Chapter II

Literature review

2.1 The concept and development of farming systems approach

Farming Systems Research and Development has always evolved because it is affected by so many factors overtime such as: farmers' objectives, credit, the adequacy of roads and transport systems, the size and requirements of markets, the types of marketing channels that exist, the government policies, attitudes, resources, priorities, and problems.

Farming System Research is an approach to agricultural research and development, that would be consider into aspects such as: views the whole farm-household as a system and focuses on the interdependencies and interrelationships between the natural and human environments, among the components under the management of the farm household and how these components interact with the physical, biological and socio-economic factors out of the household's control (Shaner *et al.,* 1982; Van Der Veen, 1986).

According to Shaner *et al* (1982) the purpose of FSR is to generate more appropriate technologies for farmers and, where possible, to improve policies and support services for farm production, to raise farm families' welfare, and to enhance society's goals.

More specifically, FSR aims at increasing the productivity of farming systems by generating technologies for targeted groups of farmers and by developing greater insights into which technologies fit where and why (Shaner *et al.,* 1982).

Thus the central research objective of FSR and the mainstream approach is the same: increasing the production of the farm family (Norman and Collinson, 1985; Brouwer and Jansen, 1989).

The development of relevant and feasible technology for small farmers must be based on a full knowledge of the existing farming system and that (ii) technology should be assessed not only in terms of its technical performance, but also in accordance with the goals, needs and socio-economic situations of the targeted small-farm system as well. This approach encourages the direct communication of farmers, development workers and researchers.

Fresco (1986) discerned two mainly streams (i) francophone, which appears as a "more formal, long-term and large scale research aimed at developing the potential of a geographical region", and (ii) anglophone, which aims at incremental changes rather than at a profound change of traditional agriculture.

All this diversity resulted in confusion in terminology and conceptualization of FSR. Merrill-Sands (1986) thus proposed a new term Farming Systems Perspective - FSP for the generic research concept using farming system as the framework for analysis.

'Systems agriculture' is akin to the agro-ecosystem approach developed by Conway (1985) in encompassing the interactive complexity of the farmer and his natural and socioeconomic environment (Shand, 1985). In comparing Systems Agriculture with FSR, Macadam *et al* (1990) stated that the two have a common emphasis on farmer experience and collaboration and in emphasizing on-farm improvements. These common features can be interpreted as: (i) action and effect orientation, (ii) emphasis of farmer participation, (iii) appreciation of a trans-disciplinary perspective, (iv) holistic approach, (v) integration of research and extension functions, and (vi) action on the premise that a system is determined by the inquirer's interests.

2.2 Major factors affecting the development of agricultural production

Some of these factor are internal to, or part of, the farming system, whereas others are external. The principal exogenous (external) factor which influence the development of farming systems - policies, institutions, public goods, markets, and the information.

2.2.1 Market systems

Markets have a critical role to play in agricultural development, as they form the linkages between farm, rural and urban economies upon which the development processes outlined by Mellor (1985).

Similarly, information and educational services affect household strategies and decisions. Technologies, which determine the nature of production and processing, and natural resources, are largely endogenous (internal) factors and are therefore depicted as lying mainly within the boundary of the farming system.

Markets, new technologies, government educational activities and outside cultures may compel local households to change the way they conduct their lives, including the way they structure their agroecosystem and interact with them.

In general terms, the biophysical factors tend to define the set of possible farming systems, whilst the socio-economic factors determine the actual farming system which can be observed at a given time.

2.2.2 Economic and sustainable crop intensification

Farmers change their farming systems into the farming systems with lower input costs, create a more even distribution of the workload throughout the year, improve the effect of applied fertilizers and organic materials, reduce weed pressure and the need for insect and disease control activities, and lead to higher and more stable yields (Mary, 1999).

In the agriculture developmental direction, that always goes to the sustainable agriculture because the sustainable agricultural development that guarantees about an income and livelihood for farmer households. In the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs
- enhance environmental quality and the natural resource base upon which the agricultural economy depends
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- sustain the economic viability of farm operations
- enhance the quality of life for farmers and society as a whole (Tant *et al.*, 1992).

