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Review Article

Review on Integrated Livestock Farming System for Sustainable Future

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Abstract

She term 'integration' is received from Latin «integrare» which meant to making complete through accumulation of portions, or to association shares into entire. The livestock farms can operate autonomously in definite farming systems and their yields merely added. The major goal of integrated Farming System is to cultivate conventional resource improvement and utilization performances that lead to considerable and continuous growth in agrarian manufacture. The major social and economic advantage of combined agricultural is that ingredients to the several different systems that encompasses subsystems leads to intra-farm through the reduction of dependence on single farm inputs. IFS reduce problems related to farming due to amplified variation of yield. combining different subsystems witin fishery if wisely selected, scheduled and implemented, can provide more profite particularly for small and marginal farmers. Each subsystem could stand alone but it has to be supported by any livestock component with biodigester for the use of manure as fertilizers. 'Sustainable agriculture' as a management system for renewable natural resources that provides food, income and livelihood for present and future economic productivity and ecosystem services of these resources.

Keywords: Farm, Future, Integration, livestock, sustainable, system.

1. Introduction

Agriculture is a backbone economic livelihood of the society [1]. Zinash and Alemu stated that agriculture employs 80-85% of the population. Livestock sector holds forty percent of agricultural product and it plays significant role to national economy as it contributes 13-16 percent of the total Gross Domestic Product. Livestock is corner stone of the country's economy both at household and national levels, and in the past provided significant export earnings. Livestock contribute 15 to17 percent of GDP and 35 to 49 percent of agricultural GDP and 37 to 87 percent of the household incomes [2]. In the present scenario, it is hardly difficult to meet out the ever-increasing requirement for the ever-rising population in Ethiopia. Regrettably food producing enterprises like agriculture and its allied activities namely livestock farming, horticulture, floriculture and aquaculture they have conquered by the small and marginal farmers in developing nations [3]. Hence, they are unable to invest more capital for doing intensive farming activities to produce more and meet the requirement. In this situation, Integrated Farming System (IFS) plays an imperial role to maximize their profit and production to hit the nutritional necessity with food security with less investment [4].In Integrated farming system it is more advantageous that the farmers are able to produce more by using optimum resource operation and reusing of waste materials and labor engagement [3].

Consumers have worries about sustainability but many widely used livestock production methods do not satisfy consumers' need for a maintainable scheme. Nevertheless, production can be sustained in environments that provide the needs of animals resulting in good welfare, allow coexistence with a wide diversity of organisms native to the area, minimize carbon foot print and provide a fair lifestyle for the people working there. Essential Preservation need not just comprise tiny islands of natural vegetation in a barren world of agriculture, as there can be great increases in biodiversity in farmed areas. Herbivores, especially ruminants that consume materials inedible by humans, are important for human food in the future. However, their diet should not be just ground level plants. Silvopastoral systems, pastures with shrubs and trees as well as herbage are described more productive than pasture alone. When compared with widely used livestock production systems, Silvopastoral systems can provide efficient feed conversion, higher biodiversity, enhanced connectivity between habitat patches and better animal welfare, so they can replace existing systems in many parts of the world and should be further developed [5].

The livestock revolution is stretching the potential of current production, but it is also provoking environmental problems. Therefore, while it is essential to satisfy consumer demand, improve nutrition and direct income growth opportunities to those who need them most, it is also necessary to lessen environmental stress. An integrated farming system consists of a range of resource exchangeable practices that target to reach tolerable profits and tolerate production planes.

Objectives

- The main objective of this paper was to impress the integration of livestock farming system for sustainable future

1.1. Concept of Integrated Farming System (IFS)

The basic aim of IFS is to derive a set of resource development and utilization practices, which lead to substantial and sustained increase in agricultural production. The emergence of Integrated Farming Systems (IFS) has initiated to develop a framework for an alternative development model to improve the feasibility of small sized farming operations in relation to larger ones. Integrated farming system (or integrated agriculture) is a commonly and broadly used word to explain a more integrated approach to farming as compared to monoculture approaches. It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock and may sometimes be known as Integrated Bio systems. In this system, an inter-related set of enterprises used so that the "waste" from one component becomes an input for another part of the system, which reduces cost and improves production and/or income.

