IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 7, Issue 10 Ver. I (Oct. 2014), PP 36-42
www.iosrjournals.org

Integrated Farming Systems - A Review

Rajju Priya Soni[1*], Mittu Katoch[2] and Rajesh Ladohia[3]
[1&2]Senior Research Fellows, Department of Agronomy, Forages and Grassland Management,
[3] Senior Research Fellow, Department of Tea Husbandry and Agroforestry.
[1, 2&3]CSK HPKV, Palampur 176 062, H.P. (INDIA)

Abstract: *Integrated Farming systems (IFS), and ways of thinking about them, evolved in space and time. Rapid evolution took place in the last two decades when crop and livestock yields increased, together with concerns about their socio-economic and biophysical tradeoffs. The application of farming systems research (FSR) to agricultural development was a response to problems arising from a predominantly reductionist approach to research and a cornucopian view of external inputs. Modern technologies were either not welcome or caused unexpected negative trade-offs. This paper reviews definitions and forms of FSR and the need for evolution in thinking about agricultural development. Application of thermodynamic theory (TDT) to the study of farming systems influences discussion between cornucopians and conservationists, and between reductionist and holistic approaches to research. There is a need to recognize context (suitability of technology), and to pay more attention to relations within systems (system dynamics) and to defining criteria for sustainability. The paper links biophysical and socio-economic processes, gives a physical background for the anthropomorphic concepts of waste, and reviews aspects of objectivism and constructivism. It is argued that FSR can only advance if the full portent of these issues is considered in thinking about development of IFS. The complexity of the reality should make scientists think more carefully about the appropriate strategy that will get people out of poverty. Research in Asia of replications of the famous Bangladesh Grameen Bank micro-credit programs show that there is an ideal progression for farm families in the sub-continent that even the poor aspire too. According to this experience poor women invest in small livestock and the household step by step gets out of poverty. There is a great and unmet challenge for research on local resources to cater to the needs of these people.*

Keywords: *Integrated farming systems, Local feed resources, on farm research, recycling, women, poverty, and livestock.*

I. Introduction

Farming systems and thinking about farming change continuously. These processes can be called the evolution of farming systems and system philosophy, if change is called evolution and if thinking about systems is called philosophy. Rapid change took place in the last two decades in both temperate and tropical regions in terms of yield per animal or plot, and in terms of input use. All over the world the grain yields went up at spectacular rates during the green revolution and individual levels of production in animals followed a similar trend [1, 2]. Ensuring food security for a fast growing global population estimated at 9.1 billion in 2050 and over 10 billion by the end of the twenty first century is a mammoth challenge for the present agricultural production system [3]. Shrinking average farm size in India and financial constraints for higher investment in agriculture due to 80% farm families belonging to small and marginal farmer categories further heighten the challenge. For securing food and nutrition security for sizable population, productivity enhancement may provide a vital solution. This involves the adoption of scientific agronomic practices and technologies which promise an augmentation of the productive capacity of traditional agricultural systems. Agronomic practices such as the liberal use of inorganic pesticides and fertilizers during the twentieth century enhanced productivity significantly but undesirable environmental degradation accompanied by increased operational costs in agriculture raised concerns about economic feasibility and sustainability [4, 5]. About 75% of the adversely affected households belong to rural communities of developing economies whose livelihood is directly or indirectly dependent on agriculture and allied activities [6]. Unsustainable farming leads to environmental pollution and threatens the livelihood of millions of small farm holders. Strengthening agricultural production systems for greater sustainability and higher economic returns is a vital process for increasing income and food and nutrition security in developing countries [7].

Therefore IFS is a multidisciplinary whole farm approach and very effective in solving the problems of small and marginal farmers. The approach aims at increasing income and employment from small-holding by integrating various farm enterprises and recycling crop residues and by products within the farm itself. The farmers need to be assured of regular income for living at least above poverty line. The progress in production or steady growth in output is necessary to face the challenges posed by present economic, political and technological environment. In this context, farming system approach is one of the important solutions to face this peculiar situation as in this approach the different enterprises can be carefully undertaken and the location specific systems are developed based on available resources which will result into sustainable development [8].

The emergence of **Integrated Farming Systems (IFS)** has enabled us 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 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.** IFS works as a system of systems. 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 [9].

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 [10, 11, 1]. 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 [12, 13]. Due to low agricultural productivity, the small and marginal farmers as well as about 15 to 18% landless families living in the rural areas are unable to generate remunerative employment and about 40% families 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. FSR offers 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 [14]. 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.

II. Farming Systems Approach

The shortcomings of the reductionistic, command-and-control approach to agricultural research became increasingly evident, especially as it was understood that the farmers' production environment were much more heterogeneous than had been thought. Indeed, farmers in less favoured areas (and also in countries of the South) resisted these innovations and did not adopt the technological packages. This raised the awareness that technological innovations needed to be assessed not only through their immediate efficiency. They also needed to be flexible [15] and needed to take into account the farmers' perception of uncertainty and security, their long term perspectives and their farming goals [16, 17]. Thus, it was recognized that the research approach needed to be more integrative, systemic and comprehensive [18] and that multiple spatial and temporal scales needed to be taken into account [16]. Also, the limits of a science-based recommendation were acknowledged and with it the need to take an actor-oriented approach to ensure compatibility with the socioeconomic environment [19]. This led to a new developmental paradigm, which Korten characterizes as a 'people-centred learning process' rather than the earlier 'technological blueprint' approach [20]. Thus, the farming systems approach developed in the late 1970s, which had as its key characteristics an interdisciplinary approach (i.e. collaboration between a wider range of disciplines and the inclusion of socio-economic elements) [21] and the involvement of farmers in the research process [22, 23]. Initially the focus was still on how yields of particular crops could be increased. This early farming systems approach involved looking at one specific enterprise (or part of an enterprise) and identifying improvements that were compatible with the whole farming system [19]. This approach allowed several developments:

- Technical scientists were increasingly sensitised to the complexity and variability of farmers' production environment. They recognised that this environment consisted of both physical and socioeconomic components, and they also saw the need to integrate the farmer, with his/her norms and values, his/her decisions rules as a component of the systems they studied.
- The farm is understood as one system [24]. For example the livestock farming system approach proposed by animal scientists (e.g. Gibon et al., [25]), considers the farmer, the herd and the resources as one socio-technical system. The (self-)regulation properties of the system, based on the interactions between its constitutive elements (information flows, adjustments of decision rules, biological homeorhetic controls [26, 27] at different time scales could theoretically and practically be included in a model (e.g. the flock operation model of Cournut and Dedieu, [28]).
- Economists realised that farmers' behaviour could not be understood only through maximisation of profit [29] (Colin and Crawford, 2000). In his adaptive behaviour theory, Petit (1978, 1981[30, 31]) showed how

farmers interactively adjust both their objectives and their situations. For farmers and farm households, choices also take into account issues such as long-term preferences, security, lifestyle and quality of life [32, 33].

Singh et al. [34], in their efforts to develop sustainable integrated farming system models for irrigated agroecosystem of eastern Uttar Pradesh of north-eastern plain zone revealed that rice-pea-okra was the most remunerative cropping sequence with highest rice equivalent yield of 17.88t/ha and net returns than the conventional rice-wheat sequence. The rice based integrated farming system comprising of crop components, dairy, poultry and fishery was the most suitable and efficient farming system model giving the highest system productivity and ensured the multiple uses of water. This model generated significantly higher levels of employment than rice-wheat system.

The approach aims at increasing income and employment from small-holding by integrating various farm enterprises and recycling crop residues and by products within the farm itself [35, 36].

III. Optimizing The Total System

The "Farmer first and last model" (FFL) is an alternative to the "transfer-of- technology" model (TOT), and is based in the farmer's perceptions and priorities rather than on the scientist's professional preferences, criteria and priorities. The starting point is the scientific learning from and understanding of the resources, needs and problems of the resource-poor farmers and that the research stations and laboratories play a referral and consultancy role. This model is characterized by the use of informal survey methods, research and development within the farms, and with the farmers, and evaluation through the technology adoption [37] (Chambers and Ghildyal, 1985). The farming system must be fully integrated in order to optimize the use of locally "available alternative" resources. Strategies for sustainable livestock production in the tropics have been developed in Colombia and elsewhere [38].

Manure is an important source of fuel in many Asian cultures. It is estimated that 8 to 12% of the world's population depend on manure for heating and cooking [39]. Animal manure is a valuable fertilizer as well, conferring inputs to the soil over and above the simple chemical nutrients of N, P and K. As an input into the crop cultivation systems, manure continues to be the link between crop and animal production throughout the developing world. The great challenge is to develop better ways of increasing the benefits to society and to the environment that manure can bring [40]. One way to improve a better utilization of manure is undoubtedly through biogas production and cultivation of earthworms. Biogas is considered one of the cheapest renewable energies in rural areas of developing countries. Production of biogas would not only save firewood but also be beneficial for integrated farming systems by converting manure into an improved fertilizer for crops or in ponds for fish and water plants. Other benefits of biodigestion include the reduction of manure smell, elimination of smoke when cooking and the destruction of pathogens and thereby improving the environment in the farm [41].

When livestock are available, and there are suitable conditions, a simple and low-cost biodigester technology can be developed. Earthworms provide another route for the recycling of manure and are especially appropriate for the processing of excreta from goats and rabbits which, for physical reasons, is not suitable as a substrate for biodigesters. The results reported here demonstrate that the basic model has many variants but the principles are the same. It is important to identify local feed resources and the preferences of local people for different types of livestock. In all cases, there should be minimum "waste" in the system. By-products and residues originating in one component of the system become inputs for another "productive" activity. [42].

Toor *et al.* [43], conducted a study in a cluster of four villages in Phagwara Development Block, Kapurthala district, under the ICAR-funded adhoc project entitled “System Approach towards Income Enhancement” during 2003-06. A set of 11 different Integrated farming systems was developed and implemented in the farms of selected farmers with 1.5-ha holdings. The results of the study indicated that all the Integrated farming systems, involving crops (rice, wheat, and *Aloe vera*) and livestock (dairy animals, pigs, poultry, fish, rabbits and honey bees), proved more profitable than crops alone (rice-wheat system) in terms of net returns. Further, integrated systems resulted in better utilization of land, water input and human resources compared to arable farming alone and also increased employment generation.

IV. Integrative Simulation Modeling In Farming Systems Research

Integrative (bio-physical or socio-economical) simulation modeling is a promising tool in farming systems research, which will help in unraveling the complex and dynamic interactions and feedbacks among bio-physical, socio-economic and institutional components across scales and levels and are useful for taking decisions to foster sustainable farming systems. Participatory approach in integrated simulation modeling is the need of the hour to address the problem of shrinking of resource availability and competition to access of resources and its market economy. The strength of integrated simulation models is that of providing a platform for the integration of research approaches, knowledge and data in the frame of interdisciplinary or trans-disciplinary processes. Under the projected climate change scenario, there is a need to optimize the multiple input factors to achieve maximum benefit with sustainability, multi-criteria decision analysis with the integration of linear programming and simulation modeling should be taken up at different scales to address the input-output flow of resources (Fig. 1) [14].

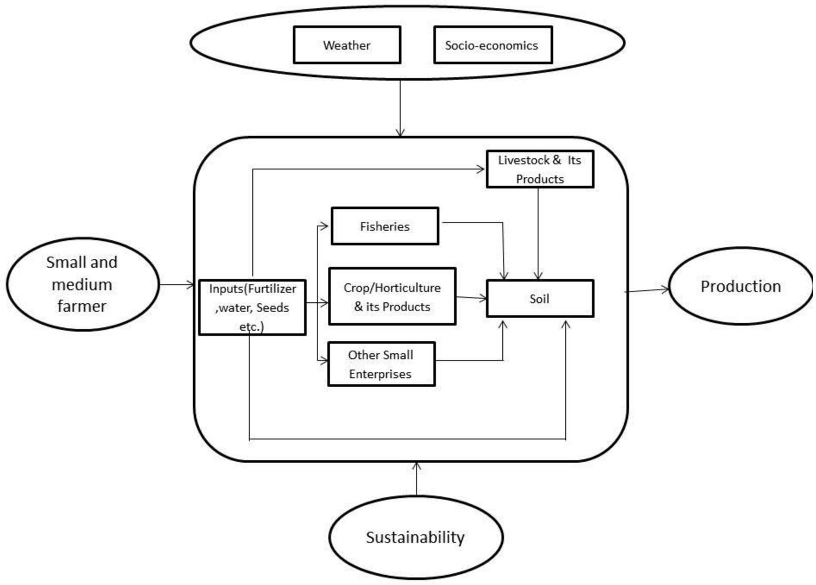

Fig. 1. Schematic representation of the integrated simulation model with input flows

The cassava tree grown in an integrated farming system, and heavily fertilized with organic manure, can produce up to 0.9 kg of leaves/m² at 45 to 60 day harvest intervals. This amounts to an annual yield of up to 60 tonnes leaves /ha [44] (Preston et al 1998). The dry matter content is around 25% and the protein content of the dry matter is 25% Cassava is grown almost everywhere in the tropics and when managed as part of an integrated farming system becomes an important source of high quality protein at farm level. Cassava leaf has a high content of HCN which can be toxic for monogastric animals but there are ways to reduce this to a safe level. The most common way is to dry the cassava leaves but the most suitable is to ensile the leaves anaerobically with 5% of molasses [9].

Cassava has one important characteristics, namely that it can be managed to maximize production of carbohydrate (in the form of the roots), or protein, by harvesting the leaves. For root production the growth cycle is from 6 to 12 months at the end of which the entire plant is harvested. When maximum protein production is the aim, the foliage is harvested at 2 to 3 month intervals by cutting the stems at 20” to 28” above the ground thereby encouraging the plant to re-grow. In this case the roots act as a nutrient reserve to facilitate the re-growth of the aerial part. This process can continue for 2 to 3 years if the nutrients exported in the leaves are supplemented with fertilizer (organic/inorganic). Dual-purpose production systems are also possible whereby one or two harvests of the leaves are taken before the plant is allowed to continue the normal development of the roots. Cassava can produce very high yields, especially of protein (up to 3,563 lbs/acre/year), which makes it an ideal element for taking advantage of recycled livestock wastes. This high yield potential is complemented by the high nutritive value of the leaves for cattle, sheep and goats and pigs. The presence of cyanogenic glucosides (HCN) does not appear to be a problem in ruminants and can be neutralized by ensiling or drying which converts the toxic cyanide into non-toxic cyanides the leaves before feeding to pigs (Table 1). Cassava leaves have anthelmic properties in goats and cattle and gives further advantages on this crop as a component of integrated farming systems [9].

Table 1: Chemical Composition Of The Dry And Ensiled Cassava Leaves

	Ensiled	**Sun-dried**
% of dry matter **- Protein** **- Fibre** **- Ether extract** **- Ash**	27.6 17.1 13.9 10.3	26.0 16.1 9.9 10.9
Mg/kg dry matter **- HCN**	147	22,5

Source: The nutritive value of sun-dried and ensiled cassava leaves for growing

Pigs by Bui Huy Nhu Phuc, R.B. Ogle, J.E. Lindberg and T.R. Preston. 1996 [45].

On-farm research has many advantages. Farmers have always experimented to produce locally-adapted technologies, practices, crops and livestock [46, 47, 48].

On-Farm Processing and Value Addition

A substantial change has already taken place in consumer preferences for graded, packaged and processed food items of daily use in urban market, especially among middle and high classes. With opening of more and more departmental stores in townships and retailing food items at competitive prices within next few years this trend will certainly filter down to rural areas also. Low-cost improved technologies are required to unleash potential and improve market efficiency and remain competitive simultaneously. Moreover, recent trends have clearly shown the accelerated use of by-products for value addition. For example, now sugarcane is not only used for sugar production but every by-product of it is used economically by sugar mills – bagasse for electricity generation, pressmud for preparation of high value organic manure and molasses for alcohol production. Similarly, in case of paddy, husk is being used as very efficient source of fuel in boilers and bran for edible oil extraction. Many vegetable oils – earlier considered to be non-edible are being extensively used as edible after development of refining technology. It is certain that advantage of all these value addition technologies will be available to farmers also [49].

"Integrated Food and Waste Management Systems" (IF&WMS) which was developed by Prof. Chan and is one version of an IFS. He introduced this concept at the Montfort Boy Farm in Fiji, a vocational school that now serves as a model for the students to replicate in their villages (A Primer on Integrated Farming Systems). Today there are numerous IF&WMS or IFS models. These systems combine livestock, aquaculture, agriculture and agro-industry in an expanded symbiotic or synergistic system, so that the wastes of one process become the input for other processes, with or without treatment to provide the means of production, such as energy, fertilizer, and feed for optimum productivity at minimum costs. The concepts associated with IFS are practiced by numerous farmers throughout the globe. A common characteristic of these systems is that they have a combination of crop and livestock enterprises and in some cases may include combinations of aquaculture and trees. It is a component of farming systems which takes into account the concepts of minimizing risk, increasing total production and profits by lowering external inputs through recycling and improving the utilization of organic wastes and crop residues. In this respect integration usually occurs when outputs (usually by-products) of one enterprise are used as inputs by another within the context of the farming systems. The difference between mixed farming and integrated farming is that enterprises in the integrated farming systems interact eco-biologically, in space and time, are mutually supportive and depend on each other.

Examples include:

1. "pig tractor" systems where the animals are confined in crop fields well prior to planting and "plow" the field by digging for roots "chicken tractor"
2. poultry used in orchards or vineyards after harvest to clear rotten fruit and weeds while fertilizing the soil
3. cattle or other livestock allowed to graze cover crop between crops on farms that contain both cropland and pasture
4. Water-based agricultural systems that provide way for effective and efficient recycling of farm nutrients producing fuel, fertilizer and a compost tea/mineralized irrigation water in the process [50].

Empowerment of women through IFS

Women play a very important role in household management including agricultural operations. This is especially true for hilly and tribal areas. There is a vast scope to improve the household profitability by judiciously utilizing family labour using innovative practices and ensuring multiple uses of various household resources. This is possible through women's empowerment through location specific trainings and critical need based support. With the improvement in educational status in the years to come, the role of women in agriculture and management of household resources will be increasingly important. As such, feminization of agriculture in the long run is expected and developing women-centric farming system models will be a real challenge as men are migrating to rural non-farm sectors [14].

V. Conclusion

There is now evidence that with the right type of institutional, credit and technical interventions, the poorest households - and especially when the work is routed through women - have tremendous capacity to pull themselves out of hardcore poverty with immediate benefit to the most vulnerable groups, i.e. children under five and pregnant women. The strategy to develop feeding systems based on the use of local resources has to go together with the socio-economical aspects. The emphasis should be on small livestock such as chickens, ducks, pigs, goats in accordance with the "ladder concept", but should respect differences in countries and cultures. Addition of organic residues in the form of animal and plant wastes could also help in improving the soil – health and thereby productivity over a longer period of time with lesser environmental hazards. On-farm research is an active process. Farmers have always experimented to produce locally-adapted technologies. Farmers are often excellent "researchers" and "extensionists". In this way, research and extension go together which is the best way. When the research is done on-farm, the process is faster and there is a "natural selection" of technologies and priorities. Therefore, there is less waste of time and money. In some aspects, especially when new technologies are being developed or adapted, it is advantageous if on-farm research is complemented with "on station" research. It improves space utilization and increase productivity per unit area. It provides diversified products. It improves soil fertility and soil physical structure from appropriate crop rotation and using cover crop and organic compost. It reduce weeds, insect pests and diseases from appropriate crop rotation. The Utilization of crop residues and livestock wastes less reliance to outside inputs – fertilizers, agrochemicals, feeds, energy, etc. The Higher net returns to land and labour resources of the farming family, but there must be a clear understanding of link with the reality of the farmer situation.

Integrated farming systems offer unique opportunities for maintaining and extending biodiversity. The emphasis in such systems is on optimizing resource utilization rather than maximization of individual elements in the system. The well being of poor farmers can be improved by bringing together the experiences and efforts of farmers, scientists, researchers, and students in different countries with similar eco-sociological circumstances i.e. through Integrated Farming System.

Empowering today's youth is our greatest responsibility. Providing a platform to create professional and business oriented farming systems for youth will be very important. Further, the role of highly educated and skilled youth will be quite useful in managing the knowledge intensive farming systems. Capacity building of youth population through advanced trainings will further empower them to go for creating input-output supply chains for primary and secondary agriculture. The only possibility of retaining youth in agriculture is through developing micro-business models in farming as it offers scope for regular sustained income. The highly productive, economically profitable, environment friendly and sustainable successful models of farming systems can pave way to attract the youths to work in rural areas even from urban areas having links to the rural system. This can reverse the process of trans-migration and also may promote agro-eco tourism.

References

[1] Alexandratos, N. (ed.), World Agriculture: Towards 2010. (An FAO Study, FAO, Rome1995).

[2] E. Porcire, and R. Rabbinge, Role of research and education in the development of agriculture in Europe. European Journal of Agronomy 7, 1997, 1-13.

[3] UNPFA, State of the World population, United Nations population fund. 2011.

[4] IAASTD, Agriculture at the Crossroads, International Assessment of Agricultural Knowledge, Science and Technology for Development, Washington, DC, Island Press. 2009.

[5] FAO, Sustainable crop production intensification through an ecosystem approach and an enabling environment: capturing efficiency through ecosystem services and management, FAO Committee on Agriculture, June 16-19. 2010.

[6] FAO, Food Security and Agricultural Mitigation in Developing Countries: Options for capturing synergies, Rome, FAO. 2009.

[7] Ravallion M, Chen S, China's (Uneven) progress Against Poverty, Journal of Development Economics, 82(1), 2007, 1-42.

[8] L.N.Dashora and Hari Singh. Integrated Farming System-Need of Today. International Journal of Applied Life Sciences and Engineering 1(1), 2014, 28-37.

[9] CARDI, A Mannual on Integrated Farming System. Caribbean Agricultural Research and Development Institute, (Ministry Of Economic Development, Belize 2010), pp.1-58

[10] J. N. Pretty, Regenerating Agriculture: Policies and Practice for Sustainability and Self Reliance, (Earthscan, London 1995.

[11] M. Giampietro, G. Cerretelli,, and D. Pimentel, Assessment of different agricultural production practices. Ambio 21, 1992, 451-459.

[12] R. Bawden, Systems thinking and practice in agriculture, Journal of Dairy Science 74, 1991, 2362-2373.

[13] D. L. Plucknett, and N. J. H. Smith, Agricultural research and Third World food production. Science 217, 1982, 215-220.

[14] PDFSR, Farming Systems Scenario. Vision 2050. Project Directorate for Farming Systems Research, Modipuram, 2013, pp. 1-23.

[15] Sebillotte, M., 1990. Some concepts for analysing farming and cropping systems and their different effects. In: Scaife A. (ed.). Proceedings of the 1st ESA Congress, Paris 5-7 Dec. 1990. ESA. Colmar, session 5, pp. 1-16.

[16] L. Lev, and D. Campbell, The temporal dimension in Farming Systems Research: The importance of maintaining flexibility under conditions of uncertainty. Journal of Rural Studies 3(2), 1987, 123-132.

[17] B, Dedieu, E. Chia, B. Leclerc, Ch. Moulin and M. Tichit, Introduction générale. In: B. Dedieu, E. Chia, B. Leclerc, Ch. Moulin, M. Tichit (eds) L'élevage en mouvement. Flexibilité et adaptation des exploitations d'herbivores. Paris: Ed Quae, 2008, pp. 11-24.

[18] R.D. Hart, and A.M. Pinchinat, Integrative agricultural systems research. In: J. Servant, A. Pinchinat (eds). Caribbean Seminar on Farming Systems Research Methodology. Pointe-à-Pitre, Guadeloupe, FWI, May 4-8, 1980. INRA-IICA Ed. 1982, pp. 555-565.

[19] D.W. Norman, The farming systems approach: A historical perspective. Presentation held at the 17th Symposium of the International Farming Systems Association in Lake Buena Vista, Florida, USA, 17-20 Nov. 2002.

[20] J. Jiggins, and N. Röling, Systems thinking and participatory research and extension skills: Can these be taught in the classroom? Occasional Papers in Rural Extension, No. 10. Dept. of Rural Extension Studies, University of Guelph. 1994.

[21] J.B. Dent, G. Edwards-Jones, M.J. McGregor, Simulation of ecological, social and economic factors in agricultural systems. Agricultural Systems 49(4), 1995, 337-351.

[22] S. Bellon, J.F. Mondain-Monval, D. Pillot, Recherche-Développement et Farming System Research: à la quête de l'opérationnalité. In Actes du Colloque Syst. de Prod. Agric. caribéens et alternatives de Dév. 9-11/5/85, Martinique. Univ. Antilles-Guyane, DAC, 1985, pp. 467-486.

[23] M. Collinson, (ed.), A history of farming systems research. (Wallingford: CABI Publishing. 2000.)

[24] P.L. Osty, L'exploitation agricole vue comme un système. Bulletin Technique d'Information. Paris: Ministère de l'Agriculture, 1978.
[25] A. Gibon , A.R. Sibbald, J.C. Flamant, P. Lhoste, R. Revilla, R. Rubino, J.T. Sorensen, Livestock farming systems research in Europe and its potential contribution for managing towards sustainability in livestock farming. Livestock Production Science 61(2-3) 1999, 121-137.
[26] D. Sauvant, F. Phocas, A mechanistic model to simulate the long term regulation of the dairy cow nutrition. Journal of Dairy Science, 75 (suppl 1), 1992, 168.
[27] L. Puilliez , O. Martin, M. Tichit, D. Sauvant, Simple representation of physiological regulations in a model of lmactating female: Application to the dairy goat. Animal 2(2), 2008, 235-246.
[28] S. Cournut, and B. Dedieu, A discrete event simulation of flock dynamics: a management application to three lambings in two years. Animal Research 53, 2004, 383-403.
[29] J.P. Colin, and E. Crawford, Economic perspectives in agricultural systems analysis. Review of Agricultural Economics 22(1), 2000, 192-216.
[30] M. Petit, The farm household complex as an adaptive system. Proceedings of the 4. Forschungscolloquium des Lehrstuhls für Wirtschaftslehre des Landbaus. Arbeitsbericht 78/1, Institut für Landwirtschaftliche Betriebs- und Arbeitslehre. University of Kiel, 1978, pp. 57-70.
[31] M. Petit, Théorie de la décision et comportement adaptatif des agriculteurs. Formation des agriculteurs et apprentissage de la décision, Dijon, ENSSAA, INPSA, INRA, INRAP.1981.
[32] J. Brossier, E. Chia, E. Marschal, M. Petit, Gestion de l'exploitation agricole familiale et pratiques des agriculteurs: vers une nouvelle théorie de la gestion. Revue Canadienne d'Economie Rurale, 39, 1991, 119-135.
[33] M. Gafsi, and J. Brossier, 1997. Farm management and protection of natural resources: Analysis of adaptation process and the dependence relationships. Agricultural Systems 55(1), 1997, 71-97
[34] K. Singh, J .S. Bohra , Y. Singh and J.P. Singh, Development of farming system models for the northeastern plain zone of Uttar Pradesh. Indian Farming. 56(7), 2006, 5-11.
[35] U.K. Behera, and I.C. Mahapatra, Income and employment generation of small and marginal farmers through integrated farming systems. Indian Journal of Agronomy, 44(3), 1999, 431-439.
[36] Kalyan Singh, J.S. Bohra, Y. Singh, and J.P. Singh, Development of farming system models for the northeastern plain zone of U.P. Indian Farming. 56 (2), 2006, 5-11.
[37] R Chambers and Ghildyal, Agriculture research for resource-poor farmers: the Farmers-First-and-Last model. Discussion paper N0 203. Institute of Development Studies. University of Sussex. Brighton, England. 1985.
[38] T.R. Preston and E. Murgueitio , Strategy for Sustainable Livestock Production in the Tropics. 2nd Edition. CONDRIT Ltd. Cali, Colombia, 1994, 89pp.
[39] T.V. Ramachandra, Efficient wood energy devices for cooking and water heating purpose. Centre of Ecological Sciences. Karnataka State, India, 1994.
[40] Tania Beteta, Experiences of recycling Manure in Colombia, M.Sc. Thesis, Uppsala, Sweden 1996.
[41] An Xuan Bui, T.R. Preston T R and F. Dolberg , The introduction of low-cost plastic polyethylene tube biodigesters on small scale farms in Vietnam.Livestock Research for Rural Development, 9(2), 1996.
[42] L. Rodríguez and Salazar Patricia y Arango Maria Fernanda, Lombriz roja Californiana y Azolla-anabaena como sustituto de la proteina convencional en dietas para pollos de engorde:. Livestock Research for Rural Development. 7(7), 1995, 20-31
[43] M.S. Toor, A.S. Sidhu, and Sukhpreet Singh, Integrated farming systems for income and employment increasing possibilities on small farms in Punjab State. Ministry of Agriculture and Cooperation, Directorate of Economics and Statistics, New Delhi, India, Agricultural Situation in India. 66(9), 2009, 519-524.
[44] T.R. Preston, L. Rodríguez , Nguyen Van Lai y Le Ha Chau, El follaje de la yuca (Manihot esculenta Cranz) como fuente de proteína para la producción animal en sistemas agroforestales., Articulo presentado en La conferencia electrónica de FAO "Agroforestería Para La Producción Animal En Latinoamérica" April to Sept .In Spanish, 1998.
[45] Bue, Huy Nhu Phuc, R.B. Ogle, J.E. Lindberg, and T.R. Preston, The nutritive value of sun-dried and ensiled cassava leaves for growing pigs. Livestock for Research for Rural Development 8(3), 1996, Retrieved from http://www.cipav.org.co/lrrd/lrrd8/3/phuc83.htm
[46] R. Chambers, A. Pacey and L.A. Thrupp (Editors), Farmer First: Farmer innovation and Agriculture Research, Intermediate Technology Publications Ltd, London. 1989.
[47] J.H.A. Brouwers, Rural People Response to Soil Fertility Decline. The Adja case (Benin).Wageningen Agriculture University Papers 93.4. Wageningen Agriculture University, the Netherlands, 1993.
[48] I. Scoones and J. Thompson, Beyond Farmer First. IT'S Publications, London.1994.
[49] PDFSR, Farming Systems Scenario. Vision 2030. Project Directorate for Farming Systems Research, Modipuram, 2011, pp. 23.
[50] G.L. Chan, What Does Integrated Farming System Do? Sustainable Communities/ZERI-NM, Inc. 2004.