CHAPTER - 1
INTRODUCTION

Indian fisheries sector, considered as a "sunrise industry" having high potentials for rural development, employment generation, domestic nutritional security, gender mainstreaming as well as export earning, that only a few other activities can provide (Ayyappan *et al.*, 1990). The sector has come a long way since independence and has contributed immensely to the food basket of the country with annual production touching 9.58 million tonnes (Goswami and Zade, 2015). The fisheries sector in the country poised to play a major role for common people of the country in the coming decade in the context of increasing population pressure (Jhingran, 1988). The state Arunachal Pradesh is blessed with immense aquatic resources in the form of 2,000 km of rivers, 2,500 ha of wetland and lakes, 1,250 ha of pond and mini barrages and 2,925 ha of rice field accessible for paddy cum fish culture (Nath, 2015). The state is also a home for 213 species of fish fauna, including high altitude coldwater fish species. However, in spite of having vast aquatic resources and fish diversity, the state is yet to catch up with rest of the country in developing its water resources for fisheries. Although, fish production from the state has increased from 2.65 lakhs tonnes during 2003-04 to 2.75 lakhs tonnes during 2013-14, still remains a huge gap between the production and demand, necessitating import of fish from other states of the country like Andhra Pradesh, Assam, Bihar and West Bengal. The per capita availability of fish in the state is low (2.16 kg/yr) against the national requirement of 11 kg/yr. Since fish is a major source of protein for the increasing world population, especially in the developing countries like Africa, Asia and South America (FAO, 2006; Gabriel *et al.*, 2007) and the major solution to the shortage of dietary protein in these countries is to increase fish production (Nnaji *et al.*, 2009). Fish production increase from capture and culture (aquaculture) fisheries operations. It has been already reported by FAO (2006, 2008 and 2010), that the capture fisheries production decreased from year 2000 to 2008 (95.6-89.7 million metric tons) while the aquaculture production increased from 35.5 million metric tons in 2000 to 52.5 million metric tons in 2008.

In India, fish and fisheries activities contribute immensely to the national economy by providing high animal food protein and generating employment, which is a means of poverty alleviation (Jhingran, 1991). The need for fish protein has been emphasized with the projected population of 120 crores and a population growth rate of 2.1% per year. It is well known that feeding of formulating feed to fish has become extravagant for the average Indian farmer. Therefore, there is a need for sustainable aquaculture feed development. Such package must, include integrated fish farming with other agricultural production as livestock.

Integration of fish with livestock has been found to make aquaculture and animal husbandry, a sustainable venture for the common man and his immediate family need. Such integration involves the recycling of livestock wastes and processing by-products as manure and/or direct food for fish. However, aquaculture production in some areas is hampered by the lack of fish farming technology, dearth of good quality fish seed, high cost of aquaculture operations, etc. The need for a low-cost system of fish production that will meet the food needs of the rural and urban poor and at the same time maximize the utilization of available resources. This need is fulfilled by integrating fish farming with other types of human activity (mainly agricultural activities). Such combination ensures that waste products from one activity become an input into the fish farming activity and this leads to reduction of production costs.

Scientific fish culture is cost intensive and as such often beyond the reach of poor marginal farmers. Further, development of fish culture in foothill areas is beset with problems of unavailability of certain essential inputs like low cost good quality fish feed, manure etc. (Singh *et al.*, 2013). In view of the above, emphasis should be paid to popularize integrated fish farming technology with low external input and no adverse impact on the environment. One such technology is the integrated livestock-fish farming system in which livestock excreta and leftover feed are recycled in fish pond for production of fish without any extraneous supply of manure and fish feed.

Different forms of integrated livestock fish farming viz. Pig-fish, poultry-fish, duck-fish, three tier livestock-fish farming, etc. have been evolved and recommended (Sharma *et al.*, 1985). Integration of fish, crop and livestock in existing water resource increase water use efficiency by producing more output per unit of water used. Integrated farming system is the viable option in order to achieve food and nutritional security at household livelihood in hilly areas with low external input cost. The pattern of nutrient flow from one commodity to other and integrated livestock-fish farming system make it a perfect paradigm for sustainable 'cradle to cradle model', where no waste is wasted. Waste from one commodity is utilized as the source for food and energy for another. As such these systems become sustainable in the long run without any adverse impact on the environment (Jena *et al.*, 2001).

Integrated poultry-fish farming involves the combination of poultry farming with fish culture where the waste (manure and spilled feed) from the poultry sub-system becomes an input into the fisheries sub-system (Sinha, 1985). Nutrients from the poultry sub-system are recycled in the pond and this allows for intensification of production and income while reducing the bad impact on the environment (Costa-Pierce, 2002). Direct use of livestock production wastes is one of the most widespread and conventionally recognized type of integrated fish farming and the practice increases the efficiency of both poultry farming and fish culture through the profitable utilization of animal and feed waste products (Little and Edwards, 2003; Nnaji *et al.*, 2009).