IFS ensure that wastes from one form of agriculture become a resource for another form. Since it utilizes wastes as resources, we not only eliminate wastes, but we also ensure overall increase in productivity for the whole agricultural systems. For example, the prices of inputs and outputs commonly change, together with reliance on external resources, farm size, farm ownership and the method of farming, often as a cause and result of increasing population pressures [6]. Such changes in yield, prices and farming methods, within and between countries, constitute temporal and spatial evolution of farming systems. Also, they are triumphs (of sorts) for the mainly reductionist philosophies behind research, which focused on single commodities such as milk and grain [7]. Due to low agricultural productivity, the small and marginal farmers as well landless families living in the rural areas are unable to generate remunerative employment and they are forced to live in poverty. With lack of food and income security, trans-migration wherein the poor families are compelled to migrate to cities in distress, keeping their agricultural lands fallow, may become a major national challenge. IFS offer the potential scope to solve the technology development problems. Research organizations in many countries are shifting towards farming system approach with heavy emphasis on participatory on-farm research [7]. It is also a fact that highly productive lands have been diverted from agriculture to infrastructural development, urbanization and other related activities. Under these circumstances the only option is to increase the productivity vertically. In view of these situations, Integrated Farming System is the only way through which the target could be achieved.

1.2. Definition and goals of Integrated Farming

The word integrated is derived from the Latin verb "integrare" which means to make whole, to complete by addition of parts, or to combine parts into a whole. The livestock and fish subsystems may function independently in certain farming systems, and their products can only be additive. However, an output from one subsystem in an integrated farming system which otherwise may have been wasted becomes an input to another subsystem resulting in a greater efficiency of output of desired products from the land/water area under a farmer's control. There is synergism in integrated farming since the working together of the subsystems has a greater total effect than the sum of their individual effects. The main biological feature of an integrated farming system is byproduct recycling; but improved space utilization, in which two subsystems occupy part or all of the space required for one subsystem, may be an important aspect of increased productivity [6]. A major socioeconomic benefit of integrated farming is that inputs to the various subsystems that comprise the farming system tend to be intra-farm, with a diminished reliance on inter-farm or agro-industrial inputs. Integrated farming systems also decrease the risks associated with farming because of the increased diversity of produce. They also lead to a more balanced diet for the farming family that chooses to eat some of its own produce.

The three major categories of farming - settled agriculture, shifting cultivation and pastoral nomadism - are adopted from an example of a classification of world farming systems by Spedding. However, settled agriculture is divided here into three phases crop dominated, integrated crop-livestock and industrial monoculture - to emphasize the role that integrated farming systems can play in bringing aquaculture to resource-poor, small-scale farmers with limited access to often costly off-farm inputs. The rationale for the three phases of settled agriculture is derived largely from studies of the agricultural farming systems of the world and their evolution by Hunting and gathering preceded the development of agriculture but are still of importance in many third-world countries, particularly with regard to fish [8]. Indeed, the capture of wild fish, as opposed to aquaculture, is still the major source of fish in most third-world countries. The mountainous areas in most parts of the world are confined mainly to shifting cultivation system because there is little potential for integration with aquaculture because of the restricted area suitable for pond construction in mountain terrain and because of the migrations of the society.

Compared to specialized farming system; Integrated farming system (IFS) a component of farming system research (FSR), introduces a change in farming techniques for maximum production and take care of optimal utilization of resources. The farm base is better recycling for productive purposes in the integrated farming system. Unlike specialized farming system (SFS) integrated farming systems activity is focused round a few selected, inter-dependent, inter-related and often inter-linking production systems based on few crops, animals and related subsidiary profession [9]. Integrated farming system involves the utilization of primary produce and secondary produce of one system as basic input of other system, thus making the mutually integrated as one whole unit. There is a need to effective linkages and complementarities of various components to develop holistic farming system.

1.3. Goals of integrated farming system

The primary goals of integrated farming system is to maxi-

mize the yield of all component enterprises to provide steady and stable income at higher level, rejuvenation of systems productivity and achieve agro-ecological equilibrium, Biosecurity stress management through natural cropping systems management and reducing the use of fertilizers and other armful agro-chemicals to provide pollution free, healthy produce and environment to the society [10]. Thus, integrated livestock farming system as a concept takes into account of components of soil, water, livestock, labor and other resources with farm family at the center managing agriculture related activity.

