CHAPTER II

LITERATURE REVIEW

2.1 General features of farming systems in Cambodia

The choice of agricultural activities within the farm households particularly under the subsistence production systems heavily depend on the type of land the farm household owned. There is an estimated 1.2-1.3 million farming households in Cambodia. These farmers have been divided into four groups with different agricultural practices and attitudes:

. Rice producers, most of whom produce rainfed lowland rice and who own a few animals and make a small income from sugar palm tapping; Other rice farmers grow either flood recession paddy rice or floating paddy and earn money with seasonal work in the cities and towns or by cutting and selling timber;

. Commercially minded non-rice farmers who produce and sell crops such as tobacco, fruits and vegetables at riverbanks, e.g. vegetable farmers in Kiensvay;

. Upland farmers who make a living from permanent or seasonal crops such as soybean and mungbean, and keep some livestock and growth some rice;

. Indigenous farmers who practice swidden agriculture in the northeast of the country (O'Brien, 1999).

Therefore, farming systems in Cambodia can be classified according to the location, the major plant product, and the timing of production of the plant product as follows:

Table 1. Farming systems in Cambodia

Location	Plant products	Time of production	Name given
River	Fruit, vegetables, other	Cool and dry season	River Bank
Bank	Rice	Dry season	Recession dry season rice
Lowland	Rice	Wet season	Rainfed lowland rice
	Rice	Dry season	Dry season irrigated rice
Upland	Rubber, legumes	Wet season	Plantation cropping
	Rice	Wet season	Upland rice
	Mixed	Wet season	Shifting/Swidden Agriculture

(Source: Maclean, 1998)

As with all classification systems there are grey areas in between each system, some time two systems may merge into one, to make a different system (for example, in an area where a dry season irrigated rice crop is grown after a rainfed rice-crop is grown during the wet season), and there are enormous variations even within one system, due to variations in all the environmental, climatic and human and social factors that constitute a system (Maclean, 1998).

Since most of people live on the alluvial plains water becomes an additional resource, which determines the farming system. In fact water is the critical determinant of the farming system in Cambodia (Hunter *et al.*, 1998).

The lowland rice based farming system is the most common system over most of the country. This can ranged from low input low output rainfed system where risk of crop failure are dependent on rainfall, to a high input high output full irrigation system where water is available year round for multiple cropping (Hunter *et al.*, 1998).

2.2 Aspects of the evolution of farming systems

The farming system approach considers both biophysical dimensions (such as soil nutrients and water balances) and socio-economic aspects (such as gender, food security and profitability) at the level of the farm – where most agricultural production and consumption decisions are taken (Dixon *et al.*, 2001).

The Green Revolution was beginning to have a great deal of success in Asia and Latin America, being based on good climate (i.e. plenty of water) and soils; very homogeneous and favorable production environments; and the adoption of improved varieties of wheat, maize and rice that were very responsive to fertilizer. In Green Revolution areas, farmers were able to benefit from the improved technologies even if they did not do things quite right and the inputs they used were very divisible (e.g. they could use a little or a lot of improved fertilizer or seed) (Norman and Worman, 1995).

In the mid-1980s, the Farm Management and Production Economic Service of FAO became actively involved in the farming systems movement and developed the FSD approach. FSD is based-on the farm household focus of FSR and emphasizes the central role the farmer plays in farming system development (Norman and Worman, 1995).

In order to present the analysis of farming systems and their future development within a framework that is broadly comparable between systems and across different regions, the about key biophysical and socio-economic determinants have been grouped together into five categories:

. Natural resources and climate;
. Science and technology;
. Trade liberation and market development;
. Policies, institution and public goods; and
. Information and human capital (Dixon *et al.*, 2001).

Figure 1. represents schematically the interrelationship of these key determinants of farm systems and, by extension, farming systems. Some of these factors are internal to, or part of, the farming system whereas others are external (Dixon *et al*., 2001).

