Integrated Crop-Livestock Farming Systems: A Strategy for Resource Conservation and Environmental Sustainability

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ABSTRACT

Conventional agriculture is known to cause soil and pasture degradation because it involves intensive tillage, in particular if practised in areas of marginal productivity. An integrated crop-livestock farming system represents a key solution for enhancing livestock production and safeguarding the environment through prudent and efficient resource use. The increasing pressure on land and the growing demand for livestock products makes it more and more important to ensure the effective use of feed resources, including crop residues. An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment. Based on the principle of enhancing natural biological processes above and below the ground, the integrated system is the combination that (a) reduces erosion; (b) increases crop yields, soil biological activity and nutrient recycling; (c) intensifies land use, improving profits; and (d) can therefore help reduce poverty and malnutrition and strengthen environmental sustainability. The waste products of one component serve as a resource for the other. For example, manure is used to enhance crop production; crop residues and by-products feed the animals, supplementing often inadequate feed supplies, thus contributing to improved animal nutrition and productivity. Integrating crops and livestock serves primarily to minimize risk and not to recycle resources. In an integrated system, crops and livestock interact to create a synergy, with recycling allowing the maximum use of available resources. Crop residues can be used for animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility, reducing the use of chemical fertilizers. A high integration of crops and livestock is often considered as a step forward, but small farmers need to have sufficient access to knowledge, assets and inputs to manage this system in a way that is economically and environmentally sustainable over the long term.

***Key words**: Integrated farming system; Crop-livestock; Environmental sustainability; Resource conservation;*

In recent years, food security, livelihood security, water security as well as natural resources conservation and environment protection have emerged as major issues worldwide. Developing countries struggling to deal with these issues and also have to contend with the dual burden of climate change and globalization. It has been accepted by everyone across the globe that sustainable development is the only way to promote rational utilization of resources and environmental protection without hampering economic growth. Developing countries around the world are promoting sustainable development through sustainable agricultural practices which will help them in addressing socio-economic as well as environmental issues simultaneously. Within the broad concept of sustainable agriculture "Integrated Farming Systems" hold special position as in this system nothing is wasted, the by-product of one system becomes the input for other. Integrated farming is an integrated approach to farming as compared to existing monoculture approaches. It refers to agricultural systems that integrate livestock and crop production. Moreover, the system help poor small farmers, who have very small land holding for crop production and a few heads of livestock to diversify farm production, increase cash income, improve quality and quantity of food produced and exploitation of unutilized resources. Population growth, urbanization and income growth are fuelling a substantial increase in the demand for food of animal origin, while also aggravating the competition between crops and livestock (increasing

cropping areas and reducing rangelands). The livestock revolution is stretching the capacity of existing production, but it is also exacerbating environmental problems. Therefore, while it is necessary to satisfy consumer demand, improve nutrition and direct income growth opportunities to those who need those most, it is also necessary to alleviate environmental stress (*Delgado et al., 1999*).

An integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment. Based on the principle of enhancing natural biological processes above and below the ground, the integrated system represents a winning combination that

(a) Reduces erosion;
(b) Increases crop yields, soil biological activity and nutrient recycling;
(c) Intensifies land use, improving profits; and
(d) Can therefore help reduce poverty and malnutrition and strengthen environmental sustainability.

Livestock and crop production systems are an integral part of one another (*Kallah and Adamu 1988*). Crop residues provide fodder for livestock (*Van Raay and de Leeuw 1971; Al hassan et al. 1983*) while, occasionally, grain provides supplementary feed for productive animals. Animals improve soil fertility through manure and urine deposition and animal power for farm operations and transport. Sale of animals sometimes provides cash for farm labor and agricultural inputs. There are several examples of completely integrated crop–livestock production systems where sustainable increases in both crop and livestock production have been achieved after considerable periods (30–40 years) of continuous cropping without resulting in land degradation. Some of them are the close settled zone (CSZ) of Kano in northern Nigeria (*Harris 1995*), Banamba in Central Mali (Abou Berthe, personal communication), and Batalay in southern Chad (K.N. Ngwara, personal communication). The key success to these farming systems is effective crop–livestock integration involving the recycling of nutrients within the system. A particular challenge facing farmers is to minimize nutrient losses through good management (*Powell and Valentin 1997*); improved feed production, quality, availability, and more efficient feeding systems; new ways to capture and conserve nutrients excreted by livestock; improved manure spreading techniques; and cropping systems that reduce nutrient losses and can improve livestock impacts on the soil environment.

