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**INTEGRATED AQUACULTURE AS A
MEANS TO SUSTAINABLE RURAL DEVELOPMENT IN
CAMBODIA**

A thesis presented in partial fulfilment of
the requirements for the degree of
Masters of Philosophy in
Development Studies at
Massey University

Stephen H. F. Dowall
1994

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GLOSSARY

AIT	Asian Institute of Technology
Baseline programme	Phase one of SCALE during which comprehensive surveying provided information and understanding of the SCALE project area (including its physical and socioeconomic environment).
BCA	Benefit Cost Analysis
BOD	Biological Oxygen Demand
Brood fish	Mature fish used for breeding.
CCRS	Chang Chamreas Research Station
CDAI	Chamcar Daung Agricultural Institute
CDRI	Cambodian Development Resource Institute
COC	Cost Of Capital
COD	Chemical Oxygen Demand
Data sheets	Forms used for the recording of information in the SCALE surveys.
DC	Development Centre
DK	Democratic Kampuchea (the Cambodian government from 1975 to 1979)
DO	Dissolved Oxygen
FAO	Food and Agricultural Organisation (of the United Nations)
FBT	Farm-based Trial
Hapa	A netting enclosure for breeding or rearing fish.
IAQS	Integrated Aquaculture System
Industrial crops	Crops other than rice (e.g. maize, tobacco, plantation, sugar cane etc).
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
Kakaban	A fibrous mat made in the shape of a two-sided comb on which female spawners can lay their eggs.
LU	Labour Unit
Monoculture	The rearing of a single fish species.
Mono-sex culture	Rearing fish of a single sex to control natural reproduction.
Multi-size culture	The rearing of fish of varying ages in the same pond.
Multi-stage culture	The movement of a uniformly sized fish stock through a series of ponds.
NGO	Non Government Organisation
NPK	Nitrogen, Phosphorous and Potassium
NPV	Net Present Value
Pilot programme	Phases two and three of the SCALE project's implementation during which FBTs are used to develop appropriate IAQS.
PLAC	Prek Leap Agricultural College
Plantation crops	All vegetable crops
Polyculture	The rearing of two or more species of fish in the same pond.
Project areas	Five main (and two strategic) areas in the Kandal province in which SCALE locates its activity (see Figure one).
Recruits	Fry and/or fingerlings caused by natural reproduction.
RLR	Rainfed Lowland Rice
SAO	Southeast Asian Outreach
SCALE	SAO Cambodia Aquaculture on Low Expenditure
Secchi disc	A round disc used for testing water quality (i.e. water turbidity and fertility)
Sex ratio	The ratio of female to male brood fish stocked for breeding.

Sex reversal	Used to produce 100 percent male progeny to control the problem of natural reproduction when growing out fish.
SOC	State of Cambodia (Government)
UNDP	United Nations Development Programme
UNTAC	United Nations Transitional Authority in Cambodia
WFP	World Food Programme (of the United Nations)

CAMBODIAN TERMS

Phum	Village
Khum	Commune
Srok	District
Khet	Province

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ABSTRACT

Cambodia has traditionally had one of the highest consumption rates of fish in the world. Next to rice, freshwater fish is the major component of the Cambodian diet. However, as a consequence of environmental degradation promoted in particular by two and half decades of war and civil unrest, Cambodia's fisheries' catch has plummeted. Further, the national population has doubled over this period and continues to grow at almost three percent per annum. This has caused a substantial deterioration in the nutritional and health status of the rural population which comprises approximately 90 percent of the total population.

As Cambodia's inland waters no longer provide the abundance of fish that they once did, the following research ascertains the potential for small-scale integrated aquaculture. This research is facilitated by an existing *in situ* project (SCALE) which is researching and developing appropriate methods of integrating small-scale aquaculture with the traditional farming systems predominant in the Kandal province of Cambodia. A case study of this project is provided in Chapter four. Much of the research involved in the design and implementation of the project was led by the author and is included in this study.

While the literature shows previous research to have advanced the potential for small-scale integrated aquaculture in Southeast Asia, this potential is considered in the light of the research conducted by the SCALE project. The environmental and socioeconomic situation of rural Cambodia and its impact on the development of subsistence farming systems through the use of small-scale integrated aquaculture is the primary focus of this research.

The viability of small-scale integrated aquaculture for improving the availability of fish to the rural poor, and as such, for contributing to the improvement of the rural population's nutritional status is found to be good. Further, the integration methodologies considered show that small-scale aquaculture can fulfill an integral role in contributing to the sustainable development of Cambodia's traditional farming systems.

Although many of the environmental conditions reflect those found in other countries of the region, there was found to be an extreme variability in the availability of water and land in many instances. Water was either scarce or in abundance, and the ability to manage its availability poor. While few rural people were landless, land holdings were found to be fragmented and often distant from the farm house, thus posing problems of security.

Socioeconomic factors are of major importance and must be accounted for if the potential of small-scale integrated aquaculture is to be realised. This will require the implementation of a development practice which relies heavily on farmer participation in the refinement of appropriate integrated aquaculture methodologies, followed by the utilisation of a farmer-based extension methodology.

In summary the research shows that methods of small-scale integrated aquaculture are available which have the capacity to accommodate the environmental and socioeconomic conditions unique to the area. In particular, systems involving the integration of fish with either rice, cattle and/or vegetables will be the most appropriate due to their ability to complement the existing farming systems in use in the project area. This is endorsed by two examples of financial analyses conducted on two of the project's farm-based trials. They show these systems to be simple and low-cost with considerable potential for facilitating the improvement of farm productivity. At the project level the cost-benefit analysis of the SCALE project shows that the wider development of small-scale integrated aquaculture can be economically justified and is an efficient use of resources in the implementation of sustainable rural development appropriate to the area.

CHAPTER ONE

INTRODUCTION

Increasingly over the last decade the main theme in rural development has become sustainability, or alternatively, how can development practice become sustainable. This thesis seeks to present one means (integrated aquaculture) of achieving sustainable rural development within the context of Southeast Asia, and in particular the State of Cambodia.

While aquaculture has always played an important part in much of Asia's agricultural and economic history, especially in China, in recent years it has become increasingly recognised as one key to resolving the region's food production problem. Aquaculture is already widely spread throughout Asia, as fish is traditionally important in the Asian diet. However, in the State of Cambodia, with the exception of traditional methods of cage culture, aquaculture is not widely or well developed. Also, the country is suffering from a massive depletion of its natural fisheries. Due to environmental degradation during the last two and a half decades of war, civil unrest and a genocidal Maoist regime (Khmer Rouge 1975-79), the fish catch and consumption by this small Southeast Asian Nation, have plummeted.¹

The national population in 1992 was almost double that of the early 1960s (despite the genocide that occurred in the late 1970s), yet the freshwater fish catch nearly halved (see Tables 1.1 and 1.2).² If the population figures in Table 1.1 are used the annual consumption of fish by these fish eating people had dropped from a high average of 26.9kg per capita per year to 13.3kg (see Table 1.3). The consumption of some rural Cambodian³ communities is now as low as 4kg per capita (FAO/OSRO, 1991; SAO, 1989).

Integrating pond culture with traditional farming practices is one possible way to compensate for the declining capacity of the natural fisheries to meet local demands. Can, however, the methods and practices which have been developed in other nations of the region, in particular Thailand, the Philippines and China, be employed in Cambodia in order to return the fisheries catch and consumption (and consequently human nutrition) to what it was pre-war and better? There are strong reasons to suggest that it can.

1.1 SUSTAINABLE RURAL DEVELOPMENT: A DEFINITION

In order to discuss adequately the rationale for using aquaculture as a means to sustainable rural development it is necessary to clarify and define sustainable rural development first. It can be defined in numerous ways according to its desired use.

1 Freshwater fish represent the greatest proportion of domestic consumption. The country is therefore especially vulnerable to the decline in overall fish catch. Rapid deforestation of inundated areas (spawning grounds) and siltation of the Tonle Sap (Great Lake) and Mekong river system are responsible for this (SAO, 1989; NACA, 1992; Dennis, 1992).

2 In the 1960s up to 70 percent of the animal protein consumed was provided by fish (FAO/OSRO, 1991). The then average 120,000 tonnes fresh fish catch was down to an average of 60,000 tonnes in the mid 1980s. In 1979, due to the Khmer Rouge regime, it was almost nil (see Table 1.2).

3 The name "Cambodian" is used rather than the ethnic name "Khmer", to ensure reference to the local people is inclusive of all ethnic groups (for example, Khmer, Cham and Vietnamese). Khmer is only used where it is part of a name (e.g. Khmer Rouge) or where reference is being made to the language of the Khmer people. Khmer is the national language and that spoken by the majority of Cambodia's citizens.

Table 1.1 Changes in Population (million) - The State of Cambodia

1963	1967	1971	1979	1982	1983	1984	1985	1986	1987	1989	1990	1991	1992
5.7	6.3	6.9	4.5	6.8	6.9	7.1	7.3	7.5	7.7	8.0	8.4	8.7	9.0

Source: Asia Yearbooks (1966, 1972, 1980, 1990); Area Handbook for Cambodia (1967); The Far East and Australasia (1979-1980, 1990); ESCAP (1983-1988); World Bank (1992)

Table 1.2 Production of the Cambodian Fisheries Subsector (Mt)

Year	Marine Fisheries	Freshwater Fisheries	Aquaculture	Total Production
1960-69*	45,000	120,000	5,800	170,800
1970	20,000	102,000	5,000	127,000
1980	1,200	18,400		19,600
1981	814	50,780		51,594
1982	3,015	65,700		68,715
1983	9,444	58,717		68,161
1984	7,721	55,093	1,010	63,824
1985	11,178	56,400	3,000	70,578
1986	7,247	64,181	2,200	73,628
1987	17,417	62,154	2,500	82,071
1988	21,000	61,200	4,600	86,800
1989	26,050	50,500	5,538	82,088
1990	39,900	65,100	6,400	111,400
1991	36,400	74,700	6,700	117,800
1992	33,700	68,900	7,241	109,841

* Average for 1960-1969.

Source: FAO/OSRO (1991); Fisheries (1991)

Table 1.3 Total Production of Cambodian Fisheries Subsector (Mt)

Year	Commercial Inland/Marine Catch	Assumed Subsistence Catch*	Total Inland/Marine Production	Kg/capita/year
1960-69	120,000			
1970	127,000	53,500	180,500	26.9
1980	19,600	50,000	69,600	14.5
1981	51,594	50,000	101,594	18.5
1982	68,715	50,000	118,715	17.5
1983	68,161	50,000	118,161	17.1
1984	63,824	50,000	113,824	16.0
1985	70,578	50,000	120,578	16.5
1986	73,628	50,000	123,628	16.5
1987	82,071	50,000	132,071	17.2
1988	86,800	40,000	126,800	16.3
1989	82,088	30,000	112,088	14.0
1990	111,400	20,000	131,400	15.6
1991	117,800	10,000	127,800	14.7
1992	109,841	10,000	119,841	13.3

* These figures are assumed and based on FAO/OSRO, (1991). The steady decrease in the subsistence catch since 1987 is to allow for the introduction of the fishery lot legislation which has increasingly restricted family fishing for subsistence purposes (see Chapter six).

First, for the Cambodian situation rural can be defined as all those communities whose populous derives its livelihood from the land, in many cases this is represented by a subsistence lifestyle. Effectively, this means all those areas and communities excluding the capital city, Phnom Penh, and in some cases provincial centres also.

Secondly, development in this rural context can be defined as that activity which renders an improvement in the well-being of the target community. This might include, for example: better access to potable water and/or health services; the installation of a reliable community irrigation system capable of supplying water for improving crop yields; or, as is relevant to this thesis, an improvement in farm production through the introduction of fish culture. Essentially, if an improvement in the quality of living, (either through improved nutrition and health, increased productivity of farm activity, or advances in the achievement of self-reliance) is obtained, a process of development can be said to have occurred.

Thirdly, if development is defined as increasing well-being or welfare, then sustainable development is simply nondeclining welfare over time, or more specifically, nondeclining per

capita welfare (Pearce and Maler, 1991). Sustainable development therefore, should be viewed as a process rather than an end in itself. In respect to rural development it avoids maximising any single variable, whether it be rice yield, fish production, economic return, or the number of farm households participating in the development activity, to ensure a long-term balance among the variables. A balance of environmental conservation, agricultural production, and community well-being is sought (Butler Flora, 1992).

All aspects of the development activity are important and include technical, environmental, economic and social concerns. However, of primary importance in achieving a process of sustainable rural development is the degree to which the socioeconomic environment of the target community has been considered, understood and accounted for in development planning. This has an underlying influence on all else. Secondly, an integral aspect of the development activity should be the building of local managerial capacity. This is what will facilitate the sustainment of increasing welfare once the community in question must continue with their development process alone.

All this presupposes that sustainable rural development is a desirable goal for developing countries. Numerous value judgements are made in making such an assumption; however, to avoid descending into a discussion of these, it will be assumed that the amelioration of rural well-being in Cambodia (as potentially achieved through systematic rural development) is accepted as being worthy of both academic interest and practical pursuit and implementation.

1.2 THE RATIONALE FOR USING AQUACULTURE AS A MEANS TO SUSTAINABLE RURAL DEVELOPMENT IN CAMBODIA

The rationale for the use of aquaculture in rural development is convincing. As outlined by Pillay (1990), reasons generally fall into two main categories.

First, the cultural and socioeconomic justifications for aquaculture have attracted attention to its potential. Some of those justifications are:

- a) The recognised need for many countries to achieve greater self-reliance in food production;
- b) Its potential for the provision of rural employment, especially for many underemployed rural populations, and as a means to improve the nutrition and income of these populations;
- c) The labour-intensive nature of certain aquacultural operations, and the potential for waste recycling and integration within the traditional agricultural systems;
- d) Production can be geared to market demand, in quantity, size, species, preservation or processing. Production can even continue during the traditional off-season of capture fisheries.

Secondly, certain biological and technological advantages have long been recognised. For example:

- a) Aquaculture is a comparatively efficient means of producing animal protein. The live weight gain per unit of food intake and the consequent protein gain are higher in respect of fish than in respect of poultry, pigs, sheep or cattle (Pillay, 1990; Santhanam et al, 1987);

- b) Cold-blooded animals, especially fish, have relatively low energy requirements. Except for the maintenance of metabolism and body functions, little energy is used for heat production or even normal locomotion (Edwards, 1980);
- c) Since the body weight and density of fish is similar to the equivalent water mass they occupy, they require only a minimal skeleton, and energy expenditure for support and movement is also minimal (Edwards, 1980);
- d) These advantages result in excellent growth rates and production per unit area. Moreover, fish can utilise a three-dimensional water column. In water recirculation systems, this factor can result in some phenomenal yields of fish;
- e) Fish are able to utilise high levels of protein in their diet. Poultry however, can lose half of the amino acids available through protein synthesis, while pigs even lose up to two thirds of these acids (Pillay, 1990). Consequently fish have a much higher protein content. For example:
 - 1kg fat pork = 8 percent protein and 41 percent fat
 - 1kg carp = 22 percent protein and 9 percent fat
 - (Edwards, 1980)

Therefore, in consideration of the employment of aquaculture in less-developed countries, its undeniably great potential for significantly increasing food resources, and consequently human nutrition, must be taken into account. For the undernourished rural poor, an increased supply of protein rich, easily digestible and generally culturally acceptable food is a valuable asset. Moreover, fish can be produced by aquaculture in simple, low-cost systems which complement (not replace) traditional agricultural practices.

1.3 THE RATIONALE FOR LOOKING TOWARD INTEGRATED AQUACULTURE

Integration of aquaculture with other agricultural systems and practices is not new. For centuries, especially in China, the combination of production of commodities such as fish, crops and/or livestock has been practised on a limited scale (FAO/UNDP, 1979). For the ancient Chinese the practice of fish-farming, and the maximum utilisation of farm resources was logical.

For example, farm wastes can be used for fertilisation and feeding fish, while the natural accumulation of silt in the ponds can be used for fertilising crops, vegetables and trees. Moreover, pond embankments can be readily used for growing cash crops, erecting animal enclosures or raising ducks (Pillay, 1990; FAO/UNDP, 1979).

It can be argued (see the following Chapter's) that there are few situations where the concept of integration cannot apply to aquaculture. Whether in a small, one-pond system or in a much larger and more intensive example. Some integration is feasible, at least to a limited extent. It has the potential not only to reduce the costs of expensive supplemental feeds, but also to enhance traditional farming practices, increase the productive capacity of land and provide an unequalled source of human nutrition (FAO/UNDP, 1979).

While probably being integral to the achievement of simple yet productive and sustainable agriculture for rural economies, to what extent can the integration of aquaculture with traditional farming systems in Cambodia aid its adoption by the ordinary farmer? It is

suggested that integration can aid such adoption to a great extent.

The integration of aquaculture with traditional farming practices is an efficient means of recycling waste. This in turn keeps the costs of inputs low and assists in increasing overall production. Where waste is available (but not abundant), fish production will take priority over disposal, but where it is abundant and unused, fish will become just as important as an efficient means of its disposal. In either situation (if properly managed) fish can naturally become a valuable part of the existing agricultural system.

In warm waters the growth rates of some species (nile tilapia - *Oreochromis niloticus*, carp - *Cyprinidae*) can be rapid, and can potentially allow the integration of fish production with traditional agricultural systems as a second crop. For example, this could occur in a rotational rice/fish system. Existing farm activities are thus enhanced and complemented, not made redundant.

In some cases, aquaculture can utilise land otherwise unsuitable for farming. The fertilisers (i.e. bottom silts) provided by ponds may even allow this land to be brought into production for traditional agricultural systems. Rice could be grown in the silt-laden pond beds (Hickling, 1962; Pillay, 1977), or the silt spread over the surrounding land. Moreover, the water from the ponds could be used for irrigation purposes.

The methods and advantages of integration are numerous. However, if the full potential of integration is to be realised in Cambodia, the direct transfer of successful integration methods, which have been achieved elsewhere, should be avoided. While integration principles derived elsewhere are important as guidelines, even more important is the careful assessment of local resources and the prevailing physical and socioeconomic conditions (especially traditional farming methods and attitudes). As Little and Muir have said:

"The extension of integrated farming technology into a particular area requires that it must be not only socially acceptable but also capable of up-take by farmers with the minimum of risk." (Little and Muir, 1987)

In summary a method of aquaculture and integration must be found which is unique, appropriate and sustainable given the conditions and constraints of the local environment. Radical change is rarely easily accepted by any community, and is generally undesirable, if not impossible. Related difficulties may be avoided if due consideration is given to the refinement of new methods to operate harmoniously with existing traditions and farming systems.

1.4 THE AIM AND OBJECTIVES OF THIS STUDY

The principal aim of this study is to examine the attributes of integrated aquaculture and to suggest how they might apply to sustainable rural development practice for the State of Cambodia.

Attention will be focused on pond culture as a possible means of fish production appropriate for integration with the traditional farming systems currently used in Cambodia. This in turn will require an examination of low-input systems to ensure that pond culture is within the reach of subsistence farmers.

While pond culture is only one method of aquaculture, it is selected for examination over other methods such as cage culture, as the use of ponds is not widely developed in Cambodia. Pen and cage culture, however, are believed to have originated in Cambodia (Pantulu, 1979; Pillay, 1990). Pond culture has only recently begun to expand and is

considered by recent studies in Cambodia conducted by the Food and Agriculture Organisation ("FAO") as being essential to the future development of the country's fisheries (FAO/OSRO, 1991).