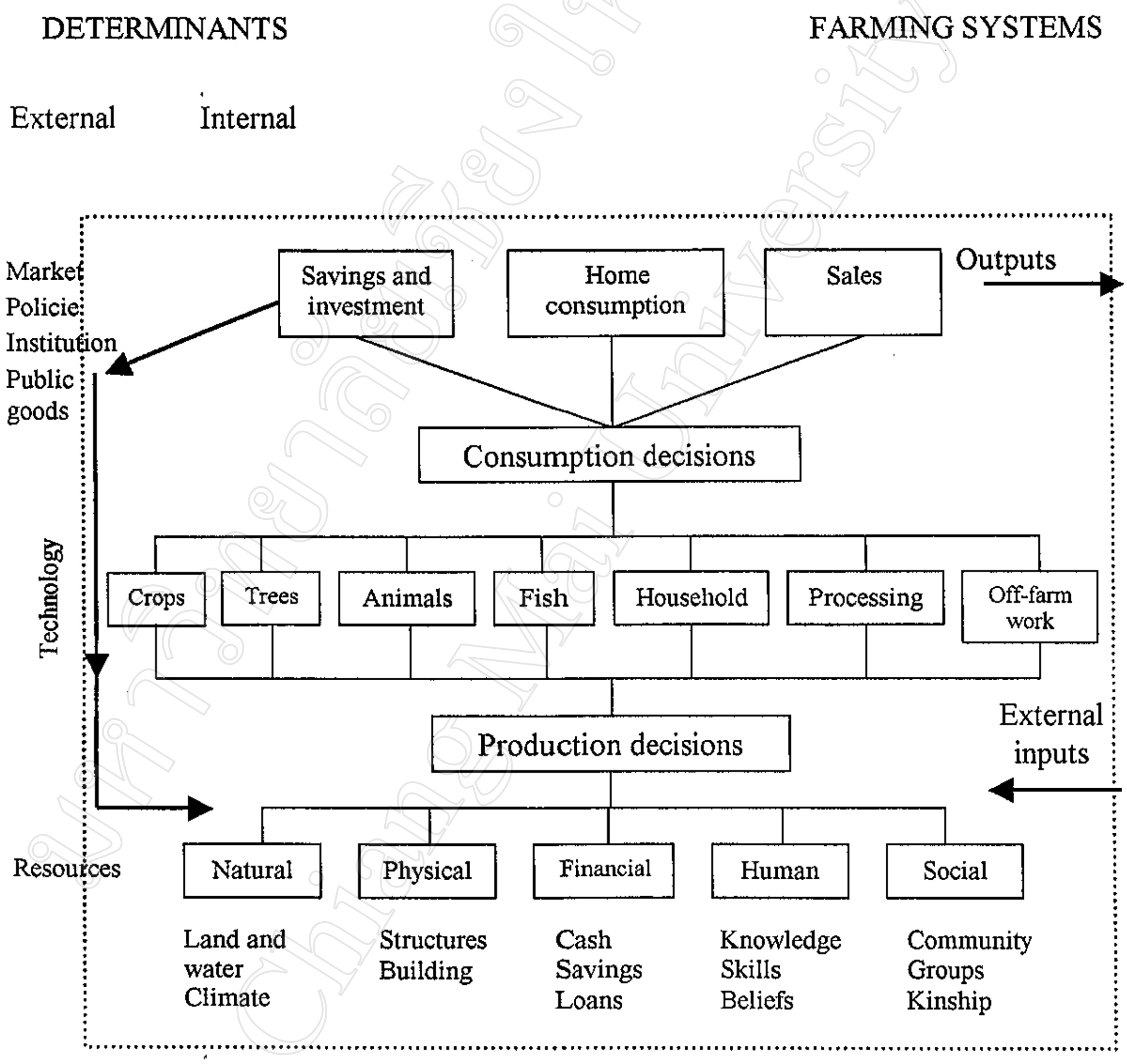

Figure 1. Schematic representation of farming systems

(Source: Dixon *et al*., 2001)

2.3 Improvement of farming systems

In the west, there is a problem of overproduction and conspicuous consumption. However, in developing countries, the major problem is in sufficient production resulting in food shortage. Therefore, in the Third World there is a need to produce more food to meet the requirement of mass population. Thus, the improvement of existing farming through raising productivity of numerous smallholdings is taken into consideration (Dreze and Sen, 1990).