Asia has a long history in integrated fish farming (IFF) dating back to more than 2400 years in China and is also well established in the other Asian countries as a source of plant and animal protein (Willman *et al.*, 1998; Prinsloo *et al.*, 1999). Asia is indeed the world's foremost continent in terms of IFF. Vast areas of land in China, India, Japan, Indonesia, Thailand, Vietnam, Philippines and Bangladesh are used for integrated fish farming (Jhingran, 1988). However, the NACA (2007) reported that while integrated fish farming is still widely practiced in many Asian countries, factors like availability of pelleted feeds and intensification of production has led to a slight decrease in the practice. In Africa, integrated fish farming has been reported in countries like Nigeria, Benin, Madagascar, South Africa, Egypt, Zambia, Cameroon and Malawi but the practice is still poorly developed and is mainly at subsistence level (Chaudhary *et al.*, 1975).

According to Gabriel *et al.* (2007) poultry-fish farming is the most popular form of integrated farming in Nigeria. The National Institute for Freshwater Fisheries Research (NIFFR) at New Bussa, Nigeria, carried out a National Aquaculture Diagnostic survey and observed that about 48% of fish farms practices integrated fish farming out of which half of them practiced chicken-fish farming, 38% practiced ruminant-cattle-fish farming, 12.4% pig-fish farming and 1.6% practiced rice-fish farming (NIFFR, 1995). The first experiment on integrated fish-cum-duck farming in Europe was conducted in 1934 but the outbreak of World War II halted the research (NACA, 1989). However, the shortage of animal protein after the war promoted the reactivation of integrated fish farming experiments in Hungary, Germany, Poland and Russia produced promising result (NACA, 1989; FAO, 2003).

Integrated Fish Farming (IFF) systems can be divided into four broad groups; viz. integrated plant-fish farming, integrated animal-fish farming, integrated animal-plant-fish farming, and integrated waste water-fish farming (Nnaji *et al.*, 2003). Poultry raised for meat and eggs by using different breeds of broiler and layers respectively, can be integrated with fish culture, in order to cut down the cost of pond fertilization and feed in fish culture to maximize the profit (Asala, 1994 and Singh *et al.*, 2013). The poultry house can be prepare over the pond or adjacent to it and excreta of the poultry can be re-cycled to fertilize the fish pond. The advantages of raising poultry over the fish culture ponds are to utilize maximally the pond space and direct feeding of poultry dropping into the pond. It saves labour in transporting manure to the pond. Such type of practice will help farmers to generate more income from sales of eggs and meat (fish and poultry) within 13 months of time.

The poultry house can be constructed with affordable budget by rural farmers by using locally available bamboos as frames and floor while hay or thatched grass as roofing material, with a floor space of 1.55 sq. feet per bird for broilers or 3.0 sq. feet per bird for layers with a lattice/slate floor which permits excreta and spilled feed into the water but is not big enough to allow chicken's feet to get caught in between and injured (Bard *et al.*, 1976). Well-managed broilers can reach marketable size of 1.5 - 2.0 kg in 6-7 weeks duration and it is possible to raise 6 batches in a year, while the layer breeds raise for about 18-22 weeks lays 250-280 eggs per bird per year (Asala, 1994). Asian farmers, in the quest to achieve higher food production due to rapidly increasing population and nutrient limitation, integrated aquaculture into their agricultural farming systems (Little and Muir, 1987).

Manure is regarded as a "complete fertilizer" with the characteristics of both organic and inorganic fertilizers and can be used without the addition of other chemicals (FAO, 2003). According to Francis *et al.* (2004) integrated poultry-fish farming leads to better utilization of land and water resources, effective recycling of wastes, improved agricultural waste resource utilization efficiency, reduction in operational expenses usually incurred through the use of feeds and fertilizers in fish ponds and more income for small land holding farmers which translates to higher living standards. This is due to the fact that about 72-79% of nitrogen (N), 61-87% of phosphorus (P) and 82-92% of potassium (K) in feed given to animals are recovered in their excreta ultimately saving the cost of feed and fertilizer of the farmer.

Aquacultures have recycled animal waste as fertilizer for centuries, with the aim of boosting pond productivity of plants and animals and have many qualities which make them valuable (Velasquez, 1980; Nash *et al.*, 1980). Poultry manure when added into a pond undergoes microbial decomposition releasing primary nutrients (N, P and K) for growth of microscopic green plants (algae or phytoplankton) which is the base of the trophic level (food chain) in aquatic systems (Aquaculture South Africa, 1999; Boyd, 1982). Nitrogen and phosphorus are the nutrients most likely to be limited for plankton growth in the pond, but, fish yield is probably more directly correlated to manure nitrogen content since nitrogen is more volatile than phosphorus. The droppings of the poultry, which serve as fertilizers, act directly on the pond bottom mud and the nutrients are released into the water for use by the phytoplankton and zooplankton. Lot of work has been done on the animal-manure (particularly farmyard, cow dung, poultry dropping, pig dung, biogas slurry etc.) utilization, for substituting the costly feed and fertilizers in fish culture ponds (Schroeder, 1980 and Dhawan and Toor, 1989).

Gabriel *et al.* (2007) mentioned that the integrated fish cum poultry farming is widely practiced because of its profitability. The excreta from the birds serve as manure, which fertilizes the pond as well as fish can feed directly. Fresh poultry manure contains about 77-80% water, but its dried form contains 5% N, 3.9% P and 2.4% K (Kroodsma, 1986).