An integral part of this study is a review and appraisal of an actual integrated aquaculture project recently initiated in Cambodia. This project, was organised by a British non-government organisation ("NGO"), Southeast Asian Outreach ("SAO") and has been largely designed by the author of this thesis. He, together with a co-director have been responsible for the project's implementation. It aims to introduce the concept of integrated pond culture to the Kandal province of Cambodia.

The research to be discussed in this thesis consists of a review and appraisal of the feasibility and economic desirability of the project and reflects part of the overall tasks involved in implementing the project in its first year. The appraisal draws on the information derived from three key surveys:

- a) a provincial level landuse survey;
- b) a commune/village level survey;
- c) a pilot farmer level survey.

These surveys form part of a comprehensive socioeconomic analysis of the Kandal province as a whole. With the exception of the landuse appraisal, the survey work was focused within five representative project areas. The landuse appraisal provided the necessary information for the selection of these areas.

Secondly, the project review and appraisal contains an economic analysis based on production estimates of the proposed development centre (including a fish hatchery) and an estimated number of farmer/village implementations included in the project over the twenty years following implementation. These are based on the preliminary plans of integrated aquaculture systems ("IAQS") which are candidates for implementation by farmers.

1.5 STRUCTURE

In accordance with the stated aims of this thesis, Chapter Two will comprise an introduction to integrated aquaculture, its origin and application for the small-scale farmer. Chapter Three will have a technical focus, looking at integrated pond culture, its management and some typical systems which might be used.

Chapters Four to Seven focus on the SAO project in Cambodia. An introduction and review of the project and its proposed development strategy will be outlined in Chapter Four. The framework for analysis of the project's baseline analysis programme, including an outline of the methodology used for the economic analysis follows in Chapter Five. The results of the baseline analysis will be presented in Chapter Six. These results and their implications will be discussed in Chapter Seven. An overall assessment of the project and the deduced potential for integrated aquaculture as a means to sustainable rural development in Cambodia will be presented. Any recommendations for the project's implementation which have become apparent from the appraisal will also be discussed in this final chapter.

CHAPTER TWO

INTEGRATED AQUACULTURE: ITS ORIGIN AND APPLICATION FOR THE SMALL-SCALE FARMER

2.1 THE CONCEPT OF AQUACULTURE

Aquaculture is a diverse term which is often misunderstood. Until recently aquaculture had never been properly defined and was consequently always surrounded by a lack of clarity. For over a decade it has been used widely to describe the culture of all forms of aquatic animals and plants in fresh, brackish and marine waters (Pillay, 1990). While aquaculture might be simply defined as 'underwater agriculture' (Stickney, 1979), in order to clarify the term FAO has provided the following definition:

"Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resource, with or without appropriate licences, are the harvest of fisheries." (FAO, 1990b, as cited by Csavas, 1990).

The history of aquaculture is long and well developed. China is able to reflect on a settled population and recorded tradition of at least 4000 years. It is therefore hardly surprising that the documented history of fish culture appears to originate there. While some authors believe that the artificial hatching of fish was being practised in China in 2000 BC (Lin, 1940), it would seem that the writings of Fan Lei, 475 BC, are the soundest evidence documented. A politician, and later a culturalist, he considered his fish ponds to be the source of his wealth (Pillay, 1990).

Ancient Egypt and central Europe also possess a long history of fish culture. The Romans reared fish in ponds during the life of their empire (Huet, 1970), and also interesting is an Egyptian bas-relief believed to show the raising of tilapia (*Cichlidae*) in ponds in 2500 BC (Pillay, 1990).

The fish ponds of medieval Europe were undoubtedly stewponds, which was the most practical means of keeping a supply of fresh fish in winter. However, it would have soon been discovered that the fish left in the ponds in spring would spawn. The development of breeding and rearing would have soon followed (Hickling, 1962).

It seems that the common carp (*Cyprinus carpio*), a native of China, can claim to be the subject species of the earliest form of fish culture. As Pillay documents, it was introduced by Chinese migrants, throughout Asia and the Far East. It apparently even reached Europe as early as the Middle Ages for culture in monastic ponds.

Interestingly, the species lost its pre-eminence in China after the 6th century AD. Ling (1977) asserts that this is due to an Emperor of the time having the same name in Chinese (Lee), as the common carp. A fish with a name considered sacred could not be cultured for common consumption! In this way other Chinese carps entered the annals of history (see below).

- a) grass carp *Ctenopharyngodon idella*,

- b) silver carp *Hypophthalmichthys molitrix*;
- c) bighead carp *Aristichthys nobilis*;
- d) mud carp *Cirrhina molitorella*.

Certain provinces of India and Pakistan must also be mentioned in the antiquity of fish culture. Indian carp were apparently the principal species cultured there, and to this day dominate aquaculture in many regions of Asia (Pillay, 1990).

The potential for aquaculture in rural development has become increasingly recognised over the past century. While China has utilised it extensively in its process of rural development for longer than most other countries, it has now become an integral part of rural development policy throughout South and Southeast Asia. However as defined above, although the applications of aquaculture are vast, many are inappropriate for use in rural development.

Generally, it is considered that the most urgent need which aquaculture must address in rural, poor and developing communities is that of increasing nutrition and the capacity for self-reliance. Three aquaculture systems of varying intensities can be used (Edwards et al, 1988).

- a) *Extensive* systems use natural feed produced without intentional pond inputs.
- b) *Semi-intensive* systems depend on fertilisation to produce natural and/or supplementary feed.
- c) *Intensive* systems involve the provision of fish nutritional requirements by pelleted feed (and/or trash fish). Little or no nutritional benefit is gained from natural pond food.

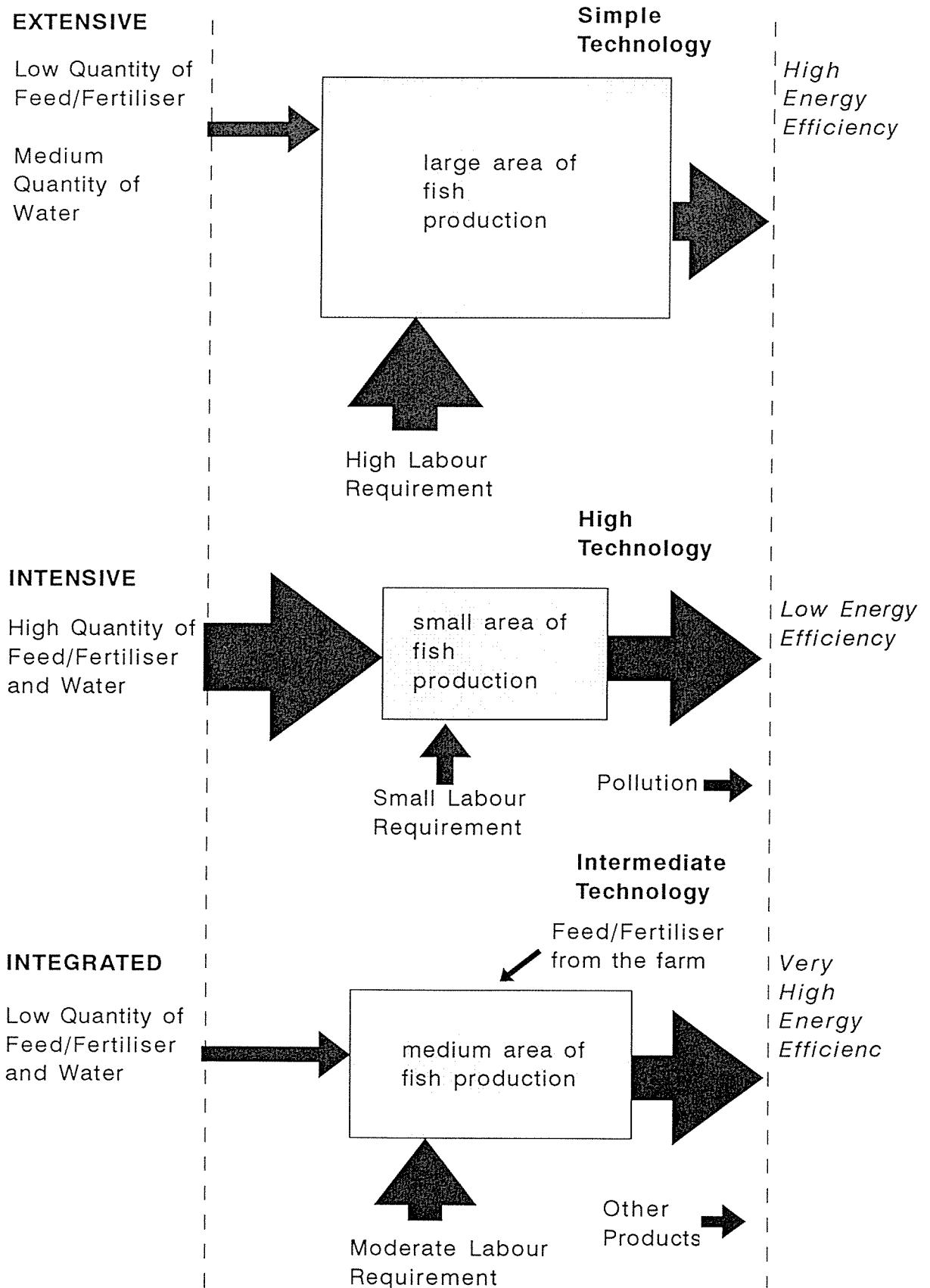
Intensive aquacultural systems are arguably inappropriate, as most rural communities have neither the resources nor knowledge required. These systems are generally more available to middle and upper income groups (Kent, 1986). On a practical level, extensive aquaculture is likely to be more appropriate to the rural poor. While the fish produced per unit area is low compared to intensive aquaculture the inputs required are minimal. Accordingly, it is likely to be more suitable to the traditional farming techniques of subsistence farmers and the rural poor.

The semi-intensive option involves the use of integration and has the potential to improve production of the extensive option while maintaining its simplicity and keeping the requirement for expensive supplements low. The utilisation of the limited resource base of small-scale farmers is more efficient, their diet is improved, and the risks among their various farming subsystems is balanced. Further, they are more fully employed and their capacity to generate surplus produce for sale is enhanced.

The three aquaculture options, extensive, intensive and semi-intensive (integrated), are represented in diagrammatic form in Figure 2.1.

Figure 2.1

Intensive, Extensive and Integrated Aquaculture



(Little and Muir, 1987)

2.2 THE CONCEPT OF INTEGRATED FARMING

2.2.1 A Definition

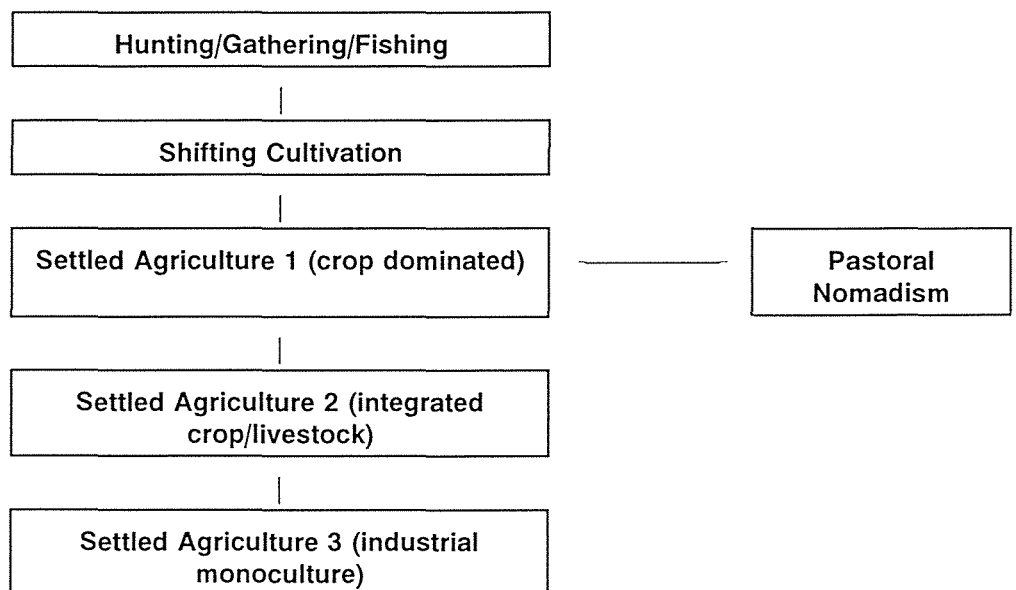
Integration requires the combination of parts into a whole. In a farming system this means that none of the parts (or subsystems) function independently, but rather, are interdependent. By the wasted output from one subsystem becoming an input for another, the efficiency of the productive capacity of the land and water at the disposal of a farmer is improved.

Although byproduct recycling is important, improved space utilisation is an integral aspect of integration. This means that productivity is also improved by two farming subsystems being able to occupy the space of one. Further, risk is minimised by the diversification of farm production.

2.2.2 The Development of Integrated Farming

In order to represent the development of integrated farming a simplified schema as compiled by Edwards et al (1988) is provided in Figure 2.2. Four major stages in the evolution of farming are shown: hunting/gathering/fishing, settled agriculture, shifting cultivation and pastoral nomadism.

Figure 2.2 Schema of Evolutionary Phases in Farming Systems



Source: Edwards et al (1988)

Although the capture of wild fish is still the major source of fish in Cambodia, and fits within the first category, the stage in which most of Cambodia's farming fits is Settled Agriculture Phase 1 (crop dominated). While livestock are an important component in the country's farming systems, the level of integration between the crop and livestock subsystems is minimal. Cattle are used predominantly for draught purposes and although their manure is available for fertilising crops, the farming systems remain mainly crop-based.

Settled Agriculture Phase 2 (integrated crop-livestock) was moved into by much of the now

developed world in the latter half of the nineteenth century (Grigg, 1974). Here mixed farming became important with pasture cultivation, in rotation with crops, providing feed for livestock. In this case the livestock feeding on crops grown on-farm, grazing on-farm pasture, and providing manure for the improvement of soil fertility is an example of an integrated crop/livestock farming system.

According to Grigg (1974) the movement into Settled Agriculture Phase 3 (industrial monoculture) by the now developed countries began in earnest after World War II. Specialisation became much more important and reliance on industrial inputs has made farming increasingly less dependent on the natural environment (Duckham, 1959, 1966).⁴ In some cases underdeveloped countries affected by the "Green Revolution" have moved into this third stage.

The valuable contribution which aquaculture can make to the development of integrated farming in underdeveloped countries, (especially Cambodia) is to aid their move from Settled Agriculture Phase 1 to Settled Agriculture Phase 2. This is feasible through the development of integrated crop/livestock/fish farming. The greatest potential for this development has been outlined by Edwards et al (1988) and can be summarised as requiring:

- a) a focus on freshwater aquaculture;
- b) a concentration on rainfed rather than irrigated areas;
- c) the combination of the storage of water for agriculture with its simultaneous use for aquaculture;
- d) the focus of research and development on small-scale (village level or family) systems.

The conclusion of the requirement to concentrate development on rainfed areas is particularly relevant in Cambodia's case. At least 90 percent of the country's agriculture is rainfed (Phnom Penh Post, 2-15 July 1993).

2.3 THE CONCEPT OF INTEGRATED AQUACULTURE

Small-scale, rainfed integrated aquaculture therefore, is an intermediate option between extensive and intensive aquaculture and involves a direct and simple link between the existing livestock and crop subsystems of traditional farming systems. It is a holistic approach to the development of aquaculture and traditional farming systems in general. While the fish are produced by recycling the byproducts of agronomy and animal husbandry into animal protein, the nutrient-rich pond water and mud can service adjacent crops.

For farming systems which only have crops it will need to be ascertained what the value of the crop byproducts are when used as green manure/compost for the cropping subsystem or alternatively for the fish subsystem as pond fertiliser and/or supplementary feed. Where both crop and livestock subsystems exist then crop residues will be best fed to the livestock and the livestock manure applied to the pond (Edwards et al, 1988). There is a potential here however, for competition between the crop and fish subsystems for the livestock manure.

These methods of undertaking aquaculture have substantial potential compared to the extensive and intensive aquaculture options. As stated by Little and Muir (1987):

"Compared with the simple technology of extensive fish culture and the expensive higher technology of many intensive farms, integrated aquaculture

⁴ Examples of industrial inputs are improved crop varieties, chemical fertilisers, pesticides, herbicides, mechanization, feed concentrates, pharmaceutical chemicals etc.

may be a viable and often superior intermediate option, giving relatively high yields with fairly low input cost." (Little and Muir, 1987).

This makes the development of aquaculture feasible for resource-poor, small-scale farmers with limited (or no) access to the off-farm inputs required for exploiting modern farming technology.

2.3.1 The History of Integrated Aquaculture

The integration of aquaculture with agriculture was an ancient practice in China. China's long history of the complete utilisation of farm resources meant that the integration of fish in traditional farming systems was logical (Pillay, 1990). In recent years this concept has been further supported by the idea of an all-round development of agriculture, animal husbandry, fisheries and other sideline occupations. The current motivation for integration in China is not only tradition but also that it is a national policy of the diversification of production (FAO/UNDP, 1979).

These practices have spread throughout Asia and have been developed through many years of experimentation by individual farmers. It is only in more recent years, however, that the real value of applying the use of integrated aquaculture in farming systems has been fully and correctly appreciated (Delmendo, 1980). Thailand has adopted the use of these integration practices extensively and provides numerous examples of efficient integration systems for the small-scale farmer (for example see Figure 2.3).

Consequently the concept of integration is attracting wide attention and developmental study. It is now recognised and practised throughout Asia and much of Europe as well. More recently, Africa and Latin America have also adopted it (Pillay, 1990).