2.3.1 Increase efficiency

There are eight main properties a system might possess, thus requiring a set of criteria by which these system properties may be assess. They are relevant to evaluation and planning both at farm-household level and at a broader social level. The eight properties of farm systems and activities, which need to be assessed, are: productivity, profitability, stability, diversity, flexibility, time-dispersion, sustainability and complementarity and environmental compatibility (McConnell and Dillon, 1997).

2.3.1.1 Productivity

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-but only to a limit. Production beyond what a family can consume or store or barter becomes irrational and may even be undesirable (McConnell and Dillon, 1997).

Productivity is conventionally measured in terms of such units, e.g., as tons, kilograms or litres of output respectively per acre, hectare or animal unit employed over some relevant time unit (typically a year). Or if desired, it may be measured in financial terms over some relevant time span as the ratio of total revenue to total cost, i.e., the value of output per unit of cost. Productivity is an appropriate measure of system and activity performance when applied to single-output enterprises or mono-product systems (McConnell and Dillon, 1997).

2.3.1.2 Profitability

Financial profit as a criterion for measuring the performance of farm-household systems is often unreliable. This is because, on small farms, money profit is often generated at the expense of weakening or distorting the system through such factors as increasing household exposure to debt for purchased farm inputs, the danger of fostering an exploitative and non-sustainable rate of resource use (causing soil degradation), reduction in the level of reliability of household food supply and increasing risk.

Profit is normally measured in money monetary terms as gross financial revenue minus total financial cost per period. Note, however, that it may – if need be -- also be assessed subjectively in qualitative terms as net gain, i.e., as total benefit less total cost however measured (McConnell and Dillon, 1997).

Associate whit profitability, however measured, is the matter of farm-size adequacy. Clearly, a prime requirement of any whole-farm system is that it be of sufficient size to satisfy the farm-based needs of its primary beneficiaries. Small should thus be assessed in terms of income adequacy, i.e., their ability to sustain the farm household's need for income in cash and/or kind without causing resource or environmental degradation. Income adequacy is thus an important aspect of profitability (McConnell and Dillon, 1997).

2.3.1.3 Stability

System stability refers to the absence or minimization of year-to-year fluctuations in either production or value of output. (The latter also implies either stability in input costs, yields and prices or counterbalancing movements in this influences or value of output.) Where conditions are favorable, price and production instability can often be countered by more careful activity selection (e.g., of drought-tolerant varieties, pest-immune crops); by diversification of activities, by seeking greater flexibility in product use or disposal, by multiple cropping over both space and time, and by increasing on-farm storage capacity and post-harvest handling efficiency (Boffa, 1999).

In some situations the most direct strategy for stabilization is imply to increase production/income to a level, which allows an annual surplus to be retained/invested in good years to cover deficiencies in poor year (McConnell and Dillon, 1997).

Measuring stability/instability

Price/yield/income stability is most conveniently measured in terms of the coefficient of variation, denoted by CV (McConnell and Dillon, 1997), which expresses the standard deviation, denoted by SD, or positive square root of the variance (V) of a sample of observations on a variable X as a percentage of the sample's mean value X. Thus

$$CV = 100(SD / \overline{X}) \tag{1}$$

$$= 100(V^{1/2} / \overline{X}) \tag{2}$$

$$= 100\left[\sum_{i=i}^{n}(X_i - \overline{X})^2 / (n-1)\right]^{1/2} / \left(\sum_{i=1}^{n} X_i / n\right) \tag{3}$$

Where n is the number of observations, X_i is the i-th observation and $\sum$ denotes the sum of the following values for i from 1 to n. The set of observations X_1, X_2, …, X_n may come from a simple generated across time or space or both.

Of cause a stable system or activity is not necessarily superior to an unstable one. Depending on relative costs/prices, and unstable activity may still be preferable to a stable one on ground of long-run relative profit. But, other things being equal, stability will usually be chosen over instability, especially in subsistence situation where the goal is food rather than money, and where a high CV for yield might be synonymous with recurring famine (McConnell and Dillon, 1997).

