Title:	**Aquaculture and Fish Farming**
Sector	**Fisheries**
Sub-Sector	**Inland/Artisanal Fisheries**
Technology Characteristics	
Introduction	Aquaculture is the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants that may entail stocking, feeding and providing protection from predators. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish. Mariculture refers to aquaculture practised in marine environments. Particular kinds of aquaculture include fish farming, shrimp farming, oyster farming, algaculture (such as seaweed farming), and the cultivation of ornamental fish. The farming of fish is the most common form of aquaculture. It involves raising fish commercially in tanks, ponds or ocean enclosures, usually for food. Fish species raised by fish farms include salmon, tilapia and catfish.
Technology characteristics/Highlights	The freshwater aquaculture systems used include pond aquaculture, rice-fish culture (either rice and fish together or rice followed by fish) on seasonal farmland, cage culture in rivers and lakes, pen culture in closed and open water bodies, and fish culture in such commonly held perennial water bodies as oxbow lakes.Aquaculture systems generally use free water sources, but some receive commercial irrigation or hire irrigation equipment. **Pond fish culture** is practiced in a closed water body and is a low-input activity for household consumption.Pond can be formed out of backyard areas excavated initially to acquire soil for construction.

	Ponds can also be constructed and connectedto other water bodies during the rainy season, receiving runoff and becoming home to indigenous fish, which people catch during and after the rainy season. Fish farmers adopt a variety of culture systems to suit the diversity of ponds. **Rice-fish culture** is common in open water bodies, and carp poly-culture and tilapia mixed culture are common. Rice-fish culture follows two patterns: • Pond or ditch beside rice land, operated in small scale and by small farmers, is usually dominated by such exotic fish as tilapia and catfish, with lesser numbers of carp. The major difficulties of this culture system are poor water quality and vulnerability to seasonal flooding, which allows fish to swim away, leaving farmers with serious economic losses[5]. • Fish culture in seasonally flooded rice land involves (a) the concurrent culture of deepwater rice with stocked fish during the flood season and dry-season rice in shallow flooded areas; and (b) the alternating culture, with dry season rice followed by stocked fish in a closedarea during the flood season. **Fish culture in communally held water bodies** is fish culture in water bodies that include rivers, oxbow lakes, canals and perennial lowland water bodies. Aquaculture operators in these types of water bodies are often fisher cooperatives, community groups and farmer groups. **Cage culture** involves the use of net boxes in open water bodies and other perennial water bodies, especially in freshwater rivers. **Pen culture** involves the use of pens made of bamboo and netting of polyethylene, nylon or plastic and usually placed in such semi-closed water bodies as irrigation and drainage canals but sometimes in large, open water bodies. Traditionally, fish feed mainly on naturally occurring plankton, though farmers sometimes apply low-protein natural materials as supplemental feed. Carp and tilapia are suitable for this type of aquaculture. **Hatchery culture** in freshwater environments chooses carp and catfish. In coastal saline environments most hatcheries choose shrimp. **Nursery culture** produces carp for freshwater aquaculture. The use of artificial illumination can increase growth rates and therefore reduce the length of the production cycle, as fish can achieve the 3kg market minimum weight six weeks earlier than in unlit cages[6].
Institutional and Organization requirements	The development of the aquaculture sector depends on the policy and institutional environment, which spans a wide range of laws, regulations, administrative directives, institutions, services, infrastructure support and incentives. Aquaculture development, in The Gambia is guided by principles laid out in the Fisheries Policy, the Fisheries Strategic Development Framework and the Program for Accelerated Growth and Employment (PAGE). Other relevant policies are National Water Policy, Agriculture and Natural Resources Policy and the Wildlife and Biodiversity Policy.
Operation and maintenance	In addition to fixed capital costs, there are variable costs for operations and maintenance of aquaculture systems. The variable costs include farm maintenance, feed, seed, fuel/energy, farm management (salary and wages), certification charges, pond preparation charges, inputs (lime, organic fertilizers) and harvesting expenses. The farm maintenance costs are as follows: • US$770 for Modified Traditional Organic Shrimp Farm of about 20ha; • US$14,610 for Semi-intensive Organic Shrimp Farm of about 20ha; and • US$3,000 for Extensive Freshwater Prawn and Freshwater Fish farm of about 20ha each.
Endorsement by experts	Aquaculture Unit exists under the Department of Fisheries and is staff with some experts. These experts have endorsed aquaculture as a viable climate change adaptation technology. The extension agents and the fisher folks engaged in aquaculture also endorse the technology.
Adequacy for current climate	Aquaculture has been practiced in The Gambia for more than 15 years though at a small scale. The current climate is adequate for the technology and the projected climate change will also be adequate for the technology.
Scale/size of beneficiary group	The Republic of The Gambia consists of both banks of the River Gambia. The country is the valley of the River Gambia and this is therefore a relatively low elevation country. The River Gambia is tidal, flows in both directions and has both freshwater and saltwater zones. Aquaculture can be practiced on both banks of the River Gambia
Disadvantages	Installation of aquaculture farms and infrastructure can cause environmental damage, conflict over resource usage, creation of a resource sink, disruption of social structure, loss of traditional occupations, and reduction in fish price due to increase in supply.
Capital Costs	
Cost to implement adaptation technology	• The fixed cost of a Modified Traditional Organic Shrimp Farm of about 20ha is estimated as US$30,700; • The fixed cost of semi-intensive culture method on a 20ha farm is estimated at US$338,800; and • The fixed cost of Freshwater Prawn and Freshwater Fish farm of about 20ha is estimated at US$14,500.
Development Impacts, direct and indirect benefits	
Direct benefits	
Reduction of vulnerability to climate change impacts	The development of aquaculture helps to increase fish supplies and protein, improve the supply of fishery products and enhances export earnings. Vulnerability to climate change induced food insecurity is reduced due to increased supply of fish food and protein. Increased income from sale and exports of fish products means that farmers and fisher folk can purchase food products other than fish. Better nourishment also translates to lower susceptibility to diseases and more hours to work.
Indirect benefits	