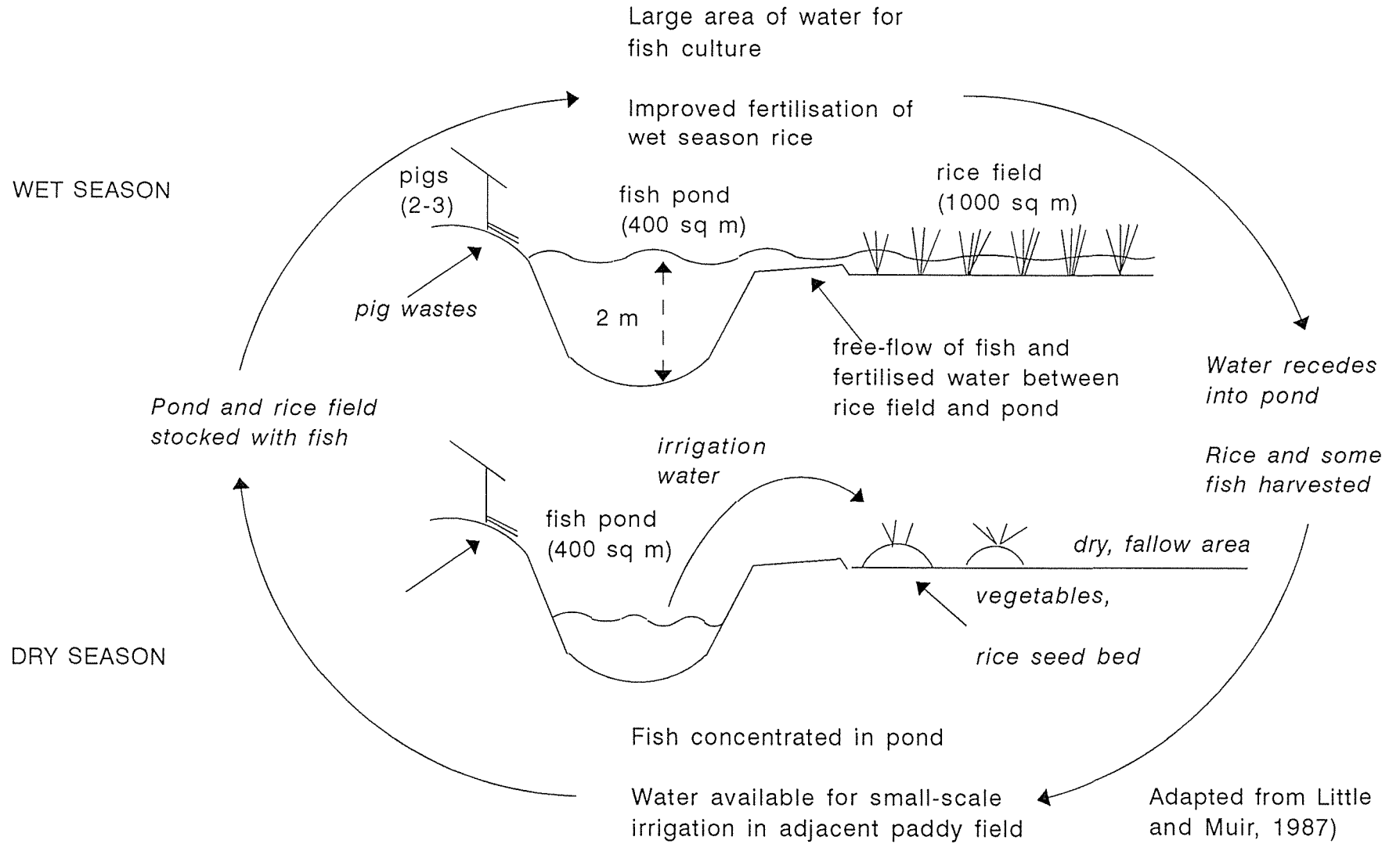
The dominance of rice in food production throughout Asia has been another cause for the natural development of integration. For centuries the collection of wild, naturally-present fish for food from rice paddies has been common. In fact, Khoo and Tan (1980) suggest it might be as ancient as rice cultivation itself.

It has been suggested that fish culture in rice paddies was introduced to Southeast Asia from India as many as fifteen hundred years ago (Tamura, 1961), and that in Indonesia it began during the mid 19th century (Ardiwinata, 1957). Food shortages in the Second World War prompted a brief escalation in rice-fish culture, which later subsided. The increasing use of insecticides harmful to fish also caused a decline in the practice (Khoo and Tan, 1980).

But integration did not only occur between aquaculture and agriculture. It became a practice within aquaculture itself, in the form of polyculture, the raising of more than one fish species in a single pond.

Figure 2.3

Pond/Rice/Pig System in Northeast Thailand



Hailing again from China, polyculture became common through the use of the Chinese carps (Sinha, 1979). Possibly the decline in the popularity and dominance of common carp initiated the system of polyculture in respect of the other Chinese carps (Pillay, 1990). More likely, however, is the theory that most Chinese carps do not spawn as readily in an artificial environment as does the common carp. This means that their larvae must be collected from rivers. Separating them into their respective species would therefore have been difficult. Due to a greater knowledge of each species, this can now be achieved reasonably successfully (Bardach et al, 1972). In the 6th century AD, however, such knowledge was unavailable, and there accordingly arose the now widely acclaimed practice of polyculture (Ling, 1977).

In time, more species were found to be amenable to successful integration with carp. According to Pillay (1990), the introduction of *Tilapia mossambica* from Vietnam into China ended the carp monopoly in pond culture. Tilapia are now widely used in polyculture systems in most developing tropical countries (Pillay, 1990).

2.3.2 Potential for Cambodia

The potential of integrated aquaculture for small-scale farmers in Cambodia can be realised by constructing small, homestead ponds (each unique in design, according to immediate conditions), which require minimal input. Existing farming systems and practices will therefore be respected, complemented and enhanced.

Further, the range of farming systems to which integrated aquaculture can be applied is diverse. It can include the use of most livestock and crops, depending on the method of culture and fish species employed. However, while it can be practiced in larger complex systems (for example, in some parts of China and Southeast Asia), until its use becomes more developed in Cambodia, simpler methods of integration are likely to be more appropriate for the small-scale subsistence farmer.

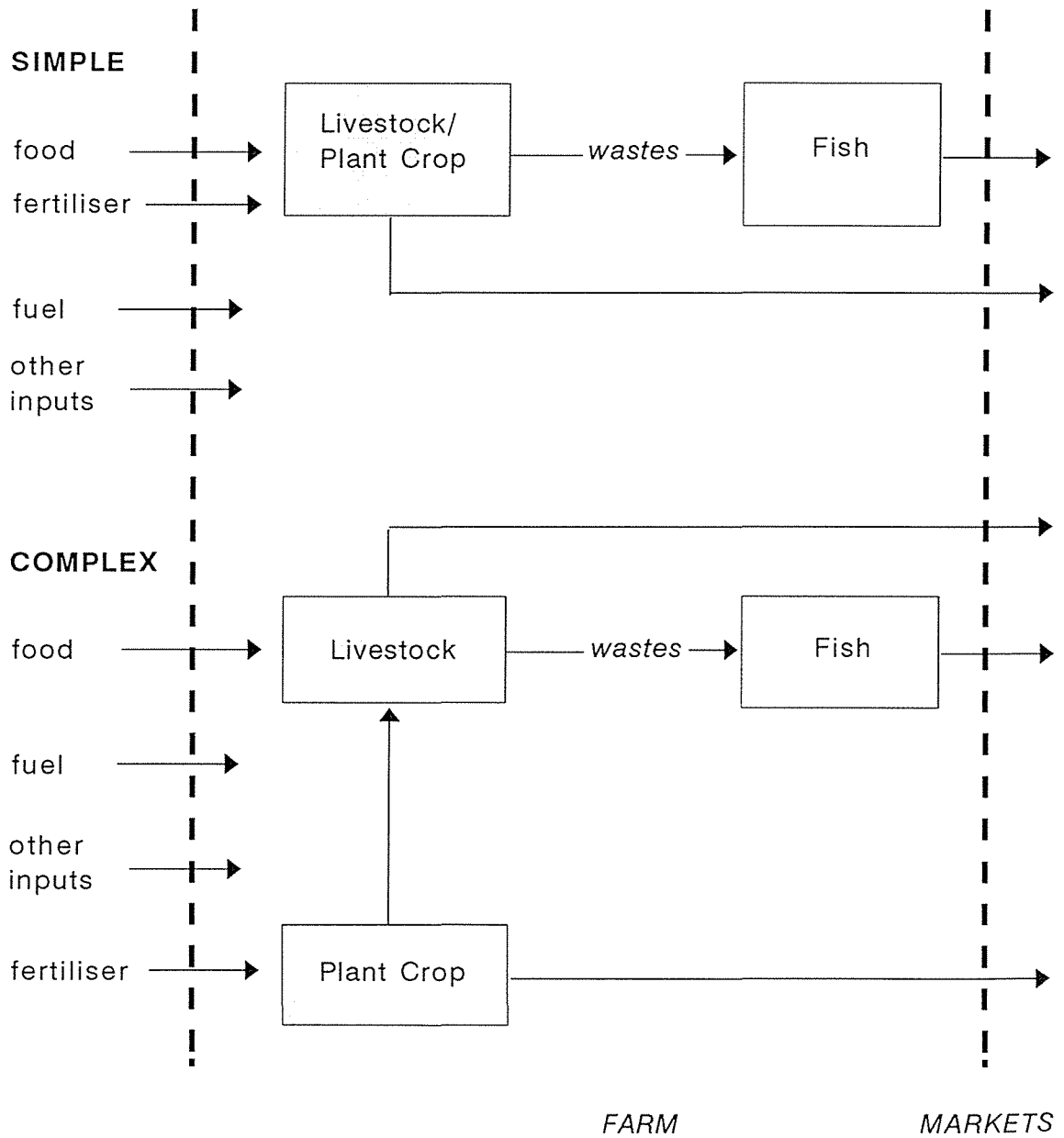
As shown in Figure 2.4 complex systems can involve the use of plant crops for livestock feed. The small farm sizes to which most Cambodian farmers are restricted (0.8 hectares, often in several separate blocks) are likely to inhibit their ability to designate areas for the growth of greenfeed. This is currently being discovered in some areas where trials in the use of green manure crops are being conducted. Most livestock therefore graze around the village under the supervision of children. When grazing is limited, naturally occurring cut greenfeed is collected from other areas, or if necessary, bought.

Increased production through the use of integrated aquaculture from small-scale farms in Cambodia could be of key importance in combating poor rural nutrition and developing its rural sector. Many people suffer from poor nutrition and health as a result of the decreasing ability of the depleted natural fisheries to support the growing population (see Table 1.1 and Figure 2.5).

In a study conducted in Northeast Thailand, Kloke and Patros (1975) found instances of farmers using fish homestead ponds as an integral part of an agricultural system. They concluded that, for a comparable area, 21 times more net income was obtained from supplemental fish farming than from irrigated rice farming, and 74 times more than from dryland rice farming alone. Supplementary feed, supplied from available farm waste,

Figure 2.4

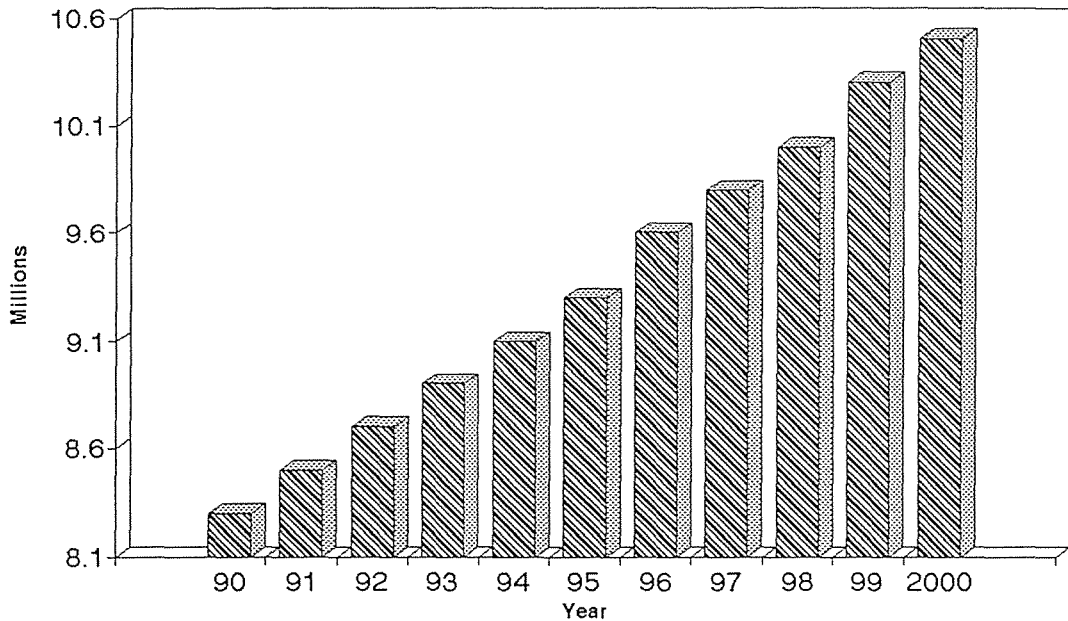
Simple and Complex Integration Systems



(Little and Muir, 1987)

Figure 2.5

Estimated Population of Cambodia
(annual average growth rate 2.48 %)



(Nandesha, 1991)

reduces cost, allows efficient recycling and produces significant increases in traditional farm production.

The system has significant, proven benefits. First, its simplicity allows it to be readily accepted by rural communities. Advanced knowledge is unnecessary, and the system complements existing practices. Farmers are therefore less likely to reject it as a result of incomprehension or sociocultural inhibitions. Secondly, it is likely to be economically feasible for poorer farmers, if not individually, at least on a cooperative basis. Also, once established, its utilisation of animal and poultry waste, crop residue and vegetation can keep operational costs low. In summary, farmers are not required to depart from their existing practices and knowledge, just complement and enhance them.

In respect to rice-fish culture, with the small labour-intensive farming operations characteristic of rural Cambodia and the use of insecticides currently not common, the potential for development is present. It can be used together with rice cultivation, on a rotational or concurrent basis to increase overall production (Khoo and Tan, 1980).

According to Shilo and Sarig (1989), however, in most developing countries the benefits of integration have not yet achieved widespread nutritional improvement. While the limitations and constraints of integrated aquaculture will be discussed later, Shilo and Sarig essentially consider this failing to be due to various socioeconomic drawbacks and rapidly increasing urban populations in the majority of less developed countries, especially in Southeast Asia.

However, it would be wrong to conclude, on the strength of this finding, that integrated aquaculture cannot have an integral role in the rural development of developing countries. Fish have a high protein content and are consequently a good remedy for the protein deficiencies of many rural communities (Edwards, 1980). While not necessarily addressing the problem of rapid population growth or boosting the economic reserves of a nation, further

development of small-scale integrated aquaculture has the potential to improve nutritional standards by yielding large quantities of protein-rich food at low cost (Bardach et al, 1972). Moreover, problems such as underemployment and rural-urban drift may be addressed simultaneously (Pillay, 1979). China is evidence of this.

The potential of small-scale integrated aquaculture therefore, is arguably significant where it is integrated with farming operations in such a way as to utilise readily available waste and farm resources (Kent, 1986). As such, agriculture, animal husbandry and fish farming are both complementary and supplementary to the ecological chain (Sinha, 1979). Simple, appropriate systems of integration are therefore the focus of attention in an effort to contribute substantially to improvement of the economic and nutritional standards of rural people.

2.4 THE ORGANISATION OF AQUACULTURE DEVELOPMENT FOR SMALL-SCALE FARMERS

If aquaculture is to meet the socioeconomic needs of rural communities effectively, its development must be planned and monitored appropriately. Maximum profitability should not necessarily be the ultimate goal (Gerhardsen, 1979). Rather, viability should be the leading principle. Poor and vulnerable rural farmers are unlikely to accept the risks involved in a new project unless it can be proven viable in their circumstances.

The orientation of any aquaculture development, particularly on a small scale and integrated with traditional farming systems, should be toward increasing the overall production and productivity of farmer activity (Gerhardsen, 1979). Only in this way may aquaculture contribute, jointly with other rural activities, to the improvement of health, education, housing, nutrition and other social conditions of rural areas (Gerhardsen, 1979).

However, while production and productivity is important, development must be based on the social, economic and behavioural patterns prevailing in the local community. Whether a farm is large or small and the adopted systems complex or simple, if it does not properly integrate with and complement existing practices and socioeconomic values, problems are likely to multiply and the maximum benefits may not be realised.

In the majority of people-oriented projects the poorest segments of the community are the target group. Therefore, for these people to benefit, a sound understanding of their behaviour, needs, desires, and capacities, whether at the individual level or within indigenous institutions, is essential (Pillay, 1990). While an aquaculture development programme will alone not meet a community's total subsistence and social needs, its integration with or addition to traditional systems and other development activities will.

No matter how technically viable a project may appear, if it does not realise the desired social benefits, its potential will be marginal. Accordingly, once the value of introducing the concept of integrated aquaculture to a community is established, a detailed study of the community itself is imperative (Pillay, 1990). The study should aim at identifying the basic needs to be satisfied and then ascertain those which can be met by the introduction of aquaculture. If it is determined that nutritional standards are low and that protein deficiencies are problematic, it needs to be determined whether the provision of more fish will address these problems. Do the people like fish? If more fish were available, would they be consumed? What are the major preferences in fish species and methods of processing, (dried, salted, smoked, fresh, pickled)? Is the maximum cost of fish production within the reach of the poorest in the community? How do the local people respond to the idea of integrating fish culture with their traditional farming systems? The issues are diverse, but neglecting to gain a sound understanding in the early stages of organisation will almost certainly continue to

impede a project's chances of success.

Pillay (1990) stresses that the degree of technology adopted will be as much conditional on the skills, educational background and cultural constraints present, as on the prevailing agro-climatic and hydrological conditions of the area. Obtaining this information is unlikely to be easy for those planning the development design. It could require a period of residence in the community in order to obtain an appreciation of factors involved.

However, the difficulties likely to be involved in conducting the required research to provide this information does not mean that these issues can be conveniently avoided. Further, it is important that adequate flexibility be incorporated in a project to make future alteration possible in the light of results received from the continuing monitoring of project implementation.

Equally important is local participation in planning and design. For who is better able to assess local needs and conditions than the subject people themselves? Sustainable development will arguably not be achieved unless integration occurs as much by human input in planning and design as by the potential efficacy of the physical systems introduced.

The desirability of substantial participation by the local community in the planning and implementation of any rural development project is now widely accepted, even by large international business organisations such as the World Bank (Bromley and Cernea, 1989; Baum and Tolbert, 1985). Aquaculture development should be no exception, especially where small-scale integrated systems are being proposed (Pillay, 1990).

Research and extension are two major facets integral to the organisation of aquaculture development. While considerable attention has been given to research in recent years, extension remains somewhat neglected (Pillay, 1979). Adequately trained and experienced field personnel, preferably recruited from the local community, are essential to the dissemination of the concept of integrated aquaculture via an appropriately-targeted education programme which involves both the field personnel and the farmers as learners and teachers.⁵ Further, this education and training should be flexible and located in the production areas to make use of existing facilities and resources as much as possible (Gerhardsen, 1979).

If scope for such an inclusive form of education and training is included in project design, the experience and information gained will aid both technique refinement and the creation of an efficient and appropriate extension process.

According to Gerhardsen (1979), another important feature of an extension service is that it should be linked to the appropriate authorities so as to convey information for making regulations and providing encouragement for aquaculture operations. This is important for two reasons. First, without such a link, the information feedback required for refining techniques appropriate to the local physical and socioeconomic conditions will be inhibited. Secondly, the techniques developed will not earn wide acceptance unless the extension service is capable of reaching to the limits of the targeted area through the work of experienced and locally-accepted personnel either under, or associated with, the local agriculture authorities.

In summary therefore, organising effective aquaculture development for small-scale farmers requires a careful analysis of farmers' needs and their socioeconomic environment. Only once these are understood and appreciated can it be ascertained how integrated aquaculture,

⁵ This should include the provision of appropriate extension training and refresher courses, which give the extension agents adequate knowledge and ability not only to assist local people in the implementation of aquaculture techniques and the development of their farming system, but to learn from them as well (Pillay, 1979).

including the planning and design of its extension methodologies, can appropriately assist, if at all. An integral part of this initial research is the involvement of the local people, to ensure the provision of their knowledge and desires, and the assessment of their developmental requirements.

2.5 SETTING OBJECTIVES

The main objective in the development of aquaculture should be producing food and especially animal protein as a means of improving dietary standards (Gerhardsen, 1979). This is of most relevance to rural communities.