2.3.1.4 Diversity

Diversity corresponds to not having all one's eggs in a single basket. It refers to a strategy of increasing the number of activities in a system and/or their separate products in order (i) to reduce overall system risk of income or family-subsistence failure and/or (ii) to increase overall production/profit (averaged over time) through a better use of available resources. A high diversity level is conductive to system stability (but diversity might conceivably be achieved at the cost of a reduction in average profit) (McConnell and Dillon, 1997).

Activity diversity

In terms of activities the most diversified farms are the small subsistence and semi-subsistence farms. The three elements contributing to the overall diversity of a farm system are: (i) the number of tree/crop/animal species present; (ii) the number of their respective products; and (iii) the number of ways in which these products can be used or disposed of. These three elements of diversity exist in both physical and economic (value) dimensions, either or both of which might be relevant to a particular analysis of farm-system diversity (McConnell and Dillon, 1997).

If diversity comparisons are to be made within or between groups of farms, it may sometimes be sufficient to express diversity level as simply the number of species of trees, crops and livestock present. Generally, however, this would be a poor measure: the species (and their associated activities) need somehow to be weighted according to their relative importance, e.g. in terms of the number of individuals within each species, or of the areas occupied by the various crops, or the amounts or values of outputs from the various activities. One relatively simple measure suited to such assessment is Simpson's diversity index (McConnell and Dillon, 1997). This is defined as:

$$DI = 1 - \sum_{i=1}^{s} (n_i / N)^2 \qquad (4)$$

Where S is the number of species or activities that are present; n_i (for i = 1to S) is the number of individuals in the i-th species or area devoted to the i-th species or activity, or income or value of the i-th species or activity; and N ($=\sum n_i$) is the total population of all individuals, or total area across all activities, or total farm income or value across all species or activities (McConnell and Dillon, 1997).

Product diversity

This refers to the number of separate final products of a system or activity. Considering the range of crops grown on many small farms, the possibilities of integrating different classes of livestock with these crops, and the total number of crop or livestock products, which can be generated, it is apparent that diversification can reach very high level. Small farm producing 40 or 50 or more final outputs are not uncommon.

Income diversity

Simpson's DI can also be calculated relative to income. Another convenient measure of income diversity is given by the income diversity ratio (R):

$$R = \left[\sum_{i=1}^{n} R_i\right]^2 / \sum_{i=1}^{n} R_i^2 \qquad (5)$$

Where R_i (i = 1 to n) is the income from the i-th activity. Note that $1 \leqslant R \leqslant n$ for $R_i \geq 0$; and the larger the value of R, the higher the degree of income diversity (McConnell and Dillon, 1997).

2.3.1.5 Flexibility

The property of flexibility of product use provides a second dimension to diversification: it refers to availability of alternative ways of product disposal. There are a maximum of four ways: consume/use, sell/barter, store or process. A product for which all of these possibilities exist is an intuitively preferable, other thing equal, to one, which can only be eaten or must be immediately sold. Further, the quality of process ability permits repetition of the consume-sell-store-process alternative at second, third or higher degree, but very few agricultural products are in fact farm-processed beyond a second-degree stage (McConnell and Dillon, 1997).

Farms of small dependent specializes family farms growing a cash crop such as cotton, tobacco, commercial sugar cane etc. have least flexibility in product use since they have no alternative other than sale. Small subsistence and semi-subsistence farms usually have a highest overall system flexibility because of the type and number of items produced. Flexibility is well illustrated by the range of ways by which jackfruit are commonly disposed of on a Kandy farm. The family will consume some (as the carbohydrate staple in place of bread or rice), sell some for cash, barter some in the village for a chicken, then clean and dice the remainder to smoke-cure and store for use over the off-season. Further, they will probably extract the seeds and consume these; or sundry and barter them for some other food item; or water-store them (for up to eight or nine months) for eventual consumption or sale or barter. Even greater flexibility is possible in the disposal of the many products of the coconut palm (McConnell and Dillon, 1997).

2.3.1.6 Time-dispersion

Time-dispersion of production or income refers to the degree to which a given production or income pattern is predictably dispersed (or, conversely, concentrated) over time – over a season or, more usually, the operating year. It is a measure of the uniformity of within-year production/income flow. Time-dispersion is a basis for distinguishing systems from which the product or income received as a lump amount at one point in the operating year (e.g., in a single harvest month) from systems, which yield a uniform flow over the operating period. The two extremes are (a) a product/income, which is perfectly dispersed, and (b) a product/income, which is all received as a single quality in only one month of the year (McConnell and Dillon, 1997).