1.4. Meritis Of Integrated Farming System

Main Advantages Of Integrated Systems: In all parts of the world, farmers work hard but do not make money, especially small farmers because there is very little left after they pay for all inputs (seeds, livestock breeds, fertilizers, pesticides, energy, feed and labour). The emergence of Integrated Farming Systems (IFS) has enabled the world nation to develop a framework for an alternative development model to improve the feasibility of small sized farming operations in relation to larger ones. Integrated farming system (or integrated agriculture) is a commonly and broadly used word to explain a more integrated approach to farming as compared to monoculture approaches [11]. It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock and may sometimes be known as Integrated Biosystems. In this system an inter-related set of enterprises used so that the "waste" from one component becomes an input for another part of the system, which reduces cost and improves production and/or income and ensure that wastes from one form of agriculture become a resource for another form. Since it utilizes wastes as resources, we not only eliminate wastes but we also ensure overall increase in productivity for the whole agricultural systems [11]. We avoid the environmental impacts caused by wastes from intensive activities such as pig farming. Here the following lists are the merits of integrated farming systm.

- Can be applied to small holders, medium and large farms;Increased animal well-being due to improved thermal comfort; Possibility of using the most suitable species and cultivars for each region and Possibility of reducing pressure for clearing natural vegetation areas; Global warming mitigation through carbon sequestration especially by forest and forage components; Intensification of nutrient cycling; Creation of attractive landscapes that may favor rural tourism activities and Increased regional production of grains, beef, milk, fibers, timber and energy.

Main Challenges Of Integrated Systems: Farmers traditionalism and resistance to adopt new technologies; Higher qualification and commitment demand from farmers, managers, technicians and worker; Higher financial investment and High investments on infrastructure because of the integrated systems multiple components. Increased complexity of the system adds risks, for example, in the management and disposal of the waste generated in the farm, including agrochemical packaging and waste water following legislation [12].

1.5. Scope of farming system

Farming enterprises include livestock(cattle, swine,equine, poultry, fish) and forage production. A combination of one or more enterprises withaquaculture, when carefully chosen, planned and executed, gives greater dividends than a single enterprise, especially for small and marginal farmers. Farm as a unit is to be considered and planned for effective integration of the enterprises to be combined with animal production activity. Integration of farm enterprises to be combined on many factors such as [12]:

1. Soil and climatic features of the selected area. 2. Availability of resources, land, labour and capital. 3. Present level of utilization of resources. 4. Economics of proposed integrated farming system. 5. Managerial skill of the farmer

1.6. Components of integrated animal farming system

The components of IFS include fish farming, poultry, pigs, cattle, sheep and goat, and fodder production. These are on small- scale and are highly productive. These are diversified and integrated and the role of animals in these systems is synergistic rather than as primary producers. Emphasis is on "small" livestock. External inputs can be minimized through waste recycling, and growing of nitrogen-fixing and pest-resistant legume and grasses in the farming system [10].

Apiary Dairy Fish farming
Poultry Goat rearing Duck rearing
sheep rearing Piggery Fodder production

The practitioner can use IAFS to:

- Improve productivity - Regulate nutrient and material flows
- Increase on-farm biodiversity - Present level of utilization of resources.
- Economics of proposed integrated farming system. - Managerial skill of the farmer
- Improve productivity,Regulate nutrient and material flows

The selection of livestock is also dependent on preference based on family consumption, potential market, and availability of resources. Livestock: Pigs, cattle, poultry, small ruminant. Each subsystem could stand alone but it has to be supported by any livestock component with biodigester for the use of manure as fertilizers [13].

1.7. Integration of fish-livestock farming

Status of aquaculture sector: Aquaculture is the fastest growing food production sector in the World with annual growth in excess of 10 percent over the last two decades. Much of this development has occurred in Asia, which also has the greatest variety of cultured species and systems. Asia is also perceived as the 'home' of aquaculture, as aquaculture has a long history in several areas of the region and knowledge of traditional systems is most widespread. Furthermore, the integration of livestock and fish production is best established.