2.3 Farm performance as measure by productivity sustainability and stability

Sustainable agriculture is both a philosophy and a science. The philosophy recognizes that farmers have always tried to be good stewards of their land, within the economic restraints imposed by society, farmers are freed to try some science-based alternatives. A strong motive for wishing to adopt new ways is anxiety about damage to natural resources and to their family's health from overuse of farm chemicals (Tant *et al.*, 1992).

Sustainable agriculture is an umbrella term that embraces, but is not restricted to nor defined by, such terms as "organic", "regenerative", "biodynamic", "ecological", "alternative" or "low input". However, just because a farm is "organic" or "alternative" does not mean that it is sustainable. To be sustainable, it must produce adequate food of high quality, be environmentally safe, protect the soil resource base, and be profitable (Reganold *et al.,* 1990).

Sustainability is the results of relationship between technologies, inputs and management. That is used on a particular resource base within a given socio economic context (Barnett, 1995). Reijntjes (1992) defined sustainability that basically refers to the capacity to remain productive while maintaining the resource base in term of the context of agriculture.

Better sustainability of smaller holdings may be explained on the basis of the fact that various resources, inputs, operations, etc. are managed in a better way which improves the productivity and efficiency of resource use in various farming system models on smaller land holdings. The general criteria used were of two basic types: first, the available natural resource base, climate, typography, farm size and tenure; second, household livelihood patterns, technologies, and farm management and organization.

The cropping system, a particular configuration of crop in space and time that is employed more or less homogeneously on a single agricultural field; and the farm system, the array of one or more cropping systems employed by a single farm household (Gerald, 1986).

A household as a social unit makes decision on the cropping systems it will employ. One household also may have an influence on the farm systems other households as a consequence of its social interactions with those households.

Productivity is primarily a measure of the relative suitability of a system or activity in a particular agro ecological environment. On commercial farms it is an indicator of relative efficiency of resource use and management performance. On non-commercial farms, productivity is a necessary condition for achieving family sustainability of farmers. Productivity beyond what family can consume or store or barter becomes irrational and may even be undesirable (McConnell, 1997).

Productivity is conventionally measured in term of such units as: tones, kilograms or litters of output respectively per acre, hectare (McConnell, 1997).

System stability is the absence or minimization of year-to-year fluctuations in either production or value of input (Boffa, 1999).

2.4 The measurement of performance of the sustainable agriculture

Productivity, profitability, stability, diversity, and sustainability were measured based on yield per hectare, gross margin, and etc (Table 2.1).

Table 2.1 Systems properties and indicators for measurement of performance

Property	Indicator
Productivity	Yield per land, animal unit or other unit of resource or the value of output per unit of cost
Profitability ❑ of activities ❑ of whole farms ❑ overtime	In financial terms or measured subjectively as net benefits ❑ Gross margin ❑ Various whole-farm profitability measures ❑ Discount measures
Stability	Coefficient of variation
Diversity ✓ of activities ✓ of products ✓ of income	Simpson's diversity index ✓ Number of activities in system ✓ Number of products of system ✓ Income diversity ratio
Sustainability	No single general quantitative measure

Source: FAO, 1997

Lockeretz (1988) has claimed about sustainable agriculture that is based on the following general concepts such as:

1) Diversity of crop species to enhance the farm's biological and economic stability that is created;