However, society's objective in the development of aquaculture in the long term is likely to be influenced by the socioeconomic features of the various groupings often identifiable in the community. These groups each have their own agenda in the development of aquaculture. Gerhardsen (1979) identifies them and their requirements as follows:

- a) Society as a whole;
 - i) Optimal resource allocation for food production, either directly or indirectly, for human consumption;
 - ii) The encouragement of rural settlement through an increased standard of living;
 - iii) The creation of production surplus for export.
- b) Producers;
 - i) Maximise income by greatest possible differential between production revenue and production cost;
 - ii) Maximise return on investment;
- c) Consumers;
 - i) Plentiful food supplies at low, reasonable prices.

National objectives also must not be overlooked. While such objectives will incorporate many of those listed in the preceding paragraph, the underlying long-term objective is a political decision necessary to balance varying interests in order to attain the greatest possible benefits for the greatest number of people, especially those marginalised in society (Gerhardsen, 1979).

Possibly the most important consideration in setting objectives is the realisation that they must attempt to reflect national, regional, and local concerns. Unfortunately this, and the requirement to heed the socioeconomic circumstances and requirements of the area targeted for development, will produce potential conflicts of interest in the setting of objectives.

For example, the creation of production surplus for export in the national interest conflicts with the more localised objective of raising the protein intake of subsistence farmers. The first will be likely to require a large and intensive aquaculture development impacting over a wide area. The second however, will require a focus on the small-scale farmer and the implementation of small integrated aquaculture systems, suited to their available resource base.

The objectives therefore, should remain situation-specific to ensure they are appropriate to the identified immediate and long-term needs for which they are designed. Further, they should be achievable and regularly reviewed to allow for amendment if it becomes necessary

in the pursuit of their fulfillment.

2.6 KNOWING THE LIMITATIONS OF AQUACULTURE

Failure haunts aquaculture development as much as other forms of rural development. While fish is a major component of the Asian diet, and in countries such as Cambodia people have traditionally fed fish occurring in natural ponds, for many the idea of doing so purposely for eventual consumption, is quite foreign (FAO/OSRO, 1991).⁶

This therefore introduces numerous constraints, largely of a socioeconomic nature, which require consideration. In general they can be divided into four categories. Some of the issues they include are discussed below.

2.6.1 Local attitudes and socioeconomic conditions

Most local constraints stem from the local cultural and socioeconomic environment and attitudes. The main concern of small subsistence farmers is security of a steady year-long living for their families. While income and production might be modest, even by local or regional standards, family security is of prime importance (Ben-Yami, 1986).

Further, the local people's ability to absorb new ideas, whether culturally, traditionally or educationally, will affect their perception of the risk to their income and production security. This will frequently dictate the ability of aquaculture development to transcend the planning stage. An example of the type of risk which can be involved is the issue of local land use and tenure referred to by Little and Muir (1987). Where tenure is insecure or by short-term lease, the fear of expropriation may dissuade farmers from undertaking pond construction, lest they cannot reap the ultimate benefit. In particular, tenure problems may discourage the adoption of aquaculture techniques where long-term investment is necessary or where the integrated use of animal wastes requires the relocation and rebuilding of animal quarters. Considerable effort is required for this, and would increase inevitable losses to the farmer if eviction were to occur.

In addition to the requirement for income/production security there are many local and regional differences in fish consumption habits which cause considerable difficulty for the transfer of technology (Ben-Yami, 1986). There is seldom any consistency in conditions between locations.

Every site contemplated for an aquaculture development therefore requires a unique formulation of objectives, techniques and strategies. In some cases these may vary little, but if little attention is given to the particular peculiarities of each location, project failure is more likely. Without doubt, the introduction of aquaculture, in any situation, requires much more than the transfer of technology, associated training, material and financial input (Ben-Yami, 1986).

As Ben-Yami notes, in project identification, often relatively little effort has been applied to ascertaining the nature of the social, cultural and political situation of aquaculture development projects, or, to making a realistic evaluation of their viability and impact. For example, what are the real needs, interests and capabilities of the would-be fish farmers? There is no ready-made technology in any situation. Inadequate participation of the rural people in planning and design or nonrecognition of their point of view and reasons for hesitation in integrating the new concept with their traditional systems often precedes and

⁶ In Cambodia naturally occurring freshwater fish is the principal source of animal protein for most rural communities.

underlies many examples of failure (Ben-Yami, 1986).

If the targeted beneficiaries are to be reached effectively, these issues need to be addressed in the conduct of a detailed socioeconomic analysis. Such an analysis should gauge the likely impacts and ramifications of the proposed development which may feature and assess whether they are acceptable and appropriate to the requirements and wishes of the farmers and local community in question.

The analysis will also need to indicate the training and support which will be required if the farmers are to extend their farming activity to include fish culture. The support required will range from technical assistance, extension services and credit availability to the maintenance of well-organised hatcheries to supply the required fish seed. The establishment and sustenance of adequate assistance, even to small groups of fish farmers, for a sufficient time period is important to ensure that the new techniques lose their initially foreign nature.

Of basic importance in conducting the analysis is the realisation that the farmers and community concerned have been utilising traditional farming systems for centuries. They will need to be convinced that the new concept can be transformed into a viable operation before they will be willing to experiment with something new. Subsistence farmers are not in a position to take risks. Not only their livelihood, but their very survival is at stake.

Further, an investigation of the community should assess the proportion of the population which is landless, and the extent to which they represent the community's poorest. When the focus is on the small-scale, subsistence farmer it is important to note that it does not generally generate the kind of wage employment which the landless could exploit. As family labour is used, aquaculture is more effective at addressing under-employment through the more efficient utilisation of their land (Ben-Yami, 1986).

The unemployed, however, are likely to be landless and consequently may only be included in development undertaken by a village or small rural community as a whole, or where natural, open-access waters can be utilised. Although, under these conditions protection of individual returns, delegation of responsibility and definition of ownership rights is difficult, this does not mean village level developments are unlikely to be successful (Little and Muir, 1987). Rather, careful consideration to ascertain how the limitations might be overcome is required.

2.6.2 Local Institutional Arrangements

Even where small-scale systems are emphasised, the availability and cost of credit will be important and likely to impose significant constraints. Subsistence farmers are unlikely to have sufficient collateral, especially if they have insecure rights of tenure. Unfortunately, in most of the societies in question, farmers will only have access to non-institutional credit at very high interest rates (Gerhardsen, 1979), often over 100 percent per annum. Cambodia, for example, has a long history of usury. In some past cases farmers were forced to borrow against the coming years' harvest (Hou Yuon, 1955). Under these circumstances government collateral-free, or subsidised credit might be necessary if farmers are to obtain starting finance. The design of the credit facility however is important if problems of dependency and low motivation are to be avoided (Little and Muir, 1987).

Gerhardsen addresses this problem by promoting a comprehensive package of advice and assistance. Institutional credit could replace or augment credit from traditional sources so that monopoly situations charging excessive interest can be curtailed. Then, as farmers gradually increase their production, they would be able to market some of their produce. Keeping development and techniques simple, appropriate and inexpensive, and avoiding dependence on purchased input as far as possible, are undoubtedly essential tasks. Few, if

any, farmers would consider using expensive credit or mortgaging their property to finance an aquaculture venture (Wijkstrom and Jul-Larsen, 1986).

2.6.3 Local Environmental Constraints

Inevitable local bias causes aquaculture development to be highly situational. The wide range of relevant issues will be examined later, but a pertinent example highlighting environmental constraints is soil acidity. In many cases throughout Africa, ponds have been constructed on sites containing unsuitable soils, rendering them totally or partially inoperative (Ben-Yami, 1986). The composition of silt, sand and clay in the soil can be another constraint. Where the percentage of clay is low the soil's water retention capacity will be poor. Of major importance also is the availability of a reliable water supply. While there are some methods of integrated aquaculture in tropical climates which can yield satisfactory results in two to three months, it is still important that the water source be adequate for the duration of the growing period.

2.6.4 The Existence of Externalities

It is necessary to investigate and understand the range of local landuses, farming systems, and the methods of production used for they may be producing externalities which are detrimental to aquaculture. A major example here is the reduction in fish/rice system yields due to incorrect or excessive pesticide applications. This may apply not only to the specific paddies stocked with fish, but may be a problem in the general area if irrigation water *per se* carries toxic substances. This factor has reduced the viability of integrated fish culture, including pond culture, significantly in some areas of Southeast Asia (Little and Muir, 1987).

2.7 NECESSARY CONDITIONS FOR SMALL-SCALE AQUACULTURE

There is a seemingly infinite list of conditions necessary for successful aquaculture development. However, where the welfare of rural people is concerned, and development is aimed at low-cost, small-scale systems, the following general conditions as cited by Ben-Yami (1986), must prevail:

- a) people's needs and attitudes favour change and, consequently, prospective fish farmers exist;
- b) political circumstances will enable equitable access by the prospective fish farmers to natural resources of sufficient quality (e.g. land, water);
- c) access by the prospective fish farmers to:
 - i) adequate supplies of seed, feed, equipment and materials;
 - ii) to disease prevention and treatment and extension services; and
 - iii) if appropriate, credit and market facilities;
- d) convincing indication of potential for personal, economic and social benefits;
- e) financial/commercial viability of both individual farms and support services;
- f) favourable natural and market conditions.

In the case of subsistence farming, market conditions may not carry significant importance. However, many subsistence farms are likely to have some marketable produce. From good harvests there may be some surplus produce available for the farmer to sell for income. Moreover, the farm family concerned may have a greater preference for pork, poultry, beef, or wild fish species and so be inclined to sell most of the fish harvest.

The importance of point (a) above is not merely restricted to the question of people's

readiness to change, but applies to all the socioeconomics involved in such decision making, including social factors likely to influence the introduction of aquaculture. For example, aquaculture development might grow from a general realisation that traditional farming systems are no longer capable of supporting the people, but may then depend on apparently trifling factors such as people's willingness to consume waste-fed fish.

Pillay (1990) implies that future development in small-scale aquaculture, if it is to be successful, will require particular sensitivity to, and respect for, the traditional systems and knowledge of rural people. Those people will require to be included in an active (not concessionary) capacity at all levels of decision-making; from identification and planning to implementation and evaluation.

The objective in this process should be to complement, rather than interfere with or replace, other agricultural or livestock practices currently employed. This need not restrict development, but if viewed positively, may become a mandate for the promotion of integration.

In this way integrated aquaculture not only provides a possible answer for the technical and economic issues of intensive aquaculture with a high level of artificial inputs, or the low yields of extensive aquaculture, it has the potential to be socioeconomically appropriate for small-scale farmers, and therefore achieve a high degree of participant acceptability.

The second likely requirement for future development will be that production quantities be kept small and simple. This will ensure that the rural people most in need of the diversification which fish culture can provide will not be deprived of the benefits of production. Furthermore, acceptable modifications will be those not requiring large investments or expensive purchased inputs (Wijkstrom and Jul-Larsen, 1986).

The SAO project reviewed in chapters four to six is a good example of an appropriate aquaculture development strategy for small-scale farmers. The baseline programme of the project outlined in chapter five provides a good example of the emphasis required on socioeconomic analysis in the planning and design of such a development strategy.

Prior to focusing on the SCALE project however, it is necessary to consider in some detail the methods of pond culture and integration which are likely to be appropriate to the small-scale farmers for which SCALE is designed. Chapter three therefore, provides an overview of some of the attributes and management considerations of small-scale integrated aquaculture.

CHAPTER THREE

FISH PONDS AND THEIR INTEGRATION

While in the previous chapter aquaculture and its integration into agricultural systems were discussed in general, we now turn to more specific discussion of small-scale aquaculture on farms using fish ponds. This will include a survey of some of the various methodologies of pond culture.

3.1 THE ATTRIBUTES OF POND CULTURE

Huet (1970) asserts that the farming of fish is generally practised in ponds, sections of shallow water laid out in such a way as to be easily drained. They do not include waters which cannot be drained (for example, naturally occurring pools, ponds and lakes). While other fish culture systems exist (cage and pen culture, for example), their use does not have the wide application of pond culture (Pillay, 1990). The previously cited situation of Cambodia testifies to this.

According to Schroeder (1980), the characteristics of a pond make it an excellent environment for converting crude, inedible nutrient material into high quality fish food. Originally bound and indigestible nutrients and minerals are released by intense microbial activity occurring in the pond's water column and on its bed. They can then provide substrates for the photosynthetic (autotrophic) and microbial (heterotrophic) production of basic fish food.

Quite simply, however, as Chakroff (1976) notes, ponds can be located close to home, which is far more convenient for obtaining the family's fish requirements than from the nearest river or market. While pond siting can be complex, involving issues of soil and water quality and topography, it nevertheless is generally possible in most environments. As will be described later, in rice growing areas it is not even necessary to take rice paddies out of production, because they can be utilised either concurrently or in rotation with fish. This simple application of pond aquaculture to small-scale systems also means that:

- a) fish growth can be controlled, and protected from predators;
- b) fish species, within the boundaries of environmental constraints, can be matched to the pond owner's preferences;
- c) where animal and agricultural wastes are used for pond fertilisation, an inexpensive supply of fish is available on demand for either subsistence or market purposes;
- d) property rights can be easily defined (Chakroff, 1976).

Improved landuse can also be viewed as an attribute of pond culture. Again, as Chakroff succinctly states;

"Some fish farmers may be more interested in fish farming when they realise they can accomplish two purposes: provide a reliable food supply and make the best possible use of their land" (Chakroff, 1976).

There are numerous improvements, some of which include the following:

- a) The fertilising of fish ponds can, in time, effectively bring poor quality soils or at least nutrient depleted soils back into crop production.
- b) Land previously of little use for traditional crops can be adapted for the building of fish ponds.

- c) Fish can be integrated into existing landuses without denying the continuation of those previous uses. For example, ponds can be incorporated in existing water supply or irrigation systems, or as already noted above, fish can be grown in rice paddies, with few changes to the paddies' design being necessary. Pillay (1990) refers to the use of pond embankments being conveniently used for the cultivation of various cash crops or for raising ducks.

3.2 INTEGRATION: BENEFITS AND PRECAUTIONS

Integration would appear to have both direct and indirect advantages, which when considered in their entirety prove its worth beyond doubt. Many of these have been listed above already, but in order to present an adequate picture of the value of integration and its benefits on a socioeconomic, technical or environmental basis, they require specific attention.

The ancient concept of aquaculture, first developed in peasant economies (Pillay, 1990), is now considered by some to be the only practical means of achieving sustainable small-scale agriculture in many parts of the developing world (Little and Muir, 1987). As the 1978 FAO/UNDP Chinese study tour found (FAO/UNDP, 1979), the provision of cheap foodstuffs and organic manure means that the cost of artificial inputs in pond culture is significantly reduced and often eliminated. Obviously, when costs are reduced profits are increased, or, in the case of subsistence ponds, fish culture will become a viable operation for poorer farmers. The study tour learned that the profit from fish culture can be improved by as much as 30-40 percent under integration.

Further, the benefits of integration are not entirely restricted to fish production. For example, in rice/fish culture Middendorp and Verreth (1986) found that the average paddy yield from the Lam Pao irrigation project of Northeast Thailand was about 15.8 percent higher than the yield from the rice fields without fish. This is verified in previous findings in Southeast Asia (Ruddle, 1982). The fish will feed on phytoplankton and submerged weeds which compete with the rice, while the fish food and excretion will improve paddy fertility (Little and Muir, 1987; Santhanam et al, 1987; Pillay, 1990). So by adding fish to existing animal and agricultural systems, overall income, self-sufficiency and self-reliance can be increased.

Also, as de la Cruz (1980) asserts, the use of fish provides a solution to problems of waste management and pollution control. A completely integrated production cycle is created where wastage is eliminated. Even the silt accumulation in the fish ponds, can be efficiently utilised as a crop fertilizer (FAO/UNDP, 1979).

In summary, Pillay (1990) asserts that integration is a means of diversifying farm production while providing food for farm families and their surrounding populations. The operational efficiency of the farm is improved through improved use of family (or village) labour and land (de la Cruz, 1980). According to Pillay, much of the hard labour is required when there is less labour demand from other farm activities anyway.

The basic principle on which integration should be based is the full utilisation and conservation of waste from inter-related farm activities. Effectively this means that "there is no waste" and "waste is only a misplaced resource which can become a valuable material for another product" (FAO, 1977b).

Integration does require the observance of certain precautions, since, not surprisingly, excessive application of organic waste could well have adverse effect. Little and Muir (1982) state that waste-fed eutrophic ponds are more productive than natural ponds, but also less stable. The variations in water quality, especially dissolved oxygen levels, may be harmful

to fish growth and may even cause acute mortalities. Schroeder (1980) does not consider this an unavoidable constraint. In fact, he blames poor yields in fish culture, as in animal husbandry in general, on poor management. While unforeseeable cloudy weather may reduce photosynthetic production and produce anoxia and possibly fish deaths, proper management should have taken climatic variations into account in the same way as it considered the pond's environment.

Nevertheless, despite management quality, dissolved oxygen ("DO") depletion remains a hazard of integration where organic wastes are used (Schroeder and Hepher, 1979; Little and Muir, 1987). With reduced oxygen production at night (reduced photosynthesis), minimal oxygen levels prior to sunrise occurs daily. It is therefore a continual concern, requiring close monitoring. As Doudoroff and Katz (1950) (as cited by Allen and Hepher, 1979) indicate, the fish are not only susceptible to the reduced DO, but also to stress from substances which they may usually tolerate under high DO levels.

In properly manured ponds, the DO concentration is often higher after an initial week of fertilisation than in comparable non-manured ponds. The increased phytoplankton populations produce oxygen, which more than compensates for that being used by the decaying organic matter (Schroeder and Hepher, 1979). However, caution is required here also. Allen and Hepher (1979) cite numerous references to the effect that supersaturation of pond waters from phytoplankton photosynthesis may adversely affect both the growth and survival of some fish species. Thus, as Little and Muir (1987) confirm, the importance of fish grazing on phytoplankton becomes apparent.

Where small-scale pond culture is involved, farmer ability in assessing water quality where the addition of waste is practised could be a problem (Little and Muir, 1987). Traditionally, waste addition is managed by the observation of water colour and fish behaviour in early morning. However, this is greatly dependent on the skill and experience of the individual. Waste management methods are discussed in section 3.7.2.

Constraints of a public health nature in integration using animal waste have not been found to be a problem. The fish pond itself functions like a stabilisation pond and adequate cleaning and cooking of the fish will eliminate any remaining pathogens (Edwards, 1980).

Composting and biogas production are used in some places to ensure pathogen transfer is prevented. The Chinese compost the animal waste with plant material and soft mud to allow it to ferment prior to use (FAO, 1977). By first using the manure to produce biogas, the residue can be used in numerous ways. Maramba (1980) refers to the liquid portion of the slurry being used to fertilize crops, with the overflow fertilising the fish ponds. The solid sludge can also be processed into animal feed.

However, while composting has been commonly practised in some areas, some research would suggest it to be unnecessary and to cause the loss of desired nutrients (see Section 3.7.2).

Social needs will probably determine the degree of social acceptance of integration using animal waste. As Allen and Hepher (1979) state, citing numerous references, the social, economic and political considerations that influence human behaviour in this regard are highly complicated. Honesty and candour, education and public involvement are the key to social acceptance.