The various types of aquaculture form a critical component within agricultural and farming systems development that can contribute to the alleviation of food insecurity, malnutrition and poverty through the provision of food of high nutri-

tional value, income and employment generation, decreased risk of production, improved access to water, sustainable resource management and increased farm sustainability. Livestock production and processing generate by-products that may be important inputs for aquaculture. The main linkages between livestock and fish production involve the direct use of livestock wastes, as well as the recycling of manure-based nutrients which function as fertilizers to stimulate natural food webs [14].

1.8. Potential links between livestock and fish production

The main potential linkages between livestock and fish production concern use of nutrients, particularly reuse of livestock manures for fish production. The term nutrients mainly refer to elements such as nitrogen (N) and phosphorous (P) which function as fertilizers to stimulate natural food webs rather than conventional livestock nutrition usage such as feed ingredients, although solid slaughterhouse wastes fed to carnivorous fish fall into the latter category. There are also implications for use of other resources such as capital, labor, space and water. Both production and processing of livestock generate by-products that can be used for aquaculture. Direct use of livestock production wastes is the most widespread and conventionally recognized type of integrated farming. Production wastes include manure, urine and spilled feed; may use as fresh inputs or be processed in some way before use [14].

Integrated livestock-fish culture approach envisages the integration of fish farming with cattle, sheep, goats, poultry, pigs or rabbit husbandry in a design allowing wastes from one system as inputs in another system. The aim is to conserve resources while increasing farm returns. Challenges facing integrated livestock-fish aquaculture include government neglect of aquaculture sector, weak aquaculture research and applications. Poor publicity, poor infrastructure, lack of clear legislations and policies and high illiteracy among potential fish farmers have also been mentioned as bottlenecks to the growth of integrated fish farming. So far, fish-poultry integration is the most popular across Africa and Asia while fish-cattle integration is unpopular in many countries. Livestock manure as source of organic fertilizer for fish ponds and biogas production can help reduce cost of investment in purchasing inorganic fertilizers. With the present high cost of pelleted fish feeds, integrated fish farming stands to reduce the cost of feeding fish while simultaneously increasing the yield, leading to high economic returns. Livestock-fish integration is one of the most practicable solutions to food insecurity and malnutrition in African community despite its current poor status. In fact, it could be the forgotten asset that can guarantee present and future aquaculture sustainability. It is advisable to build capacity among stakeholders to recognize integrated aquaculture as a 'self-feeding' biotechnology unit, which deserves special attention [15].

1.9. Relevance of livestock integrated farming

The integration of fish and livestock production is probably closer today, and more important than ever before. On a global basis most, cultured freshwater fish are produced in semi-intensive systems that depend on fertilizer nutrients. Moreover, with increasing need for multipurpose use of water resources, community water bodies used for watering livestock are increasingly stocked with fish seed and their management intensified. Several studies of small-holder aquaculture in Bangladesh, India, Thailand and Viet Nam indicate that livestock wastes are the most commonly used input. Fish yields may not be optimized for a variety of reasons, but livestock wastes purposely used in ponds, or draining into them, support the production of most cultured fish. An analysis of China, the ancestral home of aquaculture, indicates that whilst intensive practices based on formulated pelleted feed are developing rapidly, much of the vast increase in China's recent inland aquaculture production is linked to organic fertilization, provided by the equally dramatic growth of poultry and pig production. Trends in those parts of Asia which are undergoing rapid industrialization and urbanization suggest that livestock-fish systems can retain a relative advantage over intensive aquaculture for production of low-cost carps and tilapias. A strong link to the use of livestock wastes remains even when high-quality supplementary feeds are available and widely used [14].