[5]Dey MM, Bose ML, Alam MF. 2008. Recommendation Domains for Pond Aquaculture. Country Case Study: Development and Status of Freshwater Aquaculture in Bangladesh. WorldFish Center Studies and Reviews No. 1872.The WorldFish Center, Penang, Malaysia.73 p.
[6] INFOFISH, 2011: Feasibility Study on Organic Aquaculture: Shrimp, Freshwater Prawn and Freshwater Finfish.

Economic benefits: employment, growth and investment	Aquaculture products fill a distinctive niche in the market, that of the high value, high quality seafood product (e.g. smoked salmon, fresh oysters). These products will complement, rather compete with, the supply from wild fisheries in the marketplace. Decrease in the price of some species and undoubtedly an increase in consumer surplus for them can be observed. The creation of new products is a possibility. The aquaculture industry has developed a good reputation for a well-graded uniform product with good opportunities for product differentiation based on a steady supply of quality raw material. The returns to aquaculture are higher than alternatives and these returns might increase over time as the international demand for products such as shrimp increases, and the fish farmers have become increasingly familiar with the activity and therefore are better able to take advantage of their engagement in it.
Social benefits: Income	Aquaculture production from isolated regions (away from population centres) ensures that consumers will receive a high-quality product with minimal health risks. The creation of employment opportunities in depressed rural areas is often cited as one of the most important reasons why local and national governments have been willing to encourage the development of aquaculture.Aquaculture can be a focus for rural development and stabilization, and a source of employment opportunities in depressed rural economies.
Environmental benefits:	In areas where aquaculture holds high promise of export earnings farmers have always taken to farming fish and other aquatic species in large scales and the people become more prosperous over time. They then become less dependent on the natural resources and environmental depleting activities such as illegal logging of forests. These will lead to avoidance of water quality degradation and associated biodiversity losses and the avoidance of the use of chemicals for disease management in farms. Other lost income associated with a decline in water quality, such as tourism and recreational fishing are also avoided.
Local context	
Opportunities and Barriers	Those businesses that are financially strong are more likely to survive in the face of adverse changes in the environment and by supporting the strongest businesses; social as well as economic objectives will be achieved. Barriers include (a) a continuing fall in market price, associated with oversupply problem may ultimately threaten the viability of the industry itself; (b) the adoptionof new technologies and mechanization may lead to a reduction in the size of the workforce; (c) communities that become heavily dependent on aquaculture and switched away from more traditional occupations, may be increasingly vulnerable to external financia1 strains and 'boom and bust economics; (d) aquaculture as a focus for rural development under the wrong circumstances is capable of producing as unsatisfactory an outcome as any other activity; (e) environmental restrictions and disease may constrain developments for some species; and (f) given the high risk associated with aquaculture activities, any inclusion of explicitly short-term social objectives (employment, business type, etc.) as a trade-off against viability and profitability leads to a danger that enterprises will be selected with a poor chance of long term survival.
Market potential	Procurement, replacement and maintenance of aquaculture equipment and infrastructure, feed, seed, fuel/energy, and inputs (lime, organic fertilizers) will encourage business and private sector entities to participate in the procurement and maintenance processes. The market potential is huge as expansion of the application of the technology in about three-quarters of the country is viable and will be exploited.
Status	Currently, aquaculture is applied in less than one-third of the country. There is potential to expand to technology to two-thirds of the country.
Timeframe	Expansion of aquaculture from the current area of less than one-third to two-thirds of the country will require about ten years of gradual implementation.
Acceptability to local stakeholders	Local stakeholders in Kombo East District of West Coast Region and the Fulladou Districts of the Central River Region have experience in implementing aquaculture and have embraced and accepted the technology.

Concrete grow-out tanks for shrimp (LEFT) and atypical small-scale tilapia grow-out system (RIGHT)