Constraints on integration involving rice and fish are also evident. If wild species of fish enter the rice-growing areas or cultured fish are introduced too early, they can damage the crops by either eating the grain or consuming the stalks and leaves. Pesticide use may also be difficult (Koesoemadinata, 1980; Khoo and Tan, 1980), while the area in the paddy required

for digging fish refuges may actually cause a decrease in total rice production (Little and Muir, 1987). A complete list of relevant constraints is available in Singh et al (1980). However, none of these constraints need be overly restrictive.

Meanwhile, the benefits of integration are obvious. It might be that the benefits of integration will be more obtainable if rice/fish culture is promoted to farmers bound by more traditional attitudes, or where their farming system focuses predominantly on a single crop of rainfed rice. Pond culture can then be promoted to more enterprising individuals or those less bound (for climatic or environmental reasons) to a rice dominant farming system (Middendorp and Verreth, 1986). Extra operating costs and labour requirements are minimal in rice/fish culture, yet the potential for production improvement is significant (Santhanam et al, 1987).

3.3 METHODS OF CROP/FISH CULTURE

3.3.1 Rice/Fish

The different types of exploitation of rice field fisheries can be generally classified as follows (Khoo and Tan, 1980; Pillay, 1990; Little and Muir, 1987):

- a) Captural methods in which indigenous stocks are trapped in the newly flooded fields;
- b) Cultural methods⁷ in which stocks of fish are artificially introduced. Within this particular system there are two further methods of production:
 - i) Concurrent culture, in which fish are reared together with the growing of the rice crop.
 - ii) Rotational culture, where fish are grown as a single annual crop, as in Indonesia (the 'Palawidja method') or, alternatively as an intermediate crop between the rice harvest and next planting (the 'Panjelang method').

Little and Muir (1987) have produced a concise summary and comparison of the captural and cultural systems, which is presented in Table 3.1.

In its traditional form rice/fish culture requires very little extra inputs, and, in rotational culture, it provides off-season employment for farmers (Pillay, 1990). However, there are definite requirements if it is to be effective.

As cited by Pillay (1990), Little and Muir (1987), Santhanam et al (1987) and Khoo and Tan (1980), it may become necessary to:

- a) reinforce and increase the height of the bunds (paddy walls);
- b) construct ditches for areas of refuge for the fish, possibly totalling five to ten percent of the land area⁸;
- c) maintain higher water levels (10-25cm);
- d) where concurrent culture is practised, grow varieties of rice which have a strong root system, are deep water (floating) tolerant and have a suitable life span to achieve optimal fish growth.

⁷ In the concurrent cultural method, rice remains the main crop, while in the rotational cultural method, fish is the main crop (de la Cruz, 1980).

⁸ Natural ponds occurring in paddies can act as refuge areas also.

Table 3.1 Comparison of Captural Cultural Fish/Rice Culture.

	Captural	Concurrent (Bersama)	Cultural	
			Rotational	
			<i>Palawidja</i>	<i>Panjelang</i>
<i>Description</i>	No stocking of fish, fish populations enter flooded ponds and paddies, where reproduction occurs. Harvest on fish entering, during and at end of crop growing season.	Fish reared simultaneously with the growing of the plant crop.	Fish cropped after a single annual rice crop.	Fish cropped between harvest and next planting.
<i>Occurrence</i>	Very widespread compared to cultural, e.g. 4 million ha, Indonesia.	Hong Kong, India, Indonesia, Japan, Malaysia, Thailand, Vietnam.	Indonesia, Thailand.	Indonesia.
<i>Advantages</i>	Cost: minimum inputs required, some adaption of paddy field.	Fish increases plant production by fish culture residues, also help to control pests, weeds, insects, molluscs.		Particularly useful for short term fry production. May reduce water use.
			Pesticides, fertilisers, modern intensified cropping method may be used. Reduced water needs, reduction of pesticide accumulation in fish. Pest control by interruption of life cycles. Plant residues benefit fish (e.g. rice stubble, split grain). Fish residues benefit plant production (not as much as concurrent). Reduced production costs-since paddy bottom soft and clean after fish culture.	
<i>Disadvantages</i>	Natural/wild fish are typically carnivorous, not most productive. Few benefits of fish culture to plant, fish not normally fed.	Plants/fish may have different water requirements. Limits use of fertilizers and pesticides.	Only possible where water available year round i.e. irrigation systems. Highly intensive cropping methods and profitability threaten viability.	

Source: Little and Muir (1987).

In some cases however, it is not essential that the growth period of the rice be particularly long. There are some fish species available (in particular Nile tilapia) from which a harvest can be produced in as little as two months, depending on the size at which the fish seed was stocked and the level of nutrition maintained.

As mentioned in the previous section, pesticide use may require to be restricted. However, the use of Carbofuran (a typical systemic insecticide) seven days prior to fish stocking is

apparently acceptable.⁹

According to Santhanam et al (1987), fish species used in rice/fish culture must be tolerant to shallow water, high temperatures, low DO and high turbidity (see also, Khoo and Tan, 1980). Philippine experience shows that two species likely to be appropriate are the common carp and tilapia (de la Cruz, 1980).

Of further importance is the risk of predatory fish getting into the rice field. This has been found to be a particular problem in Cambodia (for example, in rice/fish culture using tilapia next to the Tonle Bati lake on the border of the Kandal and Takeo Provinces). To avoid this hazard it is necessary to stock the rice field with fish seed large enough to deter any predatory fish which may enter the field. A direct correlation has been found between fish seed size and the mouth size of the predatory fish in respect to the fish seeds susceptibility to being consumed (Edwards, 1993).

A number of the requirements mentioned above are less important in rotational rice/fish culture, although the interval between the rice harvest and fish stocking must be sufficiently long to allow degradation of pesticides (Pillay, 1990). As Pillay notes, infestation by insect pests is less, due to their life-cycles being disrupted (see also de la Cruz, 1980).

de la Cruz adds also that the benefits of rice/fish interaction are valuable. For example,

- a) fertiliser residues from fish later benefit the rice;
- b) decomposing rice stubble is a good medium for natural food growth;
- c) rice can be directly planted into the paddy bed without tillage;
- d) fish production can be achieved in the rainy months during which the climatic risk to rice is greater.

3.3.2 Vegetation/Fish

Aquatic macrophytes and/or terrestrial plants can be used as pond inputs for ponds stocked with herbivorous fish. Where animal manure is not available or in limited supply this can be a useful alternative as herbivorous fish produce large amounts of faeces which in turn have a fertilising effect (Little and Muir, 1987). Whether from wild or cultivated origin many species can be used as supplementary feeds. Green fodder can be applied directly as a feed for macrophyte feeding fish (for example, grass carp and silver barb *Puntius gonionotus*).

In some cases plant matter can be used in ponds without macrophagous fish if it is used as a green manure. As a manure it is allowed to decompose and so act as a fertiliser. As an organic manure it is either applied to the pond water or used during the ponds preparation prior to filling. Martyshv (1983) discusses the growth of green manure crops in the pond before filling with water. Alternatively, they can be piled on the pond bottom and allowed to rot before filling with water.

Unfortunately the feasibility of growing submerged vegetation in the pond together with the fish is not good. To provide adequate feed for the fish the macrophytes would need to be fertilised, which would tend to produce excess phytoplankton growth causing the submerged macrophytes to be shaded out (Edwards, 1980^b).

Edwards (1985) however suggests that this problem can be overcome by utilising a macro-

⁹ Carbofuran is a common name for 2, 3-dihydro-2, 2-dimethyl-7-benzofuranyl N-methylcarbamate. It is the active ingredient of a systemic insecticide-nematicide, Furadan (a registered trademark of FMC Corporation, Philadelphia, U.S.A). It is readily absorbed by the roots and translocated to other parts of plants when applied to the soil (Estores et al, 1980).

microphagous polyculture system (for example, silver barb and Nile tilapia). The tilapia in such a system provide an element of control on the phytoplankton production.

The use of a floating macrophyte such as duckweed will not incur the same problem as phytoplankton growth will be controlled by the shading effect of the duckweed. If a pond is small, well manured and lightly stocked with young grass carp, duckweed can be grown successfully while still providing adequate feed for the fish (Hickling, 1971).

The collection of macrophytes from near-by water bodies has potential. Duckweed in particular is often found in small, shallow and stagnant water bodies and is easily harvested by seining. It is a high quality feed with favourable protein, fat and fibre contents, especially if taken from nutrient rich water. *Lemna spp.* has been found to be a popular duckweed species (Little and Muir 1987).

Collected grasses and crop residues are often useful pond inputs and an effective way of facilitating integration. While large quantities are required when they are used as supplementary feeds for fish, they are generally wasted anyway, and can potentially allow the inclusion of macrophyte feeding fish in a polyculture system with other species. The utilisation of crop residues in this way by fish is also an efficient means of diversifying a farmer's cash cropping income and protecting it against market fluctuations. Little and Muir (1987) suggest that when crop prices are low it may become more economic for small farmers to feed some or all of their crop (maize and cassava, for example) to the fish than to market it. See Table 3.2 below for a list of some of the plant materials known to have potential as supplementary feeds for herbivorous fish.

3.4 METHODS OF LIVESTOCK/FISH CULTURE INTEGRATION

While there exists a wide range of livestock, including pigs, cattle, ducks, chickens and geese, which can be integrated with fish, attention will be focused here on cattle, pigs and ducks only.

Pillay (1990) asserts that pigs or ducks integrated with fish has produced the best results due to their high quality manure. In China, pigs are considered to be a 'cost-less fertiliser factory moving on hooves' (FAO, 1977b). Integrating the production of ducks and fish has proved to be mutually beneficial due to pond embankments providing space for duck rearing, duck excreta fertilising ponds and ducks themselves feeding on unwanted organisms growing in the ponds (Pillay, 1990).

For small-scale farmers however, the utilisation of cows (whose manure is of lower quality than both pigs and ducks) may be more appropriate. While most farmers own cows, not many resource poor farmers own pigs or ducks. Most of the A.I.T Outreach project farmers in northeast Thailand have integrated fish with cattle for this reason (Edwards et al, 1991).

3.4.1 Pig/Fish

Of considerable value in pig production is the fact that they will consume readily-acquired kitchen waste, aquatic plants and crop wastes (Delmendo, 1980). Various systems of rearing can be used. For example:

- a) In China, pond embankments are wide (possibly over 10 metres), so as to facilitate the building of sties and the planting of crops (Pillay, 1990). The waste is collected, converted into compost or processed in biogas plants, and then conveyed to the fish ponds by feeder channels running through the pond embankments (Delmendo, 1980). In some cases the sty floor is sloped to allow the waste to flow directly into the pond (Little and Muir, 1987).

Table 3.2 Vegetation With Potential for Fish Production

Plant Type	Common Name	Biological Name	Reference
Terrestrial grasses	Elephant (Napier) grass	<i>Pennisetum spp.</i>	Edwards, 1982
	Guinea grass	<i>Panicum maximum</i>	Little & Muir, 1987
	Lalang grass	<i>Imperata rundinacea</i>	Little & Muir, 1987
	Star grass	<i>Cynodon plectostachyus</i>	Little & Muir, 1987
	Para grass	<i>Brachiaria mutica</i>	Little & Muir, 1987
Terrestrial crop residues	Maize	<i>Zea mays</i>	Ruddle, 1985
	Cassava leaves	<i>Manihot esculenta</i>	Hickling, 1962
	Sweet potato leaves	<i>Ipomea batatas</i>	Ruddle, 1985
	Sugar cane leaves	<i>Saccharum officinarum</i>	Ruddle, 1985
	Velvet bean vines	<i>Mucana spp.</i>	Gohl, 1980
	Cabbage leaves	<i>Brassica spp.</i>	Edwards, 1982
Aquatic macrophytes	Water hyacinth	<i>Eichhorina crassipes</i>	Edwards, 1982 ^b
	Water lettuce	<i>Pistia stratiotes</i>	Edwards, 1982 ^b
	Duckweed	<i>Lemina spp.</i>	Van Dyke & Sutton, 1977
	Water spinach	<i>Ipomoea aquatica</i>	Little & Muir, 1987
	Azola	<i>Azola pinnata</i>	Little & Muir, 1987

- b) Alternatively, sties may be sited over the pond surface, thereby allowing waste and uneaten food to fall directly into the pond. This obviates the need to wash out sties and transport waste, as is still required in the other systems (Little and Muir, 1987).

In Central Thailand, a variation in raising pigs over ponds is the addition of poultry to the pig production resulting in a three-tier system. As described by Delmendo (1980) and Santhanam et al (1987), the chicken manure is eaten by the pigs, while the pig manure acts as both a fish food and fertiliser.

However, the direct transfer of pig waste from 20 or 30 pigs or more into larger ponds is unwise. Woynarovich (1980b) believes that the concentration of manure near the sty will be too high and could result in water fouling. Under these circumstances Woynarovich suggests use of a manuring boat, with the waste suspended in a basket 10-20 centimeters below the water line. Turbulence created by the boat will dilute and wash out the waste (see also, Little

and Muir, 1987).¹⁰ Another potential problem noted by Little and Muir is that the humid conditions created by housing sties directly over ponds can induce respiratory and farrowing problems.

The average number of pigs kept per hectare of pond is 60 (Little and Muir, 1987; Delmendo, 1980). In China, according to the 1976 FAO mission, 30-45 pigs are raised, with other inputs added (FAO, 1977a). Little and Muir report that the composition of stocked fish and the initial stocking density vary considerably according to:

- a) desired fish size at harvest;
- b) initial weight of the stocked fish;
- c) length of growing season;
- d) average water temperature;
- e) fish-carrying capacity and pond quality;
- f) the local practices utilised.

High stocking rates of fish seem common especially with the use of tilapia. Frequently, according to Delmendo (1980), tilapia are stocked at 25,000 to 30,000 per hectare. In the Philippines Nile tilapia have been raised with a small number of bottom feeding common carp and predatory snakeheads (*Channa striata*). Results reported by Cruz and Shehadeh (1980) show that a ratio of 60 pigs to 20,000 tilapia per hectare gave the highest net yield.

3.4.2 Duck/Fish

Little and Muir (1987) believe that the rationale for raising ducks on fish ponds is stronger than for many other animal/fish systems, since a pond can provide living and foraging area for the ducks as well as fish. In fact, ducks, they say, 'may be considered an extension of the polyculture within the pond, further using space and food sources unavailable to fish' (Little and Muir, 1987).

As with pigs and chickens, ducks can also be housed directly over pond water. Santhanam et al (1987) assert that it is even possible to have duck housing facilities constructed as floating pens or sheds made of bamboo, to aid effective manuring. Little and Muir (1987) suggest that in addition to constructing housing over the water, a fence of bamboo strips enclosing approximately half the pond area will confine the ducks, while allowing fish access to the entire pond. In this situation, Edwards (1983) recommends up to five ducks per square metre of floor space. Alternatively, according to Pillay (1990), the enclosures may be confined to the pond bank. About one-quarter of the enclosure will be on land, the rest in the water. The washing into the pond of manure falling on the bank, wave action and water circulation are relied on to ensure adequate distribution of the manure. Restricting the ducks to a small portion of the embankment in this way should keep embankment damage to a minimum.

This more intensive method of raising ducks allows higher amounts of manure and uneaten duck feed (up to ten percent) to be loaded into the pond, with consequently higher yields being obtained (Little and Muir, 1987). The stocking rate of the ducks is of course much higher. In Vietnam, raising 1,000 to 2,000 ducks per hectare of pond increased the average fish yield to 5000kg per hectare per year compared to about 1000kg without ducks (Delmendo, 1980). In Taiwan, Pillay (1990:532) reports about 2000 to 4000 ducks per hectare of pond, depending on the depth and abundance of water supply.

In the more extensive method of raising ducks where they roam freely on the pond, the manure is well distributed, but considerable energy is expended by the ducks in swimming

¹⁰ See reference to this method, which Woynarovich calls the 'carbon-manuring technique' in section

around which can affect growth rate and feed conversion (Pillay, 1990). Often too, the number of ducks is restricted by the food they can find in the pond water (Little and Muir, 1987). Also, their habit of resting and foraging for food on the natural slope of pond embankments can cause damage. Accordingly, Woynarovich (1980a) considers barrage ponds, made by damming shallow valleys, to be most suitable where ducks are permitted to roam freely.

Carp polycultures are commonly used in duck/fish systems (Little and Muir, 1987; Barash et al, 1982).¹¹ The three species of chinese carp (grass, silver and bighead), and common carp can be used (Pillay, 1990). Also, Santhanam et al (1987), report that with a stocking density of 20,000 per hectare of common carp, silver carp and catla for 90 days, a 2000kg per hectare yield has been obtained. Lawson (1981) noted that in Thailand 200m² ponds are stocked with 800 Nile tilapia fingerlings and 30 Khaki Campbell ducks. Moreover, in Israel, experimental results in 1977 and 1978, as shown in Table 3.3, returned interesting results in favour of duck/fish systems (Barash et al, 1982).

Table 3.3 Fish Production in Integrated (with ducks) and Control (fish only) Ponds: Summary of 1977 & 1978 Experimental Results at the Dor Aquaculture Experiment Station, Israel.

	Daily yield of fish (kg/ha)		
	1977	1978	Mean 1977+1978
Duck + Fish	39.1	33.9	36.5
Fish only	43.4	29.5	36.5

Year	Stocking rates per hectare.				
	Common Carp	Tilapia	Silver Carp	Grass Carp	Total
1977	600	1250	125	---	1975
1978	400	300	100	270	1070

Source: Barash et al (1982).

According to Woynarovich (1979), the inclusion of plankton-feeding fish, such as silver and bighead carp mean that the utilisation of manure is much higher, and the 'water-bloom' of blue-green algae can be avoided.

There are numerous benefits, both mutual and particular to ducks, which are noted by Woynarovich (1979) and are worthy of special mention (see also Barash et al, 1982):

- a) Mutual benefits:
 - i) The production of both fish and ducks increases;
 - ii) Costs of production decrease;
 - iii) Pond-reared ducks are of superior quality, while the fish are healthier;
 - iv) The feed conversion rate of the fish is improved;

¹¹ Monoculture can never utilise all of a pond's biological resources. Such wastage means less fish production and loss of profit (Woynarovich, 1979).

- v) More efficient utilisation of labour, transport and storage facilities is achieved.
- b) Benefits to ducks:
 - i) Clean and healthy environment, generally free of parasites and diseases;
 - ii) Natural pond foods are mostly protein-rich, allowing artificial feeds to be of lower quality;
 - iii) Pond-reared ducks produce excellent, clean feathers of considerable value.

3.4.3 Cattle/Fish

Although the quality of cattle (or buffalo) manure is not as good as pig or duck manure, it can still produce acceptable yields of fish.¹² Where cattle are raised more intensively for either milk or beef their waste is generally collected as a slurry. Fish yields (from a mixed age polyculture of carp and tilapia) as high as 30kg/ha/day has been reported when using this slurry as a pond input (Moav et al, 1977).

In Southeast Asia however, cattle/buffalo are raised more extensively, predominantly for draught purposes in subsistence farming systems. Their waste must be collected manually before it can be utilised by fish. In Northeast Thailand small-scale farmers have had limited success with the use of buffalo manure as a sole pond input. Four tonnes of fresh manure was required to obtain about 20kg of fish from a 200m² fish pond (AIT, 1986). It was found however, that this yield could be improved by reducing the loading rate of the manure and supplementing it with a nitrogenous fertiliser such as urea or triple superphosphate (Edwards et al, 1991).