2) Selection of crop varieties and livestock that are well suited to the farm's soil and climate and that resist pest and disease;
3) Preference for farm-generated resources over purchased materials, as well as for locally available off-farm inputs (when required) over those from remote regions;
4) Tightening of nutrient cycles to minimize loss of nutrients off the farm, realized, for example, by composting livestock manure or by rotating using legumes to fix nitrogen;
5) Livestock housed and grazed at low density, with a preference for high-roughage rations over concentrated feeds for ruminants, and herd-size scaled to the farm's ability to produce feeds and use livestock manure efficiently;
6) Enhancement of the soil's ability to take up applied nutrients for later release as needed by the crop, in contrast to direct uptake by the crop at the time of application;
7) Maintenance of the protective cover on the soil throughout the year, through tillage that leaves crop residues on the surface, and through cover crops and living mulches;
8) Rotations that include deep-rooted crops to tap nutrients reserves in lower strata and that control weeds by alternating between cool season and warm season crops;
9) Use of soluble inorganic fertilizers, if at all, only at a level that the crop can use efficiently, and use of these materials only in case livestock manure and legumes cannot cover nutrient deficits;
10) Enhancement of conditions for controlling or suppressing weeds, insect pests, and diseases; if synthetic insecticides and herbicides are used at all, they should be used only as a last resort and only when there is a clear threat to the crop.

2.5 The rice ecosystems in Asia

Rice is the staple food for nearly half the earth's population, mostly concentrated in Asia. About 92% of global rice production is in Asia. Asia produces more than 530 million tons of paddy rice every year on about 135 million hectares of harvested area. About 55% of this area is irrigated, but because yields are higher on irrigated than rainfed land, the irrigated area accounts for about 75% of Asia's total rice production (Roland *et al.,* 2002). Irrigated lowland rice is consequently the most important agricultural ecosystem in Asia and clearly one of the most important in the world.

The population lives in rural areas and depends on agriculture; the development of agriculture is synonymous with food security, poverty reduction and economic growth.

To day, the rainfed farming continues to dominate large rice region in the world. Rainfed agriculture exists from the hillside to the plain. The rainfed lowland rice farming is a practice of rice growing with impounded water in the field for part of their growth cycle (Xuan, no date)

Today, based on current projections, lowland rice could increasingly be produced within a political, economic, social, cultural, and environmental framework of less irrigation water, less labor availability, more mechanization, greater environmental considerations, and alternative income opportunities.

Lowland rice ecosystems rely upon inputs of water, fertilizers, labor, pesticides, and seed to ensure high production with intensive management. We use partial factor productivity, defined as the output of paddy grain per quantity of input of a given factor, as an indicator of the efficiency of resource use (Dawe and Dobermann, 1999). The rainfed rice farmers are generally poorer than the farmers in irrigated areas due to the lower and less stable yields under these production systems.

Improvement in the productivity of the rainfed rice production systems will require new varieties and technologies (Mellor, 1983).

2.6 The agricultural development of Vietnam

Vietnam's agricultural outputs dramatically increased during the 1980s and early 1990s. Total food production doubled in a period of only 15 years (Cuc, 1995). The country turned from a net-importer of rice to the third biggest exporter of rice in the world (World Bank, 1995).

The miracle of Vietnamese agriculture is the consequence of the superiority of household-based agricultural production and the beneficial role of decollectivization (Thomas, 2000).

2.6.1 Agriculture in Vietnam 1976-1994

Vietnam's agriculture has paid much attention to the organization of production. A series of institutional changes have been perceived as the dynamism of agricultural development, shifting the distribution of decision-making powers between the collective and the household. Collective production dominated northern agriculture for about 20 years, but never took hold in the South. In the late 1970s and early 1980s, control over production decisions shifted toward the household in the North and triggered decollectivization all over the country in the late 1980s. Today the household is the primary decision-making unit in Vietnam's agricultural sector. This section presents a brief overview over Vietnam's changes in the organization of agricultural production and reviews the performance of the agricultural sector between 1976 and 1994 (Thomas, 2000).

2.6.1.1 The development of agricultural production 1976-1994

Agricultural production grew rapidly during the period 1976-1994, While Vietnamese farmers produced only 12-13 million tons of food between 1976 and

1978, production rose to 26 million tons in 1994, because the institutional changes gradually shifted control over production decisions from the collective to households during the same period. Concurrent changes in the organization of agricultural production and output increases thus beg the question to what degree decollectivization contributed to Vietnam's agricultural miracle. Finally, after reunification the ideological motivation of members to effectively engage in collective production was significantly weakened (Anh, 1994).