When grown at any particular location, all crops fall into one of three categories in terms of time-dispersion of their products:

(i) Naturally time-dispersed crops (e.g., rubber, tea, cacao, cinnamon)

(ii) Naturally time-concentrated crops (e.g., most fruit, vegetables, field crops)

(iii) Man-made time dispersion crops, which are time-dispersed by management (e.g., relay-planted, stored-in-ground) (McConnell and Dillon, 1997).

2.3.1.7 Sustainability

Sustainable agriculture is concern with agricultural systems to remain productive in the long run. By sustainability is meant the capacity of a system to maintain its productivity/profitability at a satisfactory level over a long or indefinite time period regardless of year-to-year fluctuations (i.e., of its short-term instability). In agricultural production context, sustainability is relevant to farming systems of whatever composition, but not necessarily to the individual production phases of short-term crops. The concept involves the evaluation of farm activities and systems in terms of their (interrelated) ecological, economic and socio-structural sustainability over long time periods of many years (McConnell and Dillon, 1997).

Sustainability is a multidimensional concept. In the context of farm systems it may relate to physical, biological, economic and social structures (McConnell and Dillon, 1997). Table 2. indicates the parameters of each indicator of environmental, economic and social indicators.

Table 2. Sustainability indicators of agriculture at household and village levels

Environmental indicators	Economic indicators	Social indicators
Soil erosion	Productivity of rice yield	Land tenure
Water shortage	Land size	Education
Health impact from chemical pesticide use	Farm labor	Food sufficiency

(Source: Praneetvatakul *et al.*, 2001)

Therefore, sustainability is the ability of the agricultural system to maintain a certain well-defined level of performance (e.g., output) over time and if required, to enhance that output without damaging the essential ecological integrity of the system (Norman and Douglas 1994). The greater input of external energy, the more the natural capability of the system can be exceeded, and the less sustainable the system becomes (Gliessman, 2001).

Indicators developed for assessment of sustainable a farm level

a. Rigby, *et al.*, (2001) identified series of index as indicators for sustainability assessment at farm level (Table 3). They also reported that in Malaysia five indicators (i) insect control (ii) disease control (iii) weed control, (iv) soil fertility maintenance and (v) soil erosion control were used to assess the sustainability of agriculture at farm level. In contrast Gomez *et al.*, (1996) used (i) yield (ii) profit, (iii) frequency of crop failure, (iv) soil depth, (v) organic C and (vi) permanent ground cover as indicators at farm level.

Table 3. Farm practices used in the index

Seed Sources	Fertilizers	Pest/disease control	Crop management	Weed control
Conv = Conventional supplier	Synth = Synthetic fertilizers (super-phosphates, urea, nitrate, muriate of potash, mixed granulated NPK or compound fertilizers)	Nat = Natural pest control	R. Var = Resistant varieties/root stocks	Herb = Chemical or hormone herbicide
Org = Organic supplier	Nat = Natural fertilizers, permitted fertilizers which may be inorganic (e.g. rock phosphate, basic slag, gypsum, chalk, wood ash) and inorganic (e.g. processed animal and plant products; hoof, horn, bone, meat and fish meal, plant extracts, dry seaweed)	Synth = Synthetic pesticides, all other pesticides	Rotat = Crop rotation	C&C = Crop & Compost control (rotation, cover crops chosen to suppress weeds, composting manure and plant wastes to kill weed seeds)
Own = Own farm	Org = Organic fertilizer, Non-composted organic fertilizers (e.g. straw, manure, plant waste..) Comp = Composted fertilizer organic fertilizers aerobically composed to kill pathogens G. Man = Green Manure		Inter = Intercropping or companion cropping (to encourage ecological diversity; management of field borders to encourage predators of pest species)	C. Mgt = Management of crop (mechanical or manual cultivation; mulching flame weeding)