1.10. Integrated fish farming

Integrated fish farming systems utilize the organic waste of livestock, poultry and agriculture by products for fish production. The pond silt becomes rich in nutrient due to ongoing fish culture and this is utilized as fertilizer for fodder crops for raising livestock and poultry or as fish feed. In fish-cum sericulture system, pupae are used as fish feed, while worm faeces and wastewater from silk extraction processing plants are used as pond fertilizers [16]. Thus, a complete recycling of waste is achieved in these systems. The opportunities in this system are, considerably wide. Ducks and geese are raised in ponds. Pond dykes are used for horticulture and agricultural crops and animal rising. In addition to fish, the system provides meat, milk, eggs, fruits, vegetables, mushroom, fodder, grains etc. This system utilizes water body, water surface, land and pond silt to increase food production for human consumption. Thus this system holds great promise and potential for augmenting production, betterment of rural economy/household nutrition security and employment generation [17].

1.11. Fish-rice-poultry

This system involves fish farming, poultry keeping and rice production, or diverse combination of any of this is practicable. The system is based on the use of ponds which meet the needs of fish as well as enables rice to be grown in-situ or adjacent and compliments the rearing of poultry birds. The technical features of the integrated system are based on the complementarity of enterprises whereby nonmarketable crop residues, pond water and poultry manure for rice fields or maggots produced from manure are direct fish food. Demonstrable benefits in terms of significant income generation from the sale of fish, poultry and rice and some by-products like rice-bran are identified as perceived rationale for farmers' practice of the system. In the course of the year, enterprise products are sold within the farm or transported to nearby market-centers. variety of factors affect po-

tential linkages between livestock and fish production [14]. "Improving the productivity, profitability and sustainability of small-holder farming" Improve integration between system components at farm level [18]. However, the sustained practice of the system is largely dependent on the demand and market outlets, availability of supplementary feeds, availability of land for development and expansion, cost of pond construction and water supply, as well as the rising cost of feed and feed formulations [7]. Poultry production wastes have inherent qualities that make them particularly valuable for fish production compared to other livestock wastes. Commercial 'feedlot' production leads to concentration of nutrient-rich waste which can be handled and transported cost-effectively. The small individual size of poultry also allows their confinement and production directly over fish ponds. Poultry manure has been used widely in both fresh and brackish water aquaculture [16]. Poultry wastes, and byproducts can provide the feed support of aquaculture across a range of intensities. Poultry wastes may act mainly (1) indirectly or (2) directly to support fish production. Poultry manure can be used fresh, or after processing, to enhance natural food production in sun-lit tropical ponds. Although some nutrition may be derived directly from the waste, natural feed produced on the nutrients released from the wastes is more important. Fish feeding low in the food web - the carps and tilapias benefit most from this type of management since they can utilize plankton, benthic and detrital food organisms effectively [16].

1.12. Integration of Poultry-Fish-Duck Farming

Integrated poultry-fish farming has become popular in India for household nutritional security and women empowerment in the remote villages. Besides production of eggs and meat, poultry also provides fecal waste material, which could be used as manure or feed for aquaculture fish [19]. The integrated poultry-fish-duck farming provides employment human days and additional economic benefits per annum to a family. Additionally, the consumption of eggs and meat improves the livelihood, food and nutritional security of the families. Integrated poultry-fish system could address issues of sustainability, women empowerment and livelihood security effectively [19].

1.13. Duck-fish integration

This system utilizes the mutually beneficial biological relationship between fish and duck. Asia is considered to be the land of domesticated ducks, but the best breeds and strains currently available have been developed for their excellent egg and meat production in Europe and America, through systematic breeding, feeding, management and disease control. Ducks is of several types such as of the egg type, meat type and the ornamental type. Khaki Campbell, a prolific layer with an annual average production of 310 eggs, is recommended for duck-fish integration [19]. A fish pond being a semi closed biological system with several aquatic animals and plants which provide an excellent disease-free environment for ducks. In turn ducks consume juvenile frogs, tadpoles, dragonfly etc. Thus, makes a safe environment for fishes [19].

Figure 1: duck-fish integration source

1.14. Poultry-fish integration

Livestock production systems, and opportunities for reuse of wastes and byproducts, are changing. Vertical integration of the poultry industry by agribusiness has been stimulated by the biology and widespread acceptability of poultry, particularly chickens. Global trends in livestock production indicate that poultry, particularly layer and broiler chickens, are increasing faster than any other. The intensive nature of modern poultry production and processing tends to concentrate high quality byproducts, and this has stimulated their reuse. Poultry processing byproducts such as chicken bones, intestines and whole carcasses have greater value as 'direct' feeds and are normally used for higher value fish species raised more intensively. High fish standing stocks can be maintained and yields produced using this type of product and management. Processing wastes can be used fresh, or after further processing, as good quality supplementary, or complete, feeds [8].