2.6.1.2 Struggles over agricultural surplus and decollectivization

Land was allocated to, and production was undertaken in, households, the traditional social unit in Vietnamese villages and organizational unit of agricultural production. Also, the reforms eliminated the role of the brigades and strengthened the control by the Management Committee over cooperative members.

Yet the literature reports continued inefficiencies and increasing conflicts between members and the cooperative over the distribution of surpluses (Pingali and Xuan, 1992; Anh, 1994; Kerkvliet, 1995).

Cooperative members still had to maintain a large number of cooperative staff and specialized brigades undertook specific tasks in agricultural production. Land was frequently re-assigned between households, so that they did not have any incentive to invest into the improvement of the land. Cooperatives subsequently raised contract quotas to siphon off surpluses retained by the household. Farmers were reported to be left with as little as 20% of their agricultural produce. Consequently, farmers returned contracted land to cooperatives or just plain refused to deliver parts of, or their whole, quotas (Chung, 1991).

Around 1988, household control over agricultural production further expanded as households received long-term usufruct rights over agricultural land. In the Mekong Delta, most farmers got back the land that they had originally farmed before the collectivization drive. The reforms significantly reduced the operations of the cooperative, abolishing its administrative functions.

In sum, review of the literature suggests that agricultural cooperatives in Vietnam did not facilitate an efficient organization of agricultural production, both under fully collectivized production and the 'end product contract'. Particularly in the period after reunification when the central government pushed for the consolidation of cooperatives, cooperative performance was hampered by members' resistance to the organizational model of agricultural production and procurement demands imposed by the government. Initial gains made through increase in household control over production resulted in growing production, but dissipated due to conflicts over the distribution of agricultural surplus. It was not before decollectivization that agricultural organization provided the incentives to households that facilitated drastic increases in agricultural production (Didier and Florence, 1995).

2.6.2 Vietnam's agricultural miracle looking back

The agricultural production and an important role of decollectivization in the dramatic increase in Vietnam agricultural production in recently years. This explanation of agricultural growth: as expansion in agricultural land, public investment into irrigation, increased fertilizer supplies, and improvements in agricultural producer prices were important factors in Vietnamese agricultural development (Cuc, 1995).

2.6.2.1 The relative contributions of land expansion and yield improvements

At the most basic level, increases in agricultural output can be disaggregated into increases due to expansion in sown area and to yield improvements. Vietnam's sown area has expanded significantly during the last two decades. While in 1976 Vietnam's farmers worked 5.3 million hectares of rice, they cultivated 6.6 million hectares in 1994 (Cuc, 1995). Yet the expansion in harvested area was not evenly distributed over the 18-year period. The area cultivated for rice expanded at a moderate pace during the late 1970s, slowed down during the 1981-88 period, and then significantly accelerated after 1989. During the last period (1989-1994), the sown area expanded at an annual rate of 2.4 percent.

Agricultural yields have shown even more pronounced fluctuations. While yields increased from 2,230 kg/hectare in 1976 to 3,560 kg/hectare in 1994, they declined between 1976 and 1980 (Cuc, 1995). Increases were especially high between 1981 and 1988, when yields improved at an annual rate of 4.6 percent, and were slightly less dramatic between 1989 and 1994.

This simple disaggregation of trends in rice production shows that the expansion of sown area and yield improvements played different roles through the three periods after 1976. Between 1976 and 1980, increases in sown area could not prevent a decline in rice production due to drastic declines in yields. During 1981 to 1988, rapidly increasing yields facilitated substantial growth of rice production despite of stagnating sown areas. Finally, after the 1988 reforms, a combination of significant yield improvements and the highest rate of expansion in sown areas during the 18-year period (both in absolute and relative terms) completed Vietnam's agricultural miracle (Long, 1993).