(Source: Rigby *et al.*, 2001)

b. In the input/output model suggested by Tellarini and Caporali, (2000) for sustainability assessment of farm, agro-ecosystem performance indicators can be calculated both in terms of energy and monetary value; in addition, they can be 'direct' i.e., obtained as relationship between homogenous entities: energy/energy; money/money, etc, or 'crossed', i.e., obtained by relating dimensionally different measurements: energy values with monetary values and vice versa. Since the flows within the farm and between farm and external world may be expressed as energy or as monetary values or as nutrients, all the indicators can be calculated for each of these flows. Indicators have been categorized as (a) structural indicators, which describe the most relevant characteristics of agricultural systems, and (b) functional indicators, which aim to measure the efficiency of the different systems (Table 4). Both the indicators have been calculated in energy and monetary value.

Table 4. Input, output and functional indicators

Structural indicators related to inputs	Structural indicators related to outputs	Functional indicators
Indicator of dependence on non-renewable energy sources	Indicator of immediate removal	Indicator of gross (net) output from total farm inputs
Indicator of obligatory re-use	Indicator of total removal	Indicator of gross (net) output from annual farm inputs
Indicator of immediate voluntary re-use	Indicator of obligatory internal destination	Indicator of gross (net) output from external non-renewable inputs
Indicator of deferred voluntary re-use	Indicator for immediate voluntary internal destination	Indicator of gross (net) output from total external inputs
Global indicator of voluntary re-use	Global indicator of immediate internal destination	
Indicator of farm autonomy		
Indicator of overall sustainability		

(Source: Tellarini and Caporali, 2000)

2.3.1.8 Complementarity and environmental compatibility

When applied to activities, this last of the eight properties requires that any crop or livestock component of a system be capable of structural integration with all other components of the system and it environment in terms of management practices, resources and technologies used, and disposal of product/by-products. Such structural integration is especially important in relation to long-term activities where bad decisions made regarding one activity and their adverse effects on other activities might not be easily rectified. This probably is a statement of the obvious. However, the more that is learned about the residual effects of herbicides and pesticides and their further effects lower down the food chain, the more apparent it becomes that this property of systems and their components has been neglected in the past (McConnell and Dillon, 1997).

2.3.2 Integrated farming systems

Integrated systems that combine crops and animals are particularly related to the sustainable development. Animals play an important role in small farming systems throughout Asia (Devendra, 1983). In the mixed farming system, animals have contributed more than producing food because the provide the drought power for farm operation and haulage, provide dung and urine for improvement of soil fertility, and also dung sometimes is valued for fuel. In most cases the animals contribute a multiple purpose to the farm family subsistence. They not only provide food but also serve as a mean of survival and security (Devendra, 1994).

There are two types of integrated systems: integrated crop-livestock production systems that are the combination of one or more types of animal species with the crops and fish. Even though three subsystems function independently, they are complementary enterprise. Therefore, the output residues of one subsystem may become the inputs of the other subsystems. And usually, this integration of components produces outputs more than that of the sum of individual effects (Devendra, 1983).

There are eight main advantages of the integrated farming system (IFS):

. Diversification in the use of production resources
. Reduce risk
. The use of farm labors to achieve the high productivity, raise income and access to goods and service
. The interaction of integrated component and complementation provides the efficiency use of resource
. Use of biological and chemical energies are more efficient within the system including less dependence on external sources
. Increase the economic output
. The systems provide the sustainable environment; reduce the external inputs recycling and no pollution, and contribute to environment protection; and
. Development of stable household (Devendra, 1994)

2.3.2.1 Crop-livestock systems

The combination between crop-livestock systems have contributed in increasing income per household even quality of land is improved. Experiment in the Philippines indicated that the combination of cowpea + cassava + swine and cowpea + sweet potatoes + swine reduce the dependence on commercially mixed feeds and solves a potential marketing problem for cowpea (IRRI, 1988).

Indonesian experience shows that cropping patterns have produced enough calories and protein for the family. The improved and introduced farming systems in livestock produce higher income than of farmers who were producing only crops or only livestock (IRRI, 1988).

The majority of animals are permanently housed in backyards and fed indigenous gasses and sedges (Thorne and Tanner, 2002).