Key principles :

Cyclic. The farming system is essentially cyclic (organic resources – livestock – land – crops). Therefore, management decisions related to one component may affect the others.

Rational. Using crop residues more rationally is an important route out of poverty. For resource-poor farmers, the correct management of crop residues, together with an optimal allocation of scarce resources, leads to sustainable production.

Ecologically sustainable. Combining ecological sustainability and economic viability, the integrated livestock-farming system maintains and improves agricultural productivity while also reducing negative environmental impacts. Some lessons learned and recommendations

- The maintenance of an integrated crop livestock system is dependent on the availability of adequate nutrients to sustain animals and plants and to maintain soil fertility. Animal manure alone cannot meet crop requirements, even if it does contain the kind of nutrients needed. This is because of its relatively low nutrient density and the limited quantity available to small-scale farmers. Alternative sources for the nutrients need to be found.
- Growing fodder legumes and using them as a supplement to crop residue is the most practical and cost-effective method for improving the nutritional value of crop residues. This combination is also effective in reducing weight loss in animals, particularly during dry periods;
- Given their traditional knowledge and experience, local farmers are perfectly able to apply an integrated system. In practice, however, relatively few adopt this system, mainly because they have limited access to credit, technology and knowledge. The crop-pasture rotation system is complex and requires a substantial capital outlay for machinery and implements. Associations of grain and livestock producers are useful for filling these gaps and can promote the adoption of a crop livestock system;
- Better livestock management is needed to safeguard water. Livestock water demand includes water for drinking and for feed production and processing. Livestock also have an impact on water, contaminating it with manure and urine. All of these

aspects need to be given due consideration.

- Intensification of agriculture through appropriate incorporation of small livestock has the potential to decrease the land needed for agricultural production and relieve the pressure on forests.

Advantages : Economic analysis of different farming systems (one hectare of irrigated land or 1.5 ha of un-irrigated land) indicated that under irrigated conditions, mixed farming with crossbred cows yielded the highest net profit, followed by mixed farming with buffalo, and arable farming. Mixed farming with Hariana cows made a loss (*Singh et al. 1993*). Comparative productivity and economies of dairy enterprises (mixed farming with three crossbred cows on one hectare of canal irrigated land versus mixed farming with three *Murrah* buffalo) indicated that mixed farming with crossbred cows under canal-irrigated conditions was more efficient for the utilisation of land, capital, inputs and the labour resources of the farmer (*Kumar et al. 1994*). Baseline surveys in Gujarat India, indicated that around 75 per cent of rural households kept cattle in the face of under-employment. More particularly, the farm surveys showed that cattle kept mainly for milk, contributed 32 per cent and 20 per cent for tribal and non-tribal ethnic groups respectively (*Patil and Udo 1997*). By comparison to cows and buffaloes, lactating goats contributed between 54-68.9 per cent to total farm income through the sale of milk (*Deoghare and Bhattacharyya 1993; 1994; Deoghare and Sood 1994)*. The significance of milk production from goats and the links to food security and livelihoods of the poor has recently been reviewed (*Devendra 1996*). In an integrated system, livestock and crops are produced within a coordinated framework. (*Van Keulen and Schiere, 2004*). The waste products of one component serve as a resource for the other. For example, manure is used to enhance crop production; crop residues and by-products feed the animals, supplementing often inadequate feed supplies, thus contributing to improved animal nutrition and productivity.

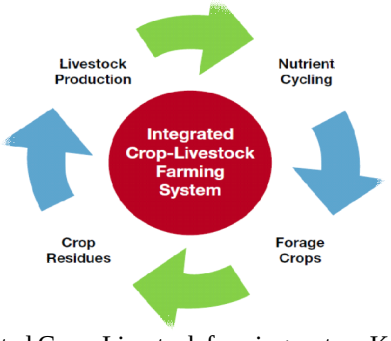

Fig 1. Integrated Crop–Livestock farming system:Key aspects

The result of this cyclical combination is the mixed farming system, which exists in many forms and represents the largest category of livestock systems in the world in terms of animal numbers, productivity and the number of people it services. (*Van Keulen and Schiere, 2004*).

Animals play key and multiple roles in the functioning of the farm, and not only because they provide livestock products (meat, milk, eggs, wool, and hides) or can be converted into prompt cash in times of need. Animals transform plant energy into useful work: animal power is used for ploughing, transport and in activities such as milling, logging, road construction, marketing, and water lifting for irrigation. Animals also provide manure and other types of animal waste. Excreta have two crucial roles in the overall sustainability of the system:

(a) *Improving nutrient cycling*: Excreta contain several nutrients (including nitrogen, phosphorus and potassium) and organic matter, which are important for maintaining soil structure and fertility. Through its use, production is increased while the risk of soil degradation is reduced.

(b) *Providing energy:* Excreta is the basis for the production of biogas and energy for household use (e.g. cooking, lighting) or for rural industries (e.g. powering mills and water pumps). Fuel in the form of biogas or dung cakes can replace charcoal and wood.

Crop residues represent the other pillar on which the equilibrium of this system rests. They are fibrous by-products that result from the cultivation of cereals, pulses, oil plants, roots and tubers. They are a valuable, low-cost feed resource for animal production, and are consequently the major source of nutrients for livestock in developing countries. The overall benefits of crop-livestock integration can be summarized as follows:

- Agronomic, through the retrieval and maintenance of the soil productive capacity;
- Economic, through product diversification and higher yields and quality at less cost;
- Ecological, through the reduction of crop pests (less pesticide use and better soil erosion control); and
- Social, through the reduction of rural urban migration and the creation of new job opportunities in rural areas.

This system has other specific advantages

- It helps improve and conserve the productive capacities of soils, with physical, chemical and biological soil recuperation. Animals play an

important role in harvesting and relocating nutrients, significantly improving soil fertility and crop yields.

- It is quick, efficient and economically viable because grain crops can be produced in four to six months, and pasture formation after cropping is rapid and inexpensive.
- It helps increase profits by reducing production costs. Poor farmers can use fertilizer from livestock operations, especially when rising petroleum prices make chemical fertilizers unaffordable.
- It results in greater soil water storage capacity, mainly because of biological aeration and the increase in the level of organic matter.
- It provides diversified income sources, guaranteeing a buffer against trade, price and climate fluctuations.

One key advantage of crop-livestock production systems is that livestock can be fed on crop residues and other products that would otherwise pose a major waste disposal problem. For example, livestock can be fed on straw, damaged fruits, grains and household wastes (*Fakoya, 2002*). Integration of livestock and crop allow nutrients to be recycled more effectively on the farm. Manure itself is a valuable fertilizer containing 8 kg of nitrogen, 4kg of phosphorus and 16 kg of potassium to the tone (*FAO, 1999*). Adding manure to the soil not only fertilizes it but also improved its structures and water retention capacity (*ILCA, 1988; FAO, 1996*) opined that where livestock are used to graze, the vegetation under plantations of coconut, oil palm and rubber, as in Malaysia, the cost of weed control can be dramatically reduced, sometimes by as much as 40 percent. In Colombia sheep are sometimes used to control weeds in sugarcane. Draught animal power is widely used for cultivation, transportation, water lifting and powering food processing equipment. Using draught animal reduces the need for foreign exchange to buy expensive tractors and fuel (*Jahnke, 1992*). According to International food security treat *Campaign (1984)* it was estimated that 52 percent of the cultivated area in developing countries excluding China is farmed exclusively with draught animal, animal traction, bringing heavy but potentially very productive soil into production. According to *FAO (1997)* cow dung is highly valued for used for cooking and heating in many countries. Alternatively, 25kg of fresh cow dung makes on cubic metre of biogas, which can be used to provide energy for light, heat or motive power.

CONSTRAINTS

- Nutritional values of crop residues are generally low in digestibility and protein content. Improving intake and digestibility of crop residues by physical and chemical treatments is technically possible but not feasible for poor small farmers because they require machinery and chemicals that are expensive or not readily available (*Keftasa and International Livestock Centre for Africa, 1988*).
- Crop residues are primarily soil regenerators, but too often they are either disregarded or misapplied.
- Intensive recycling can cause nutrient losses.
- If manure nutrient use efficiencies are not improved or properly applied, the import of production and transportation, and the surpluses lost in the environment.
- Farmers prefer to use chemical fertilizer instead of manure because it acts faster and is easier to use.
- Resource investments are required to improve intake and digestibility of crop residues. Mixed farms are prone to using more manure than crop farms do. Manure transportation is an important factor affecting manure use.

Challenges

- Develop strategies and promote crop livestock synergies and interactions that aim to

  (a) Integrate crops and livestock effectively with careful land use;

  (b) Raise the productivity of specific mixed crop-livestock systems;

  (c) Facilitate expansion of food production; and

  (d) Simultaneously safeguard the environment with prudent and efficient use of natural resources.
- Devise measures (for instance, facilitating large-scale dissemination of bio-digesters) to implement a more efficient use of biomass, reducing pressures on natural resources; and develop a sustainable livestock manure management system to control environmental losses and contaminant spreading.

Opportunities

- Intensification of agriculture which is currently occurring in most farming systems favours crop–livestock integration.
- Poor soil fertility, unavailability or increases in prices of fertilizers, and labour shortages, have forced farmers to rely on alternatives such as manure and traction.
- Farmers can grow crop in the wet season and engage in livestock enterprises in the dry season.
- Livestock enterprises are more lucrative than crop

farming so it is advantageous to integrate livestock into farm activities.

- Many indigenous, emerging, and developed technologies are available to support sustainable crop–livestock integration. These include improved cereal and grain legume varieties, cropping systems, weed and nutrient management strategies, the eradication of most livestock diseases, and the development of modeling and all-year-round feed packages for animals.

Socioeconomic factors : Systems modeling and GIS applications, combined with socioeconomic information, such as identification of areas where market driven intensification is ongoing and impact is likely to be greater (*Ndubuisi et al. 1998*), should have a role in optimizing the targeting of new technologies. For instance, an approach needs to be included encompassing the "whole system" while aspects including the determinants of farmer decision-making and opportunities for using technologies (such as improved varieties, cropping systems, better ruminant nutrition, weed and nutrient management) to enable existing sustainable systems to address the challenges of increased intensification need to be included.

Establishing effective input (e.g., fertilizer) and support services (e.g., veterinary delivery systems) and establishing infrastructure (e.g., roads, processing, and marketing facilities); are important. An appropriate strategy would be to select technologies with the highest potential impact from the above areas, in order to form a holistic package for testing and dissemination with a view to maximizing total productivity at the farm level. This holistic approach should be supported by socioeconomic information such as determinants of farmers' decision making for certain technologies as well as the development of tools to assess whole farm impacts of new interventions.

CONCLUSION

Sustainable development is the only way to promote rational utilization of resources and environmental protection without hampering economic growth and integrated Farming Systems hold special position as in this system nothing is wasted, the by-product of one system becomes the input for other. India has a considerable livestock, poultry population and crop wastes. All efforts have to be mobilised to reclaim the resources and to put them to use effectively. Suitable technology has to be developed for the treatment of wastes and their all round effective utilisation, so that, it can help in to reducing the poverty and malnutrition and strengthen environmental sustainability.

The increase in demand for livestock products presents opportunities for small farmers who can increase livestock production and benefit from related income. (*Delgado et al.,1999*). However, in terms of environmental impact, the growing number of livestock and the increase in livestock processing can have a negative impact on natural resources unless actions are taken to identify farming practices that are economically and ecologically sustainable. The highly improved integrated crop-livestock system can guarantee more sustainable production and therefore constitutes a valid new approach. Experience in the use of this system has shown that

(a) Adopting sustainable management practices can improve production while preserving the environment;
(b) Residues, wastes and by-products of each component serve as resources for the others; and
(c) Poor farmers have the traditional knowledge needed to integrate livestock and crop production, but because of their limited access to knowledge, assets and inputs, relatively few adopt an integrated system.

The challenge for development practitioners is to ensure that poor small farmers can increase the productivity of traditional farming systems, adopting an effective integrated system that produces usable biomass while conserving natural resources, and can therefore be sustainable in the long term. Within this framework some key questions discussions are:

- How can livestock production increase to meet the growing demand for livestock products, using methods that the resource base can sustain?
- Do the strategies devised for raising productivity in integrated crop-livestock systems take into account the stage of development of the target population with respect to the nature of crop-livestock interactions?
- Do the farmers concerned have the right skills, knowledge, capital and technology to set up this system?
- Are the roles and responsibilities of men and women given sufficient consideration?
- How can additional needed nutrients be obtained? And, can the productivity of the system be increased without stressing the environment?
- Is enough good-quality feed available to sustain animals, especially during the dry season?

- Are nutrients that are relocated from grazing areas to croplands efficiently recovered?
- Are the different components of the farming system (crop, livestock and, eventually, fish) efficiently integrated?

Therefore, a lot of extension attention is however required to educate farmers on utilization of crop-livestock production systems.

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