2.6.2.2 The importance of investment in irrigation, increased fertilizer availability, and improvements in agricultural prices

Attention to the factors underlying the expansion of sown areas and yield improvements further helps to understand the causes of agricultural growth. Three factors seem to be of crucial importance: government investment into irrigation, the increased availability of fertilizer, and significant improvements in the terms of trade between agriculture and industry in favor of agriculture (World Bank, 1995).

Government investments in irrigation and the reclamation of agricultural land have played a significant role as a factor of agricultural growth. The Vietnamese government has consistently reserved a sizable share of its total investment outlays for the expansion of agricultural area (Khiem and Pingali, 1995). Consequently, Vietnam's irrigated area for rice cultivation increased from 3.3 million hectares in 1976 to 5.3 million hectares in 1993. The increase in irrigated area was highest in the late 1970s. During the following years, the irrigated area continued to grow at an average rate close to three percent.

2.6.2.3 Changes in irrigated area and fertilizer availability, 1976-1993

Fertilizer availability also increased continuously after 1982, following a decline in availability during the late 1970s. In 1993, farmers had more than four times the amount of fertilizer available per hectare of sown rice than during the early 1980s. Fertilizer availability increased at an annual rate of 17.6 percent during the 1981-88 period and 4.0 percent during 1989-93. Fertilizer availability appears to be strongly correlated with the incidence of agricultural growth. Rice production declined when fertilizer became less available, while it increased once fertilizer was supplied in ever larger quantities. Yet the data also show, that massive improvements in fertilizer availability during the 1981-88 period did not translate into corresponding growth rates (National Statistic Department, 1995).

Finally, exchange of agricultural produce and inputs gradually shifted toward market mechanisms during the 1980s, boosting relative prices of agricultural products. At the end of the 1970s, the procurement of agricultural produce and supply of inputs was tightly controlled by the state (Pingali and Xuan, 1992). In the early 1980s, households began to sell rice surplus above the quota for delivery to the state to private traders (Pingali and Xuan, 1992). In the late 1980s, markets for agricultural output and input markets became increasingly liberalized (Pingali and Xuan, 1992).

2.7 Farming systems of the Mekong Delta

In the Mekong Delta, there are various types of farming systems under various natural conditions (Xuan and Matsui, 1998; Sanh *et al.*, 1999). Besides, there is one result in which classification of farming systems is made based on ecosystem classification in the whole Mekong Delta (Yamada *et al.*, 1999).

International Rice Research Institute (1997) defined that rainfed lowlands are characterized by lack of water control, with floods and drought being potential problems. Adverse climate, poor soils, and a lack of suitable modern technologies keep farmers from being able to increase productivity. The rainfed lowland rice ecosystems may be divided into five subecosystems: (1) favorable rainfed lowland, (2) drought-prone, (3) submergence-prone, (4) drought- and submergence-prone, and (5) medium-deep water. The rice farming in rainfed lowlands has uncertainty characteristics, crops suffer droughts, floods, pests, weeds, and soil constraints and most rainfed lowlands depend on erratic rainfall, conditions are diverse and unpredictable (Xuan, 1997).

Most rainfed lowland rice farmers are poor and must cope with unstable yields and financial risks. They adapt their cropping practices to the complex risks, potentials, and problems they face. They typically grow traditional, photoperiod-sensitive cultivars and invest their labor instead of purchasing inputs. They weed, may redistribute seedlings to ensure good crop stands, and usually harvest by hand. Suitable modern varieties and associated production technologies have been limited. Farmers have built well in their fields to irrigate upland crops in the dry season (District Statistic Department, 2002).

The adoption of a cropping system reflects the farmers' response to a series of interacting technical elements (physical and biological factors), economic elements (farm level resources and market conditions), and human elements (Thanh, 1994).

2.7.1 Current land use

Efforts for agricultural development in this delta have threatened the sustainability. The extension of HYVs cultivation has caused the great change in agro-ecosystems and cropping patterns. The HYV area has rapidly changed from 0.45

million hectares increased to 2.46 million hectares in 1975 and 1995 and to 2.58 in 2000, respectively.