The survey conducted in Svay Rieng, Cambodia indicated the raising domestic animal is quite necessary to contribute in increasing food consumption in family and for market. Pigs and cattle can be sold on market to generate income for meeting demand while poultry supply meat and eggs for home consumption. Integration of animals with rice are beneficial to human health and survival, therefore rice productivity has to be improved along with healthier animals (CIAP, 1996).

2.3.2.2 Rice-fish farming systems

Research result from Indonesia has revealed that fish grown with the rice does not decrease the yield of rice varieties IR-64 (115 days), Ciliwung (120 days), and Cisadane (135 days) during wet and dry season. However, the experiment indicates that the rice-fish systems provide higher total income than that of the rice monocropping alone. The treatment: rice + rice-fish + fish-fish or rice + fish-fish-rice give the highest rice equivalent production of more than 19 tons $year^{-1}$ and also farmers could have the fresh fish for consumption which is 80 percent higher than that of farm family with no fish in the rice fields (IRRI, 1992).

Korea has experienced that by adopting rice-fish systems weed control becomes 28 percent more effective than with herbicide application. The system increases rice yield by about 5 percent compare with rice monoculture plus herbicide (IRRI, 1991).

Rice-fish culture can actually increase rice yields (up to 10 percent in some cases) while providing farmers with an important source of protein and extra income (Nesbitt, 1996). After the system of rice–fish culture is adopted, further increases in economic benefit can be realized by improving the combinations of rice and fish and by designing and choosing different kinds of component technologies (Gregory, 1997).

The interaction among individual components or sub-system within the farm system can have significant effects on the performance of the entire system as shown in Figure 2 below that represent by the following fish in the rice paddy system.