Figure 2: Fish-poultry integration source: www.poultry-duck picture.com

Economically viable, simple and well-tested poultry-fish integration utilizes poultry droppings of fully built-up poultry litter recycled into fishponds with fish production. Broiler production provides immediate returns to the farmers. It is essential to study the market demand of the products which will be available for sale, before taking up the venture. Success of the system depends mainly on the efficiency of farmers, his experience, aptitude and ability in the management of the flock. This involves procurement of good livestock, housing, feeders' water trays and management practices, which also include prevention and control of diseases. The left-over animal feeds and excreta is utilized to enhance the

biological productivity of water. The poultry litter is applied to the pond in daily doses and is deferred on the days when algal bloom appears in the pond. One adult chicken produces about 25 kg of compost (poultry manure) in one year, 1000 birds would provide "sufficient litter for fertilization of 1 ha water body. The advantage raising chicken on pond is not only efficient utilization of resources but also: i) hygienic condition in chicken house constructed on pond is better as feces fall directly to the pond. ii) Housing does not compete for the extra land. iii) Chicken excreta proved food and fertilizer for fish culture.

1.15.Cattle-fish integration

Fish farming using cow manure is well established practice; it is most abundant one in terms of availability. A cow excretes dung and urine which provides enough time for the fish to consume the edible portion available in the dung. The fasces and urine are extremely beneficial for filter-feeding and omnivorous fishes such as silver and carp. A unit of 5-6 cows can provide sufficient input for 1 ha water body. Cow is built in the vicinity of the fish ponds to simplify the handling of the cow manure [19].

1.16.Goat-fish integration

Goat farming is an age-old practice but its integration with fish farming has not been explored. The solid excreta of goats are several times richer in nitrogen content and phosphoric acid than the excreta of other animals. Goat urine is equally rich in both nitrogen and potash. Goat droppings have the advantage of direct application into grow-out fish ponds as the size of droppings is of around 6-7 mm pellet, coated with mucus and floats in semi dried state. The droppings have been observed to be consumed by the fish. Goats can be kept under a house constructed on the elevated portion of the dyke for facilitating the waste disposal into the ponds [19].

Figure 3: Fish-goat integration. Source

1.17. Sustainability of Integrated Livestock Farming

Sustainability can be defined as "practice that meets the needs of the present without compromising the ability of future generations to meet their own needs". However, from the number of published books and articles in professional journals, there seem to be many contrasting views and opinions as to exactly what "sustainability" is, if and how it can be achieved or in some cases, whether it is an elusive dream of attaining the so-called 'heaven on earth'. The United States Department of Agriculture defined 'Sustainable agriculture' as a management system for renewable natural resources that provides food, income and livelihood for present and future economic productivity and ecosystem services of these resources. In understanding its complexity, one popular framework shows sustainability issues as being classified into three categories: social/political, environmental, and economic issues.

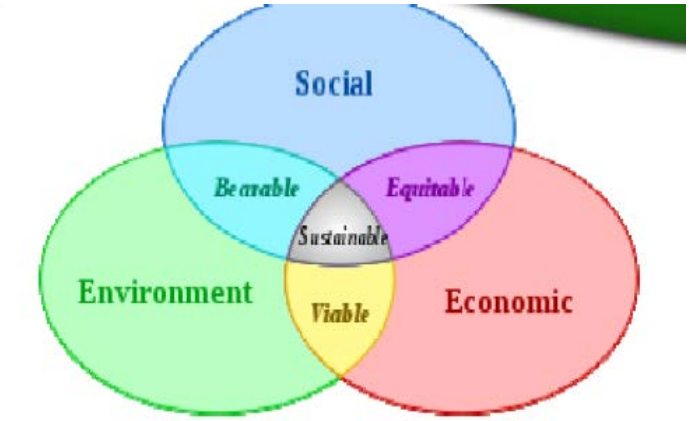

Figure 4: Sustainability
Source: (Mensah & Castro 2004)

According to the evidence from the three concerns were explained as the following [20].