Yejin *et al.* (1987) found that application of fresh manures in the pond lead to faster growth of fish than the application of fermented or stored manures in the pond, as the fishes feed directly on the manure detritus and products of nutrient release into the system. Mariakulandai and Manickam (1975) reported that the chemical composition of poultry manure varies because of factors like sources of manure, feed given to the animals, age of animals, condition of animals, manner of storage/handling and litter used. A nutrient value (physical, chemical and biological quality) of animal manures usually deteriorates during storage. It is estimated that 80-90% nitrogen of animal manures is loss under some climatic condition. According to Huet (1975), the mechanism of manure cycling in fresh water is such that under the right condition, efficient nutrient linkage can be achieved. Hopkins and Cruz (1982) also observed that poultry-fish systems can yield returns more than 90%. Likewise the cost of production of poultry, especially feed cost looks prohibitive. According to Adebowale and Olubamiwa (2008), the cost of formulating fish feed is usually about 70% of the production cost and used of animal manure considerably reduces operational costs and makes it possible for low income fish farmers to engage profitably in such enterprise.

Livestock wastes, including animal manure and poultry by-products, which are a menace to the environment, are sources of wealth creation in fish farming. In India, million tons of manure is produced annually from the well established livestock industries that are expanding very rapidly. India is one of the largest importers of frozen fish in the world, with a fish demand of between 9.2-12.3 million metric tons per year (2013–2014). This situation calls for increased of fish production, which can be achieved through the effective utilization of livestock wastes. Properly treated animal manure can be serving as an organic fertilizer/feed component. Consequently, there is enhanced fish farming profitability, efficient resource utilization and conservation of environment due to waste management. This large turnout of wastes from poultry, piggery, cattle rearing, etc. encourages the growth of microbes, attracts houseflies, constitutes a health hazard to man, animals and thus become a menace to the environment. Litter materials often need to be provided beneath the cage to reduce drudgery of daily cleaning. The droppings readily produce maggots when not cleaned or mixed with litter.

Integration with fish farming turns livestock wastes as assets in production due to a rich source of nutrients. The digestive tract of poultry is very short, only six times its body length. Therefore, some of the eaten foodstuffs are excreted by the poultry before being fully digested. Research has shown that about 80% (dry weight) of foodstuff is utilized and digested by the poultry thus making 20% available to the fish in an integrated fish cum poultry culture system. Furthermore, while picking the feedstuffs, the chicken scatters 10% of their food and these, drop directly for fish consumption. Usually, good chicken foodstuff has a protein content of over 18% and the total protein content of the dry chicken excreta is 10-30%, energy between 1100–1400 Kcal/kg manure and soluble vitamins are synthesized in high concentration (Tuleun, 1992).

The gap between the demand and supply of inorganic fertilizers is increasing day-by-day due to intensive cropping of the high yielding varieties of cereals. Biodegrading livestock wastes can be used as manure in pond fertilization. Fish ponds are frequently located in a manner that wastes from chickens, raised in suspended battery cages, drop directly into the pond. For cattle, pig, sheep or goat, it may be more practical to transport the manure from cattle farms to the fish ponds. Nitrogenous wastes from these farms efficiently influence the pond water productivity as it supplies the essential nutrients needed for multiplication and growth of plankton. The wastes also serve as a direct feed to fish in ponds. Livestock manure contains considerable quantities of nutrients for fish production. Fish cum poultry is the most common type of integration being practiced in rural areas by resource poor farmers. It is widely practiced because of its profitability. It reduces the cost of inputs, such as fertilizers and feed, so as to maximize profit (Gabriel *et al.*, 2007).

Arunachal Pradesh is a state in the north-eastern part of India and dominated by tribal population. The demand for meat and meat product is very high in the state. Due to this reason, backyard broiler farming is prevalent in many households and most of them are practicing deep litter system. A more recent method of broiler production is so called the integrated poultry-fish rearing system. This system is advocated because of its advantages of optimizing the use of available resources gain from the farmer's investment. However, till date, no precise work has been done in the context of poultry cum fish farming in foothill areas of Arunachal Pradesh state. So, a noted technological gap is observed in this particular state. The poultry cum fish is the most common type of integration being practiced in rural areas by resource poor deprived farmers in many parts of the country. But the state has no such type of location specific technology for farming because each area has its unique feature of climatic condition, soil type and water. So, there is an urgent need for developing a suitable location specific integrated farming system and popularizing it for uplifting the rural people's economy in the state.

Considering the above facts, the present study was intended to develop a location specific technology with the following broad objectives:

1. To assess the physico-chemical and biological characteristics of the pond water under poultry, fish integration in different locations of Papumpare district.

2. To evaluate the nutrient load and primary productivity of the pond under the integrated system.

3. To determine the species-specific growth performance of fishes culture in integrated poultry fish farming system (IPFFS).

4. To establish an interrelationship amongst various water parameters and fish pond.

5. To refine integrated poultry-fish farming for better productivity in the foothill region of Arunachal Pradesh.