An alternative means of compensating for the low quality of cattle/buffalo manure is to utilise a polyculture system which includes herbivorous fish. While this requires access to suitable quantities of terrestrial or macrophyte vegetation, the fertilising effect of the herbivorous fish will contribute to pond fertility (see Section 3.3.2).

In summary, the wide range of benefits cited above of livestock/fish integration is not attainable without achieving a balanced relationship between livestock and fish stocking densities. Research conducted by Hephher (1975) has found that stocking density is an important variable in achieving acceptable yields. If a stocking density is too high for the fertility status of a pond, poor growth rates will result. Low stocking densities and optimal growth rates has a greater potential for maximising the total yield of an integrated pond.¹³ This is of particular importance in systems utilising low quality cattle or buffalo manure.

Secondly, the type of livestock used must be appropriate to the farming system used by a farmer. In Southeast Asia the greater prevalence of farmers with either cattle or buffalo, as opposed to pigs or poultry, would suggest that their utilisation in small-scale integrated systems is likely to be more appropriate, despite the poorer quality of their waste.

12 Buffalo manure has approximately half the nitrogen content of that found in Cattle waste (Edwards, 1983).

13 The advocacy of low stocking densities was found to be an important component of integrated aquaculture development by AIT in Northeast Thailand (Edwards et al, 1991).

3.5 POND TYPES AND CONSIDERATIONS

When designing an integrated fish farm, numerous pond systems may be considered. The following is a brief summary of the various pond types which can be utilised according to needs and site conditions:

a) Dugout and Embankment ponds

The dugout pond is excavated so that the bottom lies below the surrounding ground surface, as opposed to the embankment pond which is enclosed by a dam, embankments or their natural equivalents. Embankment ponds are preferable, however, as they can be drained dry without pumping (Bardach et al, 1972);

b) Barrage ponds

Barrage ponds are often rain or spring-fed and are located in flat or gently sloping valleys with a low dam at a suitable site to retain water (Chakroff, 1976). Overflow channels are necessary to avoid flooding, and a feeder canal from a stream to regulate flow is important;

c) Contour (Diversion) ponds

Diversion ponds divert the water from a nearby stream or river in a valley and have a slightly sloping bottom (hence the name "contour") (Pillay, 1990). Depending on the topography, embankments may be necessary, with a diversion channel feeding into the pond system from the natural water course. Either a linked or parallel pond layout can be used. As described by Huet (1970), the linked system allows water to flow across each pond in turn. Parallel layout allows each pond to have its own individual water supply and outlet;

d) Paddy ponds

Paddy ponds, according to Pillay (1990), are constructed on relatively flat areas surrounded by an embankment. Here scope exists for better layout, water supply and drainage system design. Alternatively, paddy ponds may consist of a natural pond located within the confines of a paddy.

Ponds can also be classified according to their intended use:

a) Nursery ponds

Small and shallow, these are used for nursing hatchlings until they hatch into fry (Santhanam et al, 1987). Eggs and fry can even be nursed in containers (Chakroff, 1976);

b) Rearing ponds

These ponds are larger, and are generally used for about two months to rear fry into fingerlings. The ponds are generally 1.5 to 2 metres deep (Santhanam et al, 1987);

c) Production ponds

In some systems these ponds are much larger, being from 0.1 hectares or more, and are about two to three metres deep. Used for raising fish to marketable size, their economic size depends on ecological conditions, the area and the type of fish culture

(Santhanam et al, 1987). For the small-scale farmer these ponds vary in size from 80-100m² to 1000m². They are also commonly referred to as grow-out ponds;

d) Brood ponds

In a larger operation a farm will probably require a pond for brood stock to be held in for breeding purposes (Chakroff, 1976).

It is not likely that small-scale systems will utilise all pond types, for, as Chakroff says, most farmers have little land and are most interested in including a fish pond in an already operational farm as simply and easily as possible. Pillay (1990) states that many farms may exclude transitional rearing ponds, and fry may be introduced directly to production ponds. This has been one of the main recommendations included in the AIT Outreach project's work with the development of small-scale aquaculture in Northeast Thailand. A small hapa placed in the pond (a nylon net cage suspended in a pond) is used for rearing the fry through to large fingerlings capable of surviving the open pond environment (Edwards et al, 1991).

The selection of pond size, however, must take into account biological, topographical and economic factors, and the farmer must assess the relative advantage of small or large ponds according to resources and needs. For example, Bardach et al (1972) consider the advantages of small ponds as follows:

- a) they are easier and quicker to harvest;
- b) they can be quickly drained and refilled;
- c) they are easier to manage in the treatment of disease and parasites;
- d) there is less loss involved if all or part of pond stock are lost;
- e) they are less subject to dam and levee erosion by wind.

The apparent advantages for large ponds are as follows:

- a) they cost less to construct per hectare of water;
- b) they use less space per hectare of water;
- c) they are less susceptible to DO deficiency due to greater wind action;
- d) they are more conducive to rotation with rice or terrestrial crops.

Most resource-poor, subsistence farmers will be restricted to a single-pond system producing one crop of fish each monsoon season. The pond will most likely be stocked with fry or fingerlings purchased from a distribution centre, which will then be reared to harvest, with the pond subsequently being prepared and restocked for another crop (Chakroff, 1976). A good size for a single fish pond, according to Chakroff, is between 100 and 500 square metres. If large enough it is possible to breed fish in a corner of the pond.

3.6 SITE CONSIDERATIONS

Preliminary site investigations, as suggested by Pillay (1990), should yield meteorological data such as mean monthly temperature, rainfall, evaporation, humidity, sunshine and wind speed and direction. However, detailed investigations, he states, should consider soil characteristics, topography and water sources. It is these three key factors which will now be examined.

3.6.1 Soil

According to Chakroff (1976), while generally the better the soil is, the better the fish pond will be, the siting of a fish pond on poor agricultural land should not necessarily be

discounted. Hickling (1962) reports the successful siting of fish ponds on soils often too toxic for agricultural use, and gives in example the 'Gelang' soils found in Malaysia.¹⁴ He makes further reference to fish ponds being better located on poor, muddy soil than on good agricultural land, since on the latter a variety of crops may be grown whereas the former will yield greater income from fish culture.

In short, according to Hickling, the basic requirements of fish culture are less exacting than those of agriculture, and can in fact bring unproductive land into productive use. Eventually the fertility of the ponds' bottom soil will improve (Chakroff, 1976).

The first factor to consider in gauging soil suitability for pond culture is its water retention capacity. Land containing silt and clay, which will retain water well, is preferable, according to Santhanam et al (1987). Therefore, as Hickling (1962) notes, badly drained waterlogged soils are best. However, sandy soils may also be suitable if an impermeable layer of soil lies close beneath. In fact, 'very good and highly productive' fishponds (Hickling 1962) have been made in old sand-pits in Singapore. Moreover, the constant addition of organic manure facilitates the rapid forming of mud over the sand.

Pillay (1990) states that pond embankments must be built with cohesive soils with an adequate plasticity. A mixture of sand, silt and clay in the ratio of 1:3:2 is best (Santhanam et al, 1987). In the event of only pervious soil being available Santhanam advises the construction of a core trench. This will prevent seepage of water through the embankment as well as strengthening it.

According to Bardach et al (1972), of particular importance in construction is the compaction of the pond and the embankment. They state that if compaction is insufficient to eliminate leakage, sealing the pond will be necessary. This can be expensive if chemical sealants or plastic/rubber liners are used, but it is possible to use bentonite clay if a good source of this material is available. Bardach et al assert that the clay can absorb large volumes of water, and expand from eight to twenty times its original volume, thus effectively plugging pores in the soil. However, as Chakroff (1976) reports, care must be taken with pure clay as it will crack and leak when dried out. It should be mixed with other soil or, as Bardach et al suggest, covered with a mulch of straw or hay prior to final compaction.

The nutrient status of the soil can also be important, especially where fish obtain all or most of their food from naturally occurring organisms (Bardach et al, 1972). While soil nutrients (for example, iron, calcium and magnesium) will be augmented by the addition of manure or chemical fertilisers, some, especially acids, can be harmful to fish (Chakroff, 1976; Bardach et al, 1972). Fish pond soil should accordingly have a pH level of 7-9 (Santhanam et al, 1987).

3.6.2 Topography

The most important factor in respect of topography is pond drainage (Pillay, 1990). If gravity drainage is not possible, the pond bed should be designed to facilitate rapid and complete drainage. For example, drainage efficiency may be enhanced by a system of drainage ditches dug in the pond bed (Bryant et al, (1980). Building a pond on a gentle slope (with a gradient of approximately two to five percent) will be the most practical and economic system avoiding any need to slope the pond bed artificially (Chakroff, 1976). However, as Bardach et al (1972) remind us, sloping ground will often result in irregular pond shape and bed contour, which may reduce the efficiency of harvesting. Either way, according to Chakroff, the important thing is to select a topography which makes fish farming as easy and successful as possible. Wherever possible, avoidance of low lying areas susceptible to flooding is desirable in terms of this goal.

14 Gelang soils are indicated by the growth of the tree of that name in Malaysia (Hickling, 1962).

3.6.3 Water Supply and Quantity

Water must be readily available and of a high-quality, in order to replace losses due to evaporation, seepage and drainage during management operations (Bardach et al, 1972). Bardach holds that assessments should be based on conditions prevailing during the hottest and/or driest season. It will be important to establish the 'dry year flow' so as to anticipate minimum flow (Bryant et al, 1980).

Hickling (1962) provides significant description of various water sources. Those applying to freshwater ponds are as follows:

- a) damming a stream;
- b) tides - the rise and fall of tides can effect changes in the fresh water level some distance inland (for example, the Pearl River Delta, Kwangtung Province, China);
- c) direct rainfall (ponds in Hong Kong largely rely on rainfall);
- d) pumping from a lake or river.

Bardach et al (1972) note a fifth source:

- e) well water.

Well water can have a more dependable flow and is comparatively free from disease organisms, parasites, predators, trash fish, pesticides, silt, and other contaminants and pollutants. However, the low DO and high carbon-dioxide and nitrogen content of well water requires that it be sprayed into the ponds.

Fridley et al (1988) refer to water quality as being the 'life-blood' of a system. This is because water provides the environment, contains the essential oxygen, carries the nutrients and feed, and receives waste products from metabolism. However, not all water is the ideal 'life-blood'. Accordingly, warm-water pond species which are relatively tolerant of poor water quality should be selected. Species like tilapia and carps have been utilised in aquaculture for a long time (Fast, 1986). They are tolerant to low DO for brief periods and can exist and grow in waters with a wide range of salinity and temperature.

Undoubtedly the water quality issues of aquaculture are diverse. For the present purposes however, it will be sufficient to note the salient features of several key issues, beginning with DO, the most important aspect of water quality in integrated ponds.

Section 3.2 above refers to the important role which DO plays in water quality. In short, however, DO should be maintained as close to saturation as possible. Low DO indicates that a high proportion of organic substances are removing oxygen. Biological Oxygen Demand ("BOD") can measure the oxygen-removing capacity of the water (Tebbutt, 1983). Basically, a BOD exceeding 3mg per litre is unsuitable for fish culture.

Fast (1986) lists a number of methods of predicting excessive oxygen depletion, namely:

- a) ascertaining Secchi disk or Chemical Oxygen Demand ("COD") values;
- b) measuring DO concentrations during the night and projecting DO values at dawn;
- c) familiarity with the pond;¹⁵

¹⁵ If water is too fertile, fish will surface at night to gulp air. A quick, simple test of the water's fertility is made by placing the hand in 10cm of the water. If the hand is clearly seen the water probably lacks in fertility. If not seen at all it is too fertile.

d) continuous aeration or circulation of the pond water.

Fast then describes several methods of emergency aeration (when DO drops to 1-2mg per litre and fish show sign of stress). Water with a high DO content can be flushed into the pond. Or, if necessary, mechanical aeration can be achieved by spraying the water into the air, installing aerators (FAO/UNDP, 1979), or even operating small motor boats to bubble the water (Chakroff, 1976).

Temperature is also an important quality issue. Optimal temperature varies for different fish species. If the correct temperature range for the species used is not maintained the fish will not grow and may even die (Chakroff, 1976). For example, Chakroff reports tilapia requiring 25-35°C, common carp requiring 20-25°C and grass carp requiring 25-30°C.

In some situations salinity will be a determinant too. While some fish species are quite tolerant to varying levels of salinity (for example, tilapia), it is important, before a species is introduced, to establish the salinity of a fish pond and any likely fluctuation which might occur (Fast 1986).

Further, alkalinity and pH levels can have a major effect on water quality. Generally, problems occur with a variable pH and low alkalinity. Water with a low pH value (acid) is usually lacking in dissolved salts and has a poor buffering capacity (ability of the water to neutralise the effects of added acids or bases causing changes in pH). Alkalinity is therefore important since it provides this buffering capacity. If alkalinity is low, the water will be unproductive. It will have low nutrient concentrations, little plant growth, large variations in pH and low fish yields (Hickling, 1962). But alkaline water (pH 7.0 to 8.6) has an alkalinity ranging from 0.7 to 7.0 and can support a rich and varied aquatic life.

Hardness in most fresh waters is very similar to alkalinity, as calcium, magnesium and bicarbonates predominate.¹⁶ However, where sodium carbonate is more concentrated, alkalinity will be the greater. If calcium sulphate has the greater concentration, so too will hardness be greater (Fast, 1986). Liming ponds having low alkalinity water is the accepted practice (Hickling, 1962; Chakroff, 1976; Fast, 1986; Huet, 1970).

Caused by suspended organic matter, turbidity can restrict light penetration and thus photosynthesis for oxygen and phytoplankton production (Fast, 1986). Either a silty water source or bottom feeders like common carp stirring up bottom muds can cause turbidity problems. The Secchi disc (referred to above), or the "hand test" (if your hand disappears when your arm is extended into the water to elbow depth), will indicate either turbid or fertile water (Chakroff, 1976). Generally, as the fertility of a water is improved, through the use of either organic or inorganic fertilisers, turbidity will decrease. Fertilisation causes the clay particles in the water to collect together and eventually settle.

3.6.4 Pond Size

The selection of pond size is also important and may require significant care if the pond is to appropriately fulfil requirements. Numerous factors require consideration, including the following:

- a) the annual volume of fish required;
- b) pond size in relation to overall farm size;
- c) methods of integration (fertilisation) available.

¹⁶ Hardness is the measure of total soluble salts, which are important for phytoplankton production, and bone and teeth growth in fish (Chakroff, 1976).

The type of fertiliser to be used is important, as where it is of a poor quality its capacity to produce a good yield of fish will be less. If the yield is low then a larger pond will be required to produce the required volume of fish. For example, buffalo manure is of poorer quality than duck manure, and the yield potential less. This will also require ascertaining whether the larger pond size required is appropriate given the total farm area.

3.7 MANAGEMENT OF INTEGRATED FARMING

Management issues, even in respect of a small-scale aquaculture farm, are diverse and potentially complex. According to Pillay (1990), the ability of a farmer to manage his resources (including the skill required, land, water, labour, capital and time) to his/her advantage and goal fulfillment, will to a large extent determine the farm's performance. The 1978 Chinese FAO study tour, seeing how advanced the Chinese management of integrated farming had become, realised that management practices (including the selection of fish species, crops and livestock) must be appropriate to local conditions and requirements. Objectives must be 'heavily oriented' toward economic, social and nutritional benefits. In larger systems farming cooperatives may need to be organised, if labour requirements are to be met. The systems ultimately utilised should first be designed for, and implemented and tested in, suitable pilot projects (FAO/UNDP, 1979).

In examining some of the features involved in establishing and maintaining a successful system, the following management issues will be discussed:

- a) Pond management;
- b) Organic fertiliser management;
- c) Some major freshwater species cultivated in Southeast Asia;
- d) Fish diseases;
- e) Algal bloom, weed and predator control.

3.7.1 Pond Management

According to Colt (1986), most pond management practices such as liming, fertilisation, manuring, and pond draining and drying, have developed from empirical growth trials using fish production as the measure of merit.

Where soil or water is acidic, the application of lime is favoured. Not only will this correct the acidity, thereby releasing nutrients and promoting the breakdown of waste material (as discussed in the previous section), but it (lime or calcium carbonate) will also increase the water's productivity (Santhanam et al, 1987). Moreover, counteraction of the possibly harmful effects of excess magnesium, sodium, or potassium ions and the fixation of harmful organic (humic acid) or inorganic (sulfuric) acids is likely (Hickling, 1962). Liming can also reduce oxygen depletion by making carbon-dioxide available for photosynthesis (Yamada, 1986a).

Quicklime is particularly suitable as it is almost pure CaO, and the caustic lime produced when mixed with water is an excellent disinfectant. However, it is toxic and so should be applied at least two weeks before a pond is stocked (Hickling, 1962). The application rate will depend on the pH of the soil (see Table 3.4).

Table 3.4 Liming Recommendations for Aquaculture Ponds

Lime Requirements in Hundreds of kg of Calcium Oxide/ha					
Soil pH	Clay or Loam	Loamy Sand	Sand	Mud pH	Calcium Carbonate Required in Hundreds of kg/ha
<4	40	20	12.5	<4	60-120
4-4.5	30	15	12.5	4-4.5	48-96
4.5-5	25	12.5	10	4.5-5	36-72
5-5.5	15	10	5	5-5.5	30-48
5.5-6	10	5	2.5	5.5-6	16-30
6-6.5	5	5	0	6-6.5	14-16

Source: Hora and Pillay (1962)

Draining and drying a fish pond is often considered important. Chakroff (1976) suggests it is wise for this to be an annual task, so as to get rid of any unwanted fish or disease-causing organisms. Obviously, draining is a precondition for liming the pond soil. However, where gill-rot disease is present or the precipitation of organic substances is desired, the water itself should be treated (Yamada, 1986a). Fast (1986) has compiled a comprehensive list of reasons for draining and drying, as mentioned by Hickling (1962) and Huet (1970). They include:

- a) nutrient regeneration;
- b) fish population control;
- c) the reduction of sediment oxygen demand;
- d) the oxidation and leaching of acid sulphate soils;
- e) the control of vegetation;
- f) disease control;
- g) pond maintenance;
- h) crop rotation (alternating other crops such as rice with fish).

Some maintain that pond draining and the utilisation of bottom silts as a crop fertiliser (commonly promoted in association with reasons for pond draining) is not necessary and that it can detract from the pond's ability to produce. This is due to the loss of pond fertility through the removal of the bottom silts and the effect of drying. The Issaan Development Foundation (in Udon Thani province of northeast Thailand) has found that the annual draining and drying of ponds can be detrimental to their productive capacity (Gustafson, 1993). Until 1991 Issaan had not followed the practice of draining ponds. Gustafson reports that by 1992 production was 40 - 45 percent of that achieved previously.

The farm has three cycles of production per year. At the end of 1991 they pumped all 42 of the Foundation's ponds, half of which were repumped two cycles (eight months) later. All other aspects of their pond management remained as it was prior to 1991. A clear downward trend in production was recorded by the second pumping with the residual biomass in the pond dropping to 30 percent of what it was at the first pumping. It was therefore decided to stop pumping in October of 1992. By April of 1993 (two to three cycles later) a noticeable increase in production was observed.

