), or adding “extra” features to a product (improving quality, making products more convenient or desirable, creating new products, reducing costs, etc.) which often results in greater economic value for the producer. There are two possibilities of adding value: (1) value capturing through the improvement of current production, processing, trading processes to increase productivity, reduce wastage and reduce costs, and by entering new markets with existing products. (2) Value creation through product innovation (e.g., new processed products). This enables fishers, processors or traders to tap into new and higher-value markets. It may entail producing a fish product for a special or new market (diverting low-value fish from animal feed to the higher-value human consumption market); improving end-product quality through better hygiene, handling and processing practices; applying processing and preservation techniques and technologies such as dehydration and drying, smoking or freezing; development of innovative products such as fish powders or fish-based products; and changing packaging and

labelling. Value addition can involve certification by food safety and standards bodies.

Topic 7: Fish marketing and supply chains

This sub-module provides trainers with skills that will enable them to assist aquaculture farmers to engage with markets using participatory methods. It guides on how fish and fish products can effectively be marketed market; formulate costing and pricing charts; prepare marketing tools; project supply and demand curve in the market; advertise and promote fish and fish products; maximize profit margin from fish sales and market fish in groups or clusters. It will also guide the process of market identification and selection of attractive enterprise options, based on information gathered from the market chain and analysis of local supply and demand trends and market access options.

Currently, Africa is a net importer of fish and fish products that supplies the rising populations, many of which are becoming increasingly urbanized. Improved logistics and Aquaculture Studies, market distribution systems, coupled with expanding aquaculture production and technological innovations and globalization, have enabled increasing regional fish trade. In addition, improved control in the harvesting process in capture fisheries and throughout the production process in aquaculture has enabled producers to understand the needs of consumers to further innovate the market and supply chains.

In Kenya, Lake Victoria is the largest fishery, contributing to over 82.5% of the total annual national fish production. However, unsustainable anthropogenic activities have led to the reduction of the natural fish stocks and catches. Demand for fish continues to rise owing to the rapidly growing population, increase in real incomes and ongoing changes in dietary trends. Given these circumstances, aquaculture is the most suitable alternative, complimenting capture fisheries to gradually satisfy the growing consumer demand which is expected to increase substantially in the future.

For markets and value chains, there is need for investigation of better market linkages; the formation of fish farming, processing and marketing clusters; local and foreign investment capital (Figure 3.2).

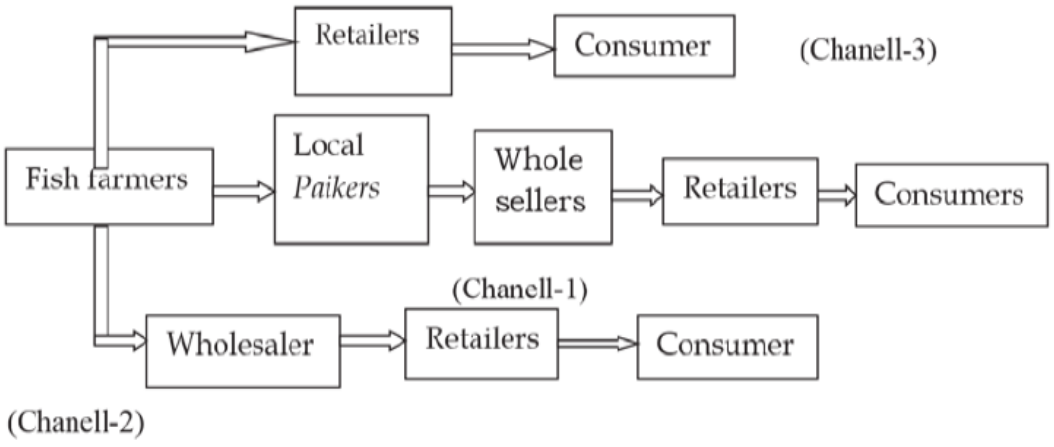


Figure 3.2. Fish Marketing and Supply Chains (Source: researchgate.net)

Topic 8: Aquaculture as a business

There are several types of fishing farming businesses. You can grow fish to be eaten as, to be stocked for anglers, or to supply aquariums. Fish farming doesn't always require a large body of water. For many species, fish farms can be located indoors or outdoors. Getting started raising farmed fish does require a significant financial outlay. Good profits, depend on the type of fish farming done and the fish species. There are two basic requirements for successful aquaculture development:

- A market adapted to the local conditions and
- A suitable fish production system adapted to the local conditions.

In Kenya, the market potential for fish is high. This is mainly the result of Kenya's fast-growing population, but also because of the active promotion of fish consumption by the Kenyan government. In any economic activity regarding aquaculture as a business, new approaches focus on the understanding of aquaculture as a business. This understanding represents a significant shift in technical requirements. Whereas early aquaculture practices were focused on limiting factors that were biological and technical in nature (i.e., identifying species and disseminating the best technologies), it is now understood that the technology must be accompanied by effective capacity building in business and market planning. In this sub-module the following aspects need to be highlighted:

- Financial planning.
- Evaluation of the economic performance of aquaculture
- Cash flow analysis
- Budget analysis and financial statements
- Preparation of a business plan.
- Forms of business.
- Business management.