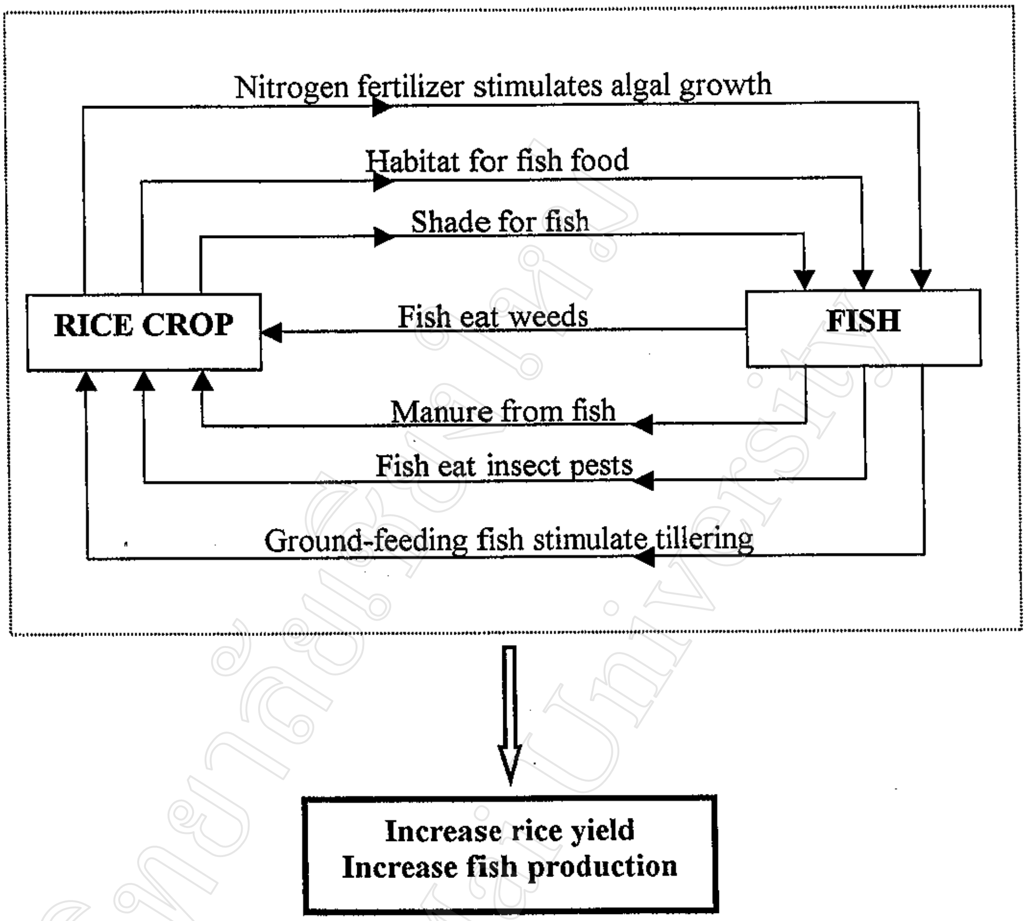

Figure 2. Interactions between fish in the rice paddy system
(Source: Craig *et al.*, 1997)

2.3.2.3 Lowland rice-based cropping system

Rice is commonly grown in the lowlands and the uplands. Rice-based cropping systems predominate in the rainfed lowlands (CIAP, 1999).

. The "all-rice" crop system is attractive in areas where irrigation is available, all year round. Rice is the base crop to grow under this condition. Continuous rice culture not only serves to maximize land use but also makes use of more farm labor.

. For the "two-rice" crop system in rainfed areas, there are some critical management techniques essential to high productivity. The first rice crop should be direct seeded in either a wet or dry paddy. In the case of dry-seeded rice (DSR), the soil is prepared and sown before the monsoon season when the soil is still dry. Land preparation for the second rice crop is then done as quickly as possible to avoid moisture stress in the incoming dry season. The rice-rice-cropping pattern in rainfed areas requires precise timing in term of crop establishment to ensure success.

. The "three-rice" crop sequence is possible only in fully irrigated areas. Precise timing and a peak labor requirement characterize the rice-rice system. Discounting the occurrence of typhoon and insect infestation, rice culture in irrigated areas is more stable and profitable than rainfed rice culture.

. Rice based cropping system with animal upland crops (Maclean, 1998)

Most rainfed lowland areas in the country experience limited rainfall at some time during the year when rice cannot be grown successfully. At this time, the common practice is either to have the field fallow or to plant upland crops that require less moisture. In some case, upland crops are planted before rice. The most common upland crops use is mungbeans, watermelon, and tomato. Mungbean is popular choice because it is:

a). Very hardy (it can grow even at minimum tillage);
b). Early maturing;
c). Drought tolerant;
d). Require minimum input, and
e). Easy to store and sell

Watermelon and tomato are also highly profitable but require a higher investment terms of farm inputs (CIAP, 1999).

2.3.2.4 Rice-animal-fish farming systems

Most of farm households possess a small number of domestic animals. These include chickens, ducks, pigs and cattle. The former two are generally raised for domestic egg and meat consumption while pigs and cattle provide valuable source of cash income on their sale. Chickens, ducks and pigs are reared on household scraps and rice bran as well as scavenging nearby the village (Maclean, 1998).

Children are often responsible for tending the cattle. During the dry season, they drive them to rice paddies, non-cropped areas and grassed roadsides. After transplanting, cut and carry techniques are more often employed to avoid the cattle breaking from their tethers into crops. During this period flooding has reduced the grazing area and rice straw is hand fed to the animals as roughage.

At nigh the animals are sheltered under the houses or in nearby sheds. It is from here that the manure is collected for application on vegetable patches or on rice nurseries and transplanting paddies. Cattle and water buffaloes provide the draft power for a majority of the farm households. Lando and Soleing (1994 a, b, c) observe that, although farmers owned an average of 3.4 animals, the distribution was uneven and in one survey in the rainfed lowland, 21 percent of farmers did not own draught animals (Rickman *et al.*, 1995). These farmers hired animals from neighbors resulting in delays in farming activities. Lower crop yields consequently result from badly time practices (Maclean, 1998).

Small pond fish farming has increase in popularity over recent years. However, only a small number of farmers have experimented with raising fish in the rice fields. The procedure is to dig trenches around or through the paddies. As the water level drops, the fish are able to retreat the deeper water in the paddy. Control of predatory fish proves to be difficult and rainfed paddies often dry out completely during the "mini-droughts" of the wet season. However, properly prepared fields can result in farm surpluses of fish, which can provide a valuable source of income (Gregory, 1997).