Gustafson concluded from these results that draining and drying ponds potentially disturbs

an important balance in the pond ecosystem. Valuable nutrients are removed which would otherwise contribute to pond water fertility.

These results certainly contrast with traditional procedure but definitely warrant further research.

If in the future these findings are verified, competition for the use of pond bottom silts may arise. This could require a willingness to compromise either maximum pond production or increased crop production by deciding whether to keep the pond silt in the pond or use it as a fertiliser. This will depend on the relative importance of each in a farming system's overall production.

The purpose of fertilisation is to aid development of the fish food organisms supplied by the pond. Either inorganic fertilisers, animal manure, nightsoil or plant material may be used. While the type, method of application, and interval between applications will vary from site to site, it is important to realise that over-fertilisation will frequently produce algal blooms and oxygen depletion (Colt, 1986). In order to focus on integration, animal manure, plant material and night soil fertilisers will be discussed in the next section (3.7.2). Here, however, the application of inorganic fertilisers deserves mention.

Santhanam et al (1987) hold that the use of chemical fertilisers varies according to the concentrations of phosphorus and nitrogen in the soil. The standard combination of nitrogen, phosphorus and potassium ("NPK") they give is 18:10:4. Bardach et al (1972) however, cite research in Malaysia which suggest that once correct lime treatment has established a neutral pH, superphosphate is the only fertiliser required. They report that superphosphate applied at 333kg per hectare:

- a) produced greater growth of blue-green algae (the principal agent of nitrogen fixation);
- b) reduced production of superfluous algae (which limits benthic productivity);
- c) lessened the danger of oxygen deficiency;
- d) diminished the need for supplementary feeding (see also Chakroff, 1976).

Over-application of inorganic fertiliser not only affects the pond environment, but can result in the precipitation or loss of much of the fertiliser. Colt (1986) refers to the consequent requirement for a good knowledge of local water chemistry.

According to Chakroff (1976) the most common phosphorus fertilisers used in fish ponds, with their suggested application rates, are:

- | | | |
|----|--------------------------------|--------------|
| a) | Basic slag | 25-30kg /ha; |
| b) | Single superphosphate | 114kg /ha; |
| c) | Granular double superphosphate | 57kg /ha. |

3.7.2 Organic Fertiliser Management

Generally, inorganic fertiliser use in small-scale systems is not great due to its supposed cost and the relative inexpense and ready availability of organic fertiliser. However, although the initial cost of inorganic fertiliser might seem relatively high, the fertiliser can last for up to three years in the pond (Chakroff, 1976). Moreover, according to Bardach et al (1972), the small amount of labour required to apply superphosphate, and the small amount of feed required when it is used, may actually make the use of inorganic fertiliser cheaper in the long term.

Nevertheless organic fertiliser is often recognised as the most appropriate and sustainable

means of enhancing the pond environment, especially for small-scale farmers (see section 3.2). In fact:

"The rationale behind raising fish on animal manure becomes apparent when it is realized that about 72-79 percent of the nitrogen, 61-87 percent of the phosphorus and 82-92 percent of the potassium in the feed rations fed to animals are recovered in their excreta." (Edwards 1980).

Having established that all the required nutrients are readily available in animal manure, finding the best method of application becomes the next strategic task.

Composting is effected by placing manure in a pit, usually circular, for ten days (Edwards, 1980; FAO, 1977). The pit is filled by layering a river silt/rice straw mixture, pig or cow manure and aquatic plants or green manure crops in 15cm layers. The top is then covered with mud, and water (three to four centimetres deep), to create aerobic conditions. When the compost is turned, superphosphate can be added, with water (to ensure moist conditions), in varying quantities depending on the type of crop or ponds the fertiliser is to be applied to (Delmendo, 1980).

This system of composting has also been applied by the Asian Institute of Technology, Bangkok, Thailand, to the treatment of nightsoil mixed with water hyacinth (Edwards et al, 1983). When applied to ponds stocked with Nile tilapia, unexpectedly high fish yields resulted. In fact, the fish were reported to be directly consuming the compost. The high temperatures produced by composting are also effective in killing off bacteria in the nightsoil.

Liquid animal manure can be produced by a process of anaerobic fermentation in bio-gas plants. Again, as Delmendo describes, varying mixes of nightsoil, animal manure and plant matter can be used. However, the plant matter should be decomposed for ten days prior to placement in the digester. The 1978 FAO/UNDP study tour of China found that in many areas the direct application of night soil and pig manure had been replaced by controlled fertilisation with fermented excreta (FAO/UNDP, 1979).

Conversely, with the exception of composting in the case of nightsoil, research conducted at the Asian Institute of Technology would suggest that composting animal manure is detrimental to nutrient availability (Edwards (1993). This is due to some nutrients (ammonia in particular) being lost during the composting process. The nitrogen component which is of particular value in promoting water fertility, is quickly rendered unavailable. This suggests that fresh animal waste is better released into the pond directly to ensure the available nitrogen can be utilised.

Untreated animal manure is common in Asia, and can give high fish yields (Delmendo, 1980). In addition to the methods of untreated manure application described in section 3.4, Woynarovich (1979) describes what he calls the 'carbon manuring technique' as a more effective process of utilising animal manure. Basically, soft, fresh manure is mixed with pond water and repeatedly spread over the entire surface of the pond. Carbon compounds are thereby released, and a continuously high primary production achieved. In this system, he reports very large quantities of manure (in Hungary 30-60 tonnes per hectare per 100 days) being applied. He appropriately describes ducks as 'carbon-manuring machines', due to their ability to distribute their droppings when allowed free access to the pond surface.

Predicting expected yields in waste-loaded systems is a highly subjective and speculative activity, since local conditions, fish species, manure loading rates and management will all affect the outcome. However, as an indication of the potential of organic fertiliser use, Delmendo (1980) suggests that from ponds receiving less than between 0.5 tonnes and 1.0 tonne per hectare per day, fish yields of 1500kg to more than 8000kg per hectare per year

might be expected.

While the value of using wastes is easily established, finding the optimal application rate to meet both natural food production and environmental requirements for fish, may be difficult (Little and Muir, 1987). Ideally, Little and Muir advise, waste should be finely fragmented so that it may be more easily dispersed in the water. Liquid manure is usually more homogenous and readily dispersible, and its effect on pond conditions will consequently be more predictable. Moreover, they advise that a high frequency of applications allows for the establishment of a more balanced food chain and the minimisation of nutrient loss. Even daily, mid-morning (when oxygen is rapidly increasing) applications are effective.

3.8 SOME MAJOR FRESHWATER SPECIES CULTIVATED IN SOUTHEAST ASIA.

This review will be restricted to commonly cultivated fish species in Southeast Asia from the carp and tilapia families.

3.8.1 Common and Chinese Carp (*Cyprinidae*)

The history of development of carp culture is lengthy, so little more than a brief insight into the salient features of carp is possible here. This must also be mindful of the context of the necessary and desirable characteristics of fish used in integrated pond culture. Santhanam et al (1987) provide us a concise list:

- a) high growth rate;
- b) efficiency in converting the organic production of water into flesh;
- c) compatibility with other species;
- d) adaptation to crowded conditions;
- e) ability to live in fluctuating temperature, pH, turbidity, carbon-dioxide and DO conditions;
- f) ability to reproduce in confined conditions;
- g) amenability to handling and harvest;
- h) possession of an established demand.

Of common carp, the varieties preferred for culture, due to their faster growth rates, are the normally-coloured or orange-coloured scale carp (*C. carpio* var. *flavipinnis*) and the mirror carp (*C. carpio* var. *specularis*) (Pillay, 1990). The common carp is an omnivore and so feeds on a variety of plant and animal matter. Young carp, up to a length of about ten centimetres, feed on protozoa and zooplankton, while the larger carp feed on benthic organisms (such as insect larvae, worms and molluscs) and vegetable matter (Pillay, 1990), hence the name 'bottom feeders'. Essentially, the success of fish culture using common carp is due to the species':

- a) ability to spawn readily in captivity;
- b) hardiness in all life stages;
- c) adaptability to either acid, alkaline or saline water (up to 20 percent);
- d) tolerance of varying temperatures and high turbidity;
- e) and catholic food habits.

(Bardach et al, 1972).

Of the Chinese carp there are three major species of relevance:

- a) grass carp;
- b) silver carp;

c) bighead carp.

While being famous for their role in the development of the polyculture system, chinese carps' widespread use in fish culture was initially hampered by their inability to spawn in ponds (Bardach et al, 1972; Pillay, 1990). Until the art of induced breeding became common, their eggs and fry were traditionally collected from rivers. The three species effectively complement each other in the pond environment, with little competition for food. The grass carp is the specialist herbivore and feeds on macrovegetation (grass and aquatic plants). When as small as 2.5 to 3.0cm in length it can ingest up to 50 percent of its body weight in land plants (Martyshev, 1983). It is therefore effectively used in weed control.

The silver carp feeds on phytoplankton, although it can consume some higher plants (Bardach et al, 1972). The main zooplankton feeder is the bighead carp. While this fish eats some phytoplankton, it generally prefers larger organisms (Pillay, 1990). Bardach et al (1972) note, however, that it may receive the bulk of its nourishment from phytoplankton.

3.8.1.1 Carp Suitability to Pond Culture

Generally carp culture is practised in stagnant or semi-stagnant ponds. Culture in cages or rice fields is not so common for the carp group (Pillay, 1990), although common carp is frequently utilised in rice/fish culture. Carp are particularly suitable to pond culture due to:

- a) their feeding on low trophic levels;
- b) pond fertilisation by organic manures and farm waste producing most of the required food;
- c) and species like the grass carp being fed at little cost on land and aquatic vegetation (Pillay, 1990).

Moreover, as Pillay continues, carp are suited to most facilities, ranging from small, undrained village ponds to large, systematised ponds.

In some regions outside China however, the chinese carp are less popular. The grass carp in particular is considered less palatable. Further, it is not simple to breed, succumbs easily to disease in fertile waters, and is less tolerant to the often low DO concentrations of fertile ponds (Edwards, 1987). The tropical carp, silver barb, is a viable alternative, especially in Indochina where it is an indigenous species (see Section 3.8.2).

3.8.1.2 Carp Spawning and Fry Production

Since common carp breed naturally in culture systems, it is possible to leave them to their own uncontrolled breeding (Pillay, 1990). They spawn year-round with the only stimuli required being an increase in water temperature often accompanied by flooding (Bardach et al, 1972). They lay their eggs near the surface and/or in shallow areas on vegetation.

Alternatively, special spawning ponds such as the Dubisch pond may be used.¹⁷ These ponds (Huet, 1970) should be small (not more than 100m²), shallow (20-30cm deep), sheltered and sunny. Surrounded by a peripheral ditch of 40 to 50cm (free of vegetation) to hold the parent fish, a central, grass-covered spawning board with a 1/15 gradient slope is provided for the eggs to be laid on. Bardach et al, (1972) specify the grass growth to a height of 40cm before filling the pond as an alternative to using the spawning board. The brood fish are stocked at the rate of one to three 'sets' per pond, with each set comprising two males and one female (Huet, 1970). Traditionally, after spawning, the brood fish are removed. The eggs are

¹⁷ The use of Dubisch ponds was developed in the nineteenth century by an Upper Silesian fish farmer named Dubisch. The technique was later modified by Hofer (Huet, 1970).

then allowed to hatch, with the fry being removed when about two to three days old.

An Indonesian variation has the eggs being removed first, not the brood stock, as less disturbance will result. This is done by using a Kakaban, or egg mat, made of a thin layer of indjuk fibre in the shape of a two-sided comb. The Bardach et al (1972) description of this system has the Kakaban placed in a 20-30 m² spawning pond which is free of mud, silt and aquatic and terrestrial plants. Five Kakabans are generally required per eight kilogrammes of female spawners. Submerged just below the surface, the Kakaban can be easily turned over when one side is full of eggs. When both sides are full, the Kakabans are removed from the pond and placed in the hatching pond.

The necessity for a separate spawning pond can be avoided by placing containers in the shallow areas of stock ponds. This system, commonly used in India, uses rectangular cloth tanks about one metre deep, called the Indian hapa (Bardach et al, 1972). In the evening the selected, ripe spawners are placed in the hapa. By morning most will have spawned. According to Pillay, (1990), the hapa can also be used as an incubator for hatching eggs. In this case, an inner hapa with a coarser mesh is placed inside the normal hapa. The fertilised eggs are added, and, when hatched, the fry fall through the coarser mesh into the outer hapa. Deterioration of the water caused by dead eggs and shells is avoided by removing the inner hapa after hatching.¹⁸

For best results it is important to select brood stock carefully. First, selection of stock from the same brood stock or their offspring will lead to inbreeding, depressed growth rates and possibly deformed fry (Pillay, 1990). Secondly, it is possible to select for desirable traits. For example (Bardach et al, 1972):

- a) high fecundity;
- b) high viability;
- c) rapid food assimilation;
- d) rapid growth.

Further, these traits may be more obtainable through hybridisation. Taking advantage of hybrid vigour can produce beneficial results, including greater resistance to disease.

In warm-water culture the induced spawning of common carp is unlikely to be necessary. However, as already suggested, the inability of chinese carp to spawn in pond culture means that it is now common practice. It is used widely in China (FAO/UNDP, 1979) and is even considered by some to be a 'sustainable technology' (Csavas, 1991). The inducing agents used are pituitary extracts of common carp, silver carp or bighead carp, and human chorionic gonadotropin (HCG). Luteinizing release hormone (LRH) or luteinizing release hormone-analogue (LRH-A) are also used (Pillay, 1990; FAO/UNDP, 1979).

The pituitary extract is usually injected into the dorsal part of the carp body in two doses, although in China both intramuscular and coelomic injections are used. The first dose should comprise only about 10 to 20 percent of the total dose. The second dose follows six to twenty four hours later. In East European countries the first dose is about 10 percent of the total; in Israel it is about 20 percent; and in India 30 percent (Pillay, 1990). Males are injected only once, usually at the same time as the second dose for females (FAO, 1977).

In warm waters brood fish should become ripe for egg-stripping within seven to nine hours. After stripping, the eggs should be immediately fertilised with the males' milt. Hatching can then be expected 24 to 28 hours later (Bardach et al, 1972; Pillay, 1990).

¹⁸ If dead or unfertilised eggs are not removed, the white, fuzzy and foul-smelling 'Saprolegnia' fungus can occur, with the potential to spread through the whole batch of eggs, with disastrous results (Bardach et al, 1972).

Numerous spawning and hatching facilities are common-place in China. Properly constructed pools, small cloth tanks or large buckets, can all be readily adapted as hatching systems to local resources and conditions (FAO/UNDP, 1979). Whatever arrangements are made for hatching, a sufficient, steady flow of water over the eggs is important (Chaudhuri and Tripathi, 1979). A velocity of 0.2 to 0.3 metres per second is suggested by Pillay (1990). If this is not possible, eggs should be lightly stirred once every 20 to 30 minutes (Kuronuma, 1968).

3.8.2 Silver barb (*Cyprinidae*)

Silver barb, *Puntius gonionotus* (*P. javanicus*) is common in Indonesia, Malaysia, Indochina and Thailand (University of Michigan, 1976). Although a freshwater fish, it thrives in brackish water with a salinity up to 7 ppm and can be cultivated in confined waters, ponds and reservoirs. The warm waters of tropical areas are most suitable, with the optimal water temperature required being between 25° and 33°C (Hora and Pillay, 1962).

While as larvae silver barb feed on unicellular algae and minute zooplankton (Hora and Pillay, 1962), as fry and adult fish higher aquatic plants and grasses are preferred (Ukkatawewat, 1979). Many aquatic macrophytes, pasture crops and green crop residues are potential feeds. Duckweed (*Lemna*) has been found to have substantial potential (Santos, 1993). The prolific macrophyte, water hyacinth, is less suitable, although can be used if processed by chopping or aerobically composting first (Little and Muir, 1987).

Like most herbivorous fish the poor ability of silver barb to convert their macrophyte intake into tissue produces large amounts of undigested and partially digested fine plant matter. This however, supports the growth of plankton making the culture of silver barb in polycultures with other filter feeding planktivorous fish (for example, Nile tilapia) feasible (Edwards, 1985).

3.8.2.1 Silver barb Suitability to Pond Culture

Silver barb is often reared in brackish water ponds with milkfish, attaining weights ranging between 250 and 500 grammes in the first year. Annual production is reported by Hora and Pillay (1962) as being up to 500kg/ha.

In Thailand freshwater pond culture is generally extensive or semi-intensive and is usually done in ponds of 200m² or greater with a water depth of one to two metres. A stocking density as high as 10-15 fry/m² has been found to be feasible if manure is provided at a rate of 150-200kg/200m²/month and daily supplementary feeding with broken rice, rice bran and vegetables at a ratio of 1:2:4 is undertaken (Santos, 1993 - from other authors).

3.8.2.2 Silver barb Spawning and Fry Production

Silver barb like to spawn in running water with a one kilogramme female producing 500,000 to 1,000,000 eggs. These eggs will hatch in eight to twelve hours if the water temperature is between 25°C to 35°C (Ukkatawewat, 1979). In rivers silver barb naturally spawn at the beginning of the monsoon season and lay their eggs on mud banks where tributaries join the main water channel.

Like common carp the potential for silver barb is good due to its ability to spawn in a pond environment. According to Hora and Pillay (1962) silver barb can breed in ponds every three to four months depending on how good their preliminary treatment is. They cite an example from Indonesia where 300 to 500m² ponds are used with a water depth of about 35 to 50cm. 300 gramme (25cm) spawners are preferred and can be stocked at the rate of one pair to about 50 to 70m² of pond area.

In reference to this Indonesian example Hora and Pillay advise that breeding is most

successful at the beginning of the monsoon season and is induced with the introduction to the pond of a strong and slightly turbid current of well-oxygenated water. It is important that the soil on the pond bottom is fertile, especially if the fry are to be reared in the pond for long periods (50 days or more). If the fish are reluctant to spawn, beating the water surface can help. Common carp fingerlings (10cm) are also able to stimulate the propagation of silver barb and can be stocked in the spawning pond at the rate of about 15 to 25 fish per 100m². Their agitation of the pond bottom is considered beneficial.

After spawning, the inflow and outflow of water should be stopped for about 20 days by which time the fry will be hardy enough for it to be started again. Approximately 50 days will be required for the fry to reach a size of about two to three centimeters. An average production of about 5000 (advanced) fry per spawner is possible after 50 days (Hora and Pillay, 1962).

Induced spawning of silver barb is also feasible and has been promoted by the Department of Fisheries, Thailand (1984). While the usual method involving the injection of the broodfish and artificial insemination is referred to, Na-Nakorn (1988) suggests that there can be difficulty in inducing ovulation.

3.8.3 Tilapia (*Cichlidae*)

This 'aquatic chicken', as some call it, is quickly becoming one of the most popular species in Asian aquaculture (Bardach et al, 1972; Tim, 1988; Pillay, 1990). Originating in Africa, it seems that tilapia arrived in Asia via Indonesia, somewhat inadvertently, prior to its discovery there in 1939. Hence the accepted common name for *T. mossambica* became Java tilapia (Bardach et al, 1972).

While all tilapia appear to be herbivorous (Bardach et al, 1972), their feeding habits do vary to the extent that they can be macrophytophagous, microphagous or omnivorous (Pillay, 1990). By being either herbivorous or omnivorous in this way means that tilapia are relatively easy to feed.

However, there are numerous other features which cause them to be very favourable to culture. They are very robust, and able to be reared in either fresh, brackish or even sea water. Moreover, while their use is restricted to warm waters, some are reasonably tolerant of cooler (not below 10°C) water temperatures (Bardach et al, 1972; Huet, 1970; Pillay, 1990). Java and Nile tilapia are particularly suited to integrated pond culture because of their incredible tolerance to high levels of organic enrichment.

There is a wide range of tilapia species. In fact, their classification has come under considerable revision and change in recent times (Pillay, 1990). Three sub-generic names are now sometimes used; *Tilapia* (substrate spawners), *Saratherodon* (biparental mouthbrooders), and *Oreochromis* (maternal mouthbrooders). Here however, only their general features will be discussed, and (as Pillay does) they will be referred to hereafter by the generic name *Tilapia*.

3.8.3.1 Tilapia: Rearing Systems

Pond culture is the most commonly practised method of cultivation of tilapia which are frequently reared in either polyculture, monoculture or mono-sex systems. However, their tendency toward prolific reproduction means that they are better suited to either polyculture (where a predator fish is included) (Bardach et al, 1972) or mono-sex culture (separating the sexes). The practice of intermittent harvesting, hybridisation, high density stocking, delaying of sexual maturity and sex reversal (see section 3.9) are also used for controlling excess natural reproduction (Mair and Little, 1991).

Tilapia have also become very popular in rice/fish culture, especially in the Philippines and Thailand, but when stocked with rice, in order to obtain a marketable fish, mono-sex culture is best. The short growth period of rice and the excessive reproduction of tilapia can restrict their being satisfactorily grown out to harvest (Pillay, 1990). Alternatively the tilapia recruits should be frequently seined to avoid over stocking.

3.8.3.2 Tilapia Spawning and Fry Production

Under favourable temperature and feeding conditions, tilapia will mature within only three months. Breeding can then occur in successive four to six week cycles (Pillay, 1990). A continuous production of fry can therefore be achieved in warm waters (a minimum of 20°C to 21°C is necessary, Huet, 1970).

Compared to carps however, tilapia reproduction is inefficient. While carp fry may number 10-12,000 per kilogramme of female fish per year, tilapia fry will be less than 900 per kilogramme of female fish per year. In pond conditions tilapia fry may number as low as 10-50 fry per female.

Many of the tilapia species spawn using constructed nests (for example the *Oreochromis* spp., *T. mossambica*, *T. nilotica*). As described by Huet (1972), the male constructs the nest by various methods depending on the species. The female will then deposit her eggs in the nest for fertilisation by the male. The mouth-brooding females will take the eggs, possibly numbering 75 to 250 (Bardach et al, 1972), into her mouth until they hatch, generally in about six days (Huet, 1970).

Three main systems can be used for the controlled production of tilapia fry: earthen ponds, hapas in ponds and tanks.

a) Earthen ponds

Pillay (1990 - from other authors) refers to the stocking of *T. nilotica*, 700g weight females and 200g males at a 4:1 ratio and at the rate of one per two m². 600m² ponds with about 0.4m depth are used. When spawning commences about one month later, the brood fish are transferred to a second pond, where their high-protein diet is continued. With continued feeding, the fry remaining in the first pond will quickly grow out, producing up to 5000 fingerlings for harvest. This process can be continued repeatedly with the brood fish being alternated between the two ponds, thus producing a continuous supply of fish. This method will produce about 4.2 fry per square metre or 10.4 fry per female.

Little (1990) conducted a variation to this method by stocking broodfish at 1:1 female to male sex ratio with the females stocked at 0.03-0.04kg per square metre of pond area. Swim-up fry were removed daily (6 x day) at the rate of about 6.2 fry per square metre per day or 5077 fry per kilogramme of female fish per month.

b) Hapas in ponds

In the Philippines, hapas are placed in ponds about one metre deep. A 1:3 male to female ratio is used when either breeding with one species, or cross-breeding. Fry will become available at about monthly intervals. The average monthly production is recorded as being about 1466 fry per cubic metre (Pillay, 1990 - from other authors).

Trials with hapa's conducted by Little (1990) used a 1:1 female to male sex ratio with two brood fish per square metre. The seed was harvested every five days with the unripe females being exchanged for conditioned fish. This method produced 65 fry

per square metre per day or 8463 fry per kilogramme of female fish per month.

c) Tanks

In the Philippines fry are removed daily (5-6 x day) from large static water tanks stocked with three broodfish per square metre (0.22 kg female/m²) at a female to male sex ratio of 2:1. Nine fry per square metre per day were produced (1277 fry/kg female/month) (Little, 1990 - from other authors).

In Thailand Little (1990) produced 224 fry per square metre per day (4138 fry/kg female/month) using flow-through recirculated water tanks with the seed being harvested every five days and the female fish being exchanged with conditioned fish after each harvest. The sex ratio used was 1:1 and the broodfish were stocked at the rate of 8 per square metre (0.27-0.8kg female/m²).

These controlled methods of fry production are effective in maintaining genetically pure lines of stock, which for the continuous reproductive capacity of the tilapia is most important, especially where hybrid production is practised. Where controlled methods are not used and uncontrolled reproduction is relied on, sufficient fry of requisite size at a particular time cannot be produced (Pillay, 1990).

Although the above systems show that fry production per unit area is typically higher as management intensifies, investment costs per unit area are also increased. However, in tanks and hapas if early seed removal from the female is practised, artificial incubation is used and broodfish are exchanged, more consistently sized seed will be produced and productivity will be improved. In all systems the maintenance of broodfish condition and the complete harvest of seed are major prerequisites in improving efficiency (Little, 1990).

The requirement to produce tilapia seed of an appropriate size has been found to be particularly important if they are to avoid incurring large losses arising from predator fish entering the paddies or ponds in which they are stocked. Some farmers in Cambodia (for example, in rice/fish culture next to the Tonle Bati lake in southern Cambodia) have suffered heavy losses in this way and are consequently skeptical of the viability of tilapia in rice/fish culture.

Addressing this problem will require the provision of specific training for farmers to extend their understanding of management requirements. The promotion of stocking larger fingerlings (approximately eight centimetres) will be important. The fingerlings to be stocked should be larger than the mouth size of the predator fish.

The requirement for large fingerlings should not be inhibiting. Where fingerlings of an appropriate size are not available they can be easily produced by farmers nursing them in the corner of a paddy or pond in hapas. The fingerlings are retained in the hapa until considered large enough to resist being preyed on by predator fish, at which time the hapa is removed and the fingerlings released. Substantial work on this procedure has been done by the Asian Institute of Technology in Thailand with encouraging results (Edwards et al, 1991).

3.9 CULTURE SYSTEMS

Monoculture and polyculture have already been mentioned above, yet their attributes within the pond system and in respect of the species discussed, requires further discussion.

Sinha (1979) states that since various species of carp have different feeding habits, their placement together in culture systems allows a better utilisation of pond resources.

Basically, competition between species can be avoided if their feeding habits are not the same (Little and Muir, 1987). For example, as outlined by Little and Muir, surface feeders will feed on higher aquatic plants, mid-water feeders on phytoplankton and zooplankton, and bottom feeders on bottom sediments. The carp range is an example of these different types:

Surface feeders	Grass carp
Mid-water feeders	Silver carp Bighead carp
Bottom feeders	Common carp Mud carp Black carp (<i>Mylopharyngodon piceus</i>)

Polyculture is also more disease-resistant (Chakroff, 1976) and effective in population control. Little and Muir (1987) refer to the potential for wild spawning to seriously depress yield. As suggested in section 3.8.2.1 tilapia are notorious for this, resulting in their offspring competing for food and space in the pond. By stocking a predatory fish such as the snakehead or clarias catfish (for example, *Clarius batrachus*) in small numbers, excessive reproduction can be controlled.

The control of filamentous algae and planktonic algal bloom is possible under polyculture. As Pillay (1990) states, the polyculture of common carp, silver carp and tilapia together is valuable, as the common carp feed on the filamentous algae, the silver carp on the planktonic algae and the tilapia on the organic ooze at the pond bottom. The result is an improvement in the oxygen regime, diversification and an overall increase in production. Again, as Little and Muir (1987) note, the ratio of fish species can be manipulated to best utilise the particular waste available.

However, small-scale farmers might find that monoculture will result in a greater familiarity with the fish species concerned, is simpler to manage and is more easily maintained (Chakroff, 1976). Common carp or tilapia have been widely used in monoculture systems over the years.

Polyculture requires experience and knowledge of the ecology of the species of fish used. Also, compared to monoculture the greater handling at harvest in polyculture may prove expensive, and is further complicated by the various species reaching their optimal size at different times (Hepher and Pruginin, 1981).

Nevertheless, most of the literature would seem to indicate that the benefits of polyculture to the small-scale farmer are such that its use and development is valuable (Little and Muir, 1987; Rabanal and Shang, 1979; Moav et al, 1977; Pillay, 1990).

The mono-sex culture system, generally involving the tilapia species, prevents reproduction and allows for faster growth rates (Mair and Little, 1991; Chakroff, 1976; Huet, 1970). An all-male stock has faster growth rates than a mixed male/female stock. Bardach et al (1972) claim male growth to be two to three times faster. Mair and Little (1991) report that the final size of hormone treated fish exceeds that of untreated male and female fish by about 16 and 30 percent, respectively.

While the use of mono-sex culture is beneficial to small-scale farmers using tilapia due to the potential for improved yield (kg harvested/unit area) and fish size, the production of the required mono-sex fry for farmer grow-out is difficult. Numerous methods for achieving a mono-sex tilapia are cited by Mair and Little (1991).

- a) manual sexing prior to sexual maturity (see also Chakroff, 1976; Pillay, 1990; Huet, 1970);
- b) sterilization by induction of triploidy;
- c) hybridization.

Most of these methods of controlling reproduction are limited. Hybridisation has attracted much attention in the past but is also limited with numerous disadvantages. Many authors report being able to produce 95-100 percent male progeny by crossing two different species of tilapia (Huet, 1970; Bardach et al, 1972; Pillay, 1990). While these authors report a number of crosses, those most consistently used are (female x male) *O. niloticus* x *O. hornorum* and *O. niloticus* x *O. aureus* (Mair and Little, 1991). In contrast, Pillay (1990) cites Majumdar and McAndrew's study (1983) which suggests that only the crossing of *T. mossambica* males with *T. macrochir* females, will produce 100 percent male progeny.

A major problem with these methods is highlighted by work conducted by AIT and cited by Mair and Little (1991). It was demonstrated that recruits could form up to 33 percent of the harvest biomass if as little as five percent of the stocked fish are fertile females.

In response to the search for greater success in sex reversal two further methodologies have been recently developed and are discussed by (Guerrero, 1982; Mair and Little, 1991).

- a) hormonal sex reversal;
- b) genetic manipulation of sex determination.

As discussed by Mair and Little (1991) while hormonal treatment has been commonly used, a lack of infrastructure and logistical factors has hampered its introduction in many circumstances. Further, due to economies of scale and the requirement to use simple technology it is not appropriate for small-scale operators. The primary objectives are to produce all-male fry and maximise the survival of fry during the period when cannibalism is a problem (10-30 days after the first breeding). The method relies on being able to ensure that an adequate intake of hormone treated feed by the fry at an early age (before 17-19 days old). Factors such as feed and water quality, water temperature and disease will all affect appetite and thus the effectiveness of sex reversal.

An alternative to the hormonal sex reversal technique is the use of genetic manipulation of sex determination. This method seeks to produce large numbers of "supermales" (YY) which should yield all male progeny when crossed with normal female fish (Mair, 1988). The main advantages this method has over hormone treatment is its potential to produce 100 percent male progeny (thus, eliminating the reproduction problem completely) and it is applicable to most fry production systems. Its main disadvantages at this stage are that it is still being developed and the initial production of the YY males is complex and time consuming. Once the YY males are produced in large enough numbers however, small-scale operators will be easily able to produce the sought after all-male fry for grow-out (Mair and Little, 1991).

3.10 POND STOCKING

Generally 'stocking rate' refers to the total number of fish seed of a particular species per unit (hectare) of water surface (Chakroff, 1976; Shang, 1986). Stocking rates will naturally vary according to pond characteristics (for example, available space and levels of natural food) and/or fertiliser available and the size of the fish stocked. In the determination of a pond's optimal carrying capacity, Shang (1986) notes three factors for consideration:

- a) fertilisation and/or supplementary feeding;
- b) plentiful supplies of dissolved oxygen;

c) the utilisation of polyculture systems.

It is important to balance fish populations with available food. As Bardach (1972) notes, in the stocking of polyculture systems involving carp, plankton feeders should predominate in order to exploit the large stock of plankton available. Phytoplankton feeders like silver carp are suitable because of their location at the bottom of the food chain. Herbivores (e.g. grass carp, silver barb) will require to be few in number unless significant quantities of supplementary feed are provided. Bottom feeding omnivores and carnivores (e.g. common carp, mud carp, black carp) will vary in number according to water depth, since shallower and lighter ponds will support greater quantities of benthic organisms. Finally, piscivorous fish quantities will vary according to the degree of uncontrolled spawning.

Where tilapia are involved in rice/fish culture, it is important that only plankton and algae feeders are stocked, since macrophages could attack the rice. In most polyculture pond systems, tilapia stocking has proved to be highly successful - total production has increased without a decrease in the production of other species (Bardach et al, 1972).

Either multi-stage or multi-size stocking may be practised in both mono or polyculture systems. "Multi-stage" refers to the movement of uniformly-sized stock through a series of ponds, increasing in size as they grow out. Table 3.5 provides an example of such a system in polyculture, including the stocking rates involved.

Table 3.5 Example of Multistage Polyculture in China

Stage	Size of Fish, g	Stocking Density/ha				Rearing Period
		Bighead	Grass Carp	Silver Carp	Mud Carp	
1	14-65 14-80 5-20	6,750	1,500	3,750	112,500	40 days
2	65-225 80-500	2,100	6,750	600	37,500	150 days
3	225-500 500-1,000 60-270	900	3,000	300	12,750	150 days
4	500-1,200	375	1,050			

Source: FAO (1977), as cited by Shang, Yung C. (1986).

While multi-stage stocking may be more appropriate in larger, multiple pond systems, it does take advantage of the maximum growth potential of the fish, and allows for a continuous cycle of stocking and harvesting (Shang, 1986). "Multi-size" stocking involves rearing fish of varying ages in the same pond. This means that the different feeding habits of young and mature fish may better utilise available pond food. High production in this way is possible, whether the fish are harvested in total at suitable intervals (Huet, 1970), or according to their size (Shang, 1986). If only marketable fish are taken they are replaced by a suitable number of smaller fish.

Many small-scale farms may observe mono-size stocking principles. Here, one species of the

same size will be reared through to harvest. However, while this system is common in fry rearing (Shang, 1986), and will produce an even sized harvest (Bardach et al, 1972), it can have disadvantages in pond culture. For example:

- a) if stocking density is overly high, overcrowding might result when the fish reach adult size;
- b) if stocking density is too low, the water space and natural food of the pond will not be efficiently utilised. As suggested earlier, this could result in the water becoming too productive in fertilised ponds, causing DO deficiencies.

Table 3.6 below contains examples of stocking densities in fry production in Indonesia, the Philippines, India and China.

Table 3.6 Stocking Rate of Fry by Country and Species

Country & Species Stocked	Stocking Rate, no. of Fry (000's)/ha	Age or Size
Indonesia Common Carp	60	3 wks old
Philippines Common Carp	50	8 - 10mm
India Common Carp	1250-2500	2 days old
China Grass Carp	303	3.0 cm
	60.6-75.8	4.8 cm
Bighead Carp	22.7	3.0 cm
	60.6-90.9	6.0 cm
Mud Carp	409.1	3.0 cm
	136.4	5.8 cm
Silver Carp	303	3.0 cm
	12.1-15.2	6-9.5 cm

Source: Bardach et al (1972); FAO/UNDP (1979).

3.11 SUPPLEMENTARY FEEDING

Since a well-managed pond is capable of maintaining high natural food levels, supplementary feeding should only be undertaken if the resulting increase in production will more than offset the cost of feed and feeding. Yamada (1986b) suggests three criteria which should dictate whether supplementary feed is required and, if so, what kind and how much feed should be used.

- a) the amount of naturally occurring food in the pond;
- b) the nutritional requirements of the fish;
- c) fish stocking density.

An additional consideration for the small-scale farmer (for which fish culture is not the

dominant component of his/her farming system) is the opportunity cost of the supplementary feed used. Is the expenditure incurred able to be more productively utilised elsewhere? In other words, does the extra fish yield obtained, and the requisite benefits provided, by investing in supplementary feed equal or exceed what can be obtained by making the same investment elsewhere in the farming system.

Where carp ponds are used, if it is assumed that maximum fish yield is required, supplementary feed will frequently be required. Bardach et al (1972) suggest that the economic population density of common carp is often greater than that which the natural water fertility can support. Or, in cases where herbivorous fish are stocked (i.e. grass carp, silver barb, tilapia), supplements of aquatic or terrestrial vegetation may require to be added to boost the supply of plant life, which is often sparse. However, food supplements used must be selected so as to avoid duplication of the nutrients already provided by the pond's natural food. Furthermore, according to Bardach, where common carp are involved, artificial feeding should emphasise high carbohydrate food. Protein already abounds in natural pond food.

Supplementary feeding need not involve great expense. FAO (1977) found that in China locally available feeds of either plant or animal origin could often be efficiently utilised at nominal cost. For example:

- a) 60-70kg of grass and vegetable tops can produce 1kg of grass carp;
- b) 50kg of snails and clams produce 1kg of black carp;
- c) 100kg of water fertilised with 77 percent bean curd residue and 23 percent fermented products residue produce 1kg of silver carp;
- d) 500g of fish waste produce 0.8kg of silver or bighead carp;
- e) 25kg of animal manure produce 500g of silver or bighead carp.

In addition to these suggestions, Santhanam et al (1987) refer to the use of powdered, groundnut oilcake and rice-bran, mixed at 1:1, soaked in water, and formed into small balls. Also, sieved flour-mill waste, kitchen waste, and chopped, boiled vegetable waste may be used. Protein-rich feed components such as silkworm pupae, soybean, cowpea, aquatic insects, trash fish and prawn waste may also be added, if they are necessary for greater growth/production.

The range of supplemental feeds available is extensive. However, where it is established that their use is truly necessary, only those readily obtainable and providing maximum growth, consistent with economic considerations, should be used.

3.12 DISEASES AND PARASITES

Freedom from diseases and parasites is obviously essential to the physical well-being of fish and the success of any aquacultural venture. In disease prevention, it is important to ensure that no artificial stress is restricting the maintenance of healthy conditions.

Conditions such as overcrowding, unbalanced nutrition, low oxygen levels, an increase in organic material, and changes in pH and temperature can each weaken the fish, making them more susceptible to disease (Sarig, 1979). Alternatively, since potential pathogens are always present in aquatic environments, favourable conditions will allow pathogens to proliferate, resulting in the manifestation of infectious diseases (Pillay, 1990; Sarig, 1979).

It is therefore important to be aware of