Economic: An economically sustainable system must be able to produce goods and services on a continuing basis, to maintain manageable levels of government and external debt, and to avoid extreme sectorial imbalances which damage agricultural or industrial production.

Environmental: An environmentally sustainable system must maintain a stable resource base, avoiding over-exploitation of renewable resource systems or environmental sink functions, and depleting non-renewable resources only to the extent that investment is made in adequate substitutes. This includes maintenance of biodiversity, atmospheric stability, and other ecosystem functions not ordinarily classed as economic resources.

Social: A socially sustainable system must achieve distributional equity, adequate provision of social services including health and education, gender equity, and political accountability and participation.

Therefore, it implies that achieving sustainability involves finding solutions which balance the importance and impacts of each of the three categories. Profitable operation of a system and demand for its products are not sufficient reasons for considering it to be sustainable and to continue production [21]. Systems were initially called unsustainable when a resource became depleted so much that it became unavailable to the system, or when a product of the system accumulated to a degree that prevented the functioning of

the system. Now, the meaning of the term is much wider, for example a system can be unsustainable because of negative impacts on human health, animal welfare or the environment. A system or procedure is sustainable if it is acceptable now and if its effects will be acceptable in future, in particular in relation to resource availability, consequence functioning and morality of action.

A sustainable agriculture is ecologically sound, economically viable, socially just and humane. These four goals for sustainability can be applied to all aspects of any agricultural system, from production and marketing to processing and consumption. Sustainable agriculture involves farming systems that are environmentally sound, profitable, productive, and compatible with socioeconomic conditions [22].

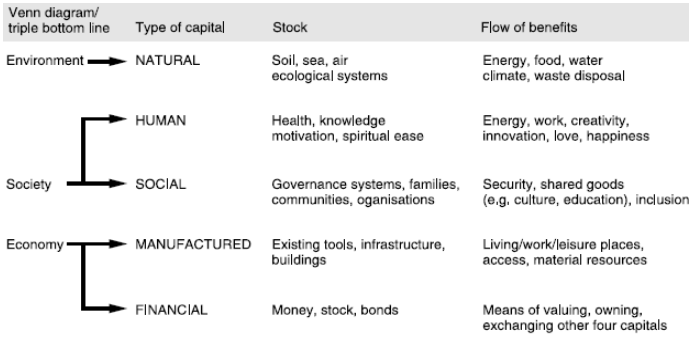

Figure 5:

1.18.Sustainability issues at micro- and macro-levels

According to WCED definition "Sustainable development is that which meets the need of the present without compromising the ability of future generation". Sustainability has become focal points of rural development. In a smallholder farmer's world, key parameters of sustainability have been identified as high levels of species diversity, nutrient cycling, capacity (total production) and economic efficiency. At the micro-level, watershed, community, farm, plot and pond may be used as a basis for assessing sustainability, but the role of people is central to development. Most poor rural people do not rely entirely on their own land to sustain them. Typical livelihoods are complex and depend on a variety of resources, many of which are off-farm. Holistic Sustainability may be considered at global, national, regional, community and household level and from a variety of perspectives. Sustainability as defined by an ecologist may be very different to that by an economist, but most can support the essence of that in the Brundtland Report which incorporates social and economic as well as environmental concerns. Important questions relate to the role of integration of aquaculture with livestock to improve sustainability of food production in socially and economically advantageous ways while safeguarding or improving the environment. For this to occur, the roles of culture and institutions both have to be considered also since they are major forces for change or conservatism. A major issue of this book is how integration, rather than specialization and separation, of livestock and fish production can enhance sustainability at all levels and perspectives.

1.19.Environmental effects

Environments have shaped cultures and dietary norms and taboos that in turn explain current distribution and dependence on livestock and fish. Recent anthropological research has shown that the concepts of the 'sacred' cow and 'abominable' pig have an environmental basis. The advantages of ruminants that digest cellulose and thus do not compete for food with humans, together with their more multipurpose attributes, are the bases for the cultural bias. The rejection of fish as food is also common among people in arid environments where surface water and natural stocks of aquatic animals are rare. The lack of large livestock in traditional slash and burn-based societies in Africa, and elsewhere, can be related to a low requirement for tillage, and their poor survival because of the tsetse fly. Animal protein needs could be met by the harvest of game and wild fish and intensification of livestock and fish production was unnecessary at the low human population densities found in typical Sweden agricultural societies. If natural supplies of wild stocks are particularly rich, much higher population densities may be supported provided human dietary energy needs are met. The rice-fish societies of lowland Asia are good examples of this situation where diets based on cultured, calorie-rich rice were balanced by diverse, aquatic plant and animal food gathered from the floodplains. Indeed, whilst natural fish supplies remain adequate, there is little interest in fish culture. Seasonal inundation of flood plains that led to dependence on aquatic-based food sources probably also limited the importance of livestock because of seasonal shortages of feed in contrast; arid environments have stimulated pastoral systems in which low densities of ruminant livestock are grazed on extensive, common property pastures. The challenges associated with increasing productivity in such marginal, community-based resources systems are similar in both water-short, livestock-based pastures and water-rich, communally exploited wetlands. Major issues include how intensification can occur whilst safeguarding equity and the environment.

1.20.Ecological basis of Sustainability

The ecosystem provides services such as clean water, climate regulation and nutrient recycling, which make it possible for us to thrive. These ecosystem services are also the basis for agricultural production, which needs to continually increase, in order to feed the expanding global population. However, agriculture as practiced today also has negative impacts on the ecosystems. In the longer term, these negative impacts will reduce the efficiency of the ecosystem services that are needed to sustain agricultural production. This creates a fundamental conflict, and many farmers are already experiencing reduced yields as a result of declining soil fertility, increasing temperatures and less rainfall. Resolving the conflict between increasing agricultural production and maintaining biodiversity and ecosystem services is an enormous challenge. A farm can also be a complex, interwoven mesh of soils, plants, animals, implements, people and other inputs, operating within a specific environmental and social context. On such farms, the farmer, with the intimate knowledge of local conditions, plants and animals, tries to enhance the natural ecological processes and to manage the whole farm to

provide a wide range of produce. Agro ecology sees a farm as a complex system in which natural ecological processes are always at work. These processes involve the breakdown of organic matter, nutrient cycling, interactions between pests and beneficial insects, competition between different plant and/ or animal communities, symbiosis between fungi or bacteria and plants and successional changes.

2. Conclusion

Integrated systems involving the available natural resources (animal, land and water) are potentially very important in the future. This is because they are characteristic of agriculture throughout the developing countries wherever integrated farming is practiced [23]. The potential importance of this system is associated with three principal considerations. Firstly, improvements to animals-crops-fish production systems through strategic interventions are directly associated with increased productivity from the preponderance of small farm systems Secondly; promoting increased attention to these systems is consistent with the search for efficiency in the integrated management and use of natural resources. Thirdly, integrated natural resource use and integrated production systems are possibly the only way to demonstrate sustainable agriculture, to address the different elements of sustainability to include nutrient recycling, food security, poverty alleviation and environmental integrity.

The main potential linkages between livestock and fish production concern use of nutrients, particularly reuse of livestock manures for fish production. The term nutrients mainly refers to elements such as nitrogen (N) and phosphorous (P) which function as fertilizers to stimulate natural food webs rather than conventional livestock nutrition usage such as feed ingredients, although solid slaughterhouse wastes fed to carnivorous fish fall into the latter category. There are also implications for use of other resources such as capital, labor, space and water. Both production and processing of livestock generate by-products that can be used for aquaculture. Direct use of livestock production wastes is the most widespread and conventionally recognized type of integrated farming. Production wastes include manure, urine and spilled feed; and they may be used as fresh inputs or be processed in some way before use [14].

In general, integrated livestock farming offers tremendous potential for food security and poverty alleviation in urban and peri-urban areas; it is an efficient way of using the same land resource to produce carbohydrate as well as animal protein and important micronutrients concurrently or serially. Optimization of available natural resources use, diversification of income generating activities and Aquatic Biodiversity conservation and sustainable use can be enhanced [24].

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