Table 2.2 shows that, in the past 25 years, the cropping mechanism in the Mekong Delta has rapidly been shifted. The government has invested so much into irrigation systems to effect largely on the cultivation development on many fields, special with fitting policy about land reform at 1989 and opening market policy. Beside successful of agricultural development are remaining some low development areas of the unfavorable of the partially irrigated area.

Table 2.2 Grown area of rice in 25 years of the Mekong Delta, Vietnam

Crops/year	1975	1985	1995	2000
	........................ha........................			
Dry and Wet season modern rice	453,120	111,783	2,467,033	2,584,220
Main rainy season traditional rice	1,255,641	1,009,026	590,367	541,830
Total	1,708,761	2,211,808	3,057,400	3,126,050

Source: Provincial Agriculture Departments, Statistic Department, and Agricultural Extension Centers in the Mekong Delta in 1993, 1995 and 2000

Since HYVs were first introduced into Viet Nam (1968), many Vietnamese farmers have been trying to modify their traditional practices and adapt the new technology in order to increase their production. However, the degree of success with HYVs has varied from place to place and from year to year (Provincial Agriculture Departments, 1995; 2000).

2.7.2 Rice ecosystems

The Mekong River Delta has three major cropping seasons: winter-spring, summer-autumn or mid-season, and wet season-long duration. Fifty-two percent of the rice in the Mekong River Delta is grown in irrigated lowlands, with the remaining

48% grown under rainfed lowland conditions (Provincial Agriculture Departments, Statistic Department, and Agricultural Extension Centers, 1993, 1995 and 2000).

The area under modern rice varieties in the winter-spring, summer-autumn, and part of the wet season-long duration crop has increased by 15-20% in recent years. On the average, winter-spring yields are highest (3.8 ton/ha) followed by yields of summer-autumn (3.4 ton/ha) and wet season-long duration rice (2.7 ton/ha). Floating rice yields are low (1.5 ton/ha) (Provincial Agriculture Departments, Statistic Department, and Agricultural Extension Centers, 1993, 1995 and 2000).

2.7.3 Rice production environment

Soils in the Mekong Delta are highly variable, but alluvial, acid sulfate, and saline soils predominate. Acid sulfate soils cover some 1.6 million ha, or 40% of soils in the delta, mainly in the Plain of Reeds, Long Xuyen Quadrangle, and Ca Mau Peninsula. The soil is rich in humus and total N, but low in P. In addition Al and Fe toxicities limit yield (Provincial Agriculture Departments, Statistic Department, and Agricultural Extension Centers, 1993, 1995 and 2000).

Alluvial soils, prevalent in 30% of the Mekong Delta, are concentrated along the banks of the Tien and Hau Rivers. That is the best soil in the Delta with humus content of 2%, total N of 0.1 to 0.25%, and medium P and K. Two to three crops can be grown on these soils each year. Coastal saline soils occupy about 20% of the total area. The soils are rich in humus, N, and clay (55-60%), but with a high salt content (Provincial Agriculture Departments, Statistic Department, and Agricultural Extension Centers, 1993,1995 and 2000).

2.7.4 Production constraints

The major constraints are flooding at the end of the rainy season, and drought in the dry season. Small farm size, which is expected to diminish even further because of population pressure, is a major constraint. The current level of physical infrastructure is inadequate to support the prospective increases of agricultural production. Two-thirds of the farms have no access to drying areas; most of the crop is sun-dried. Storage space is about 1 million m3 or 67% of the total needed. Transport for moving the crop to market is inadequate. Energy is also in short supply. Although electricity is available in most provinces, only 50% of the households have access to it (Xuan, 1997)

2.7.5 Production opportunities

The increased production of rice and productivity of rice-based farming systems remain the primary goals of the national plan. Studies in the Mekong Delta have focused on various rice-based farming systems models: rice - fish integrated with fruit trees, rice - shrimp in saline areas, rice - fish in deepwater areas, and rice - cash crops in the floating rice area (Provincial Agriculture Departments, Statistic Department, and Agricultural Extension Centers, 1993, 1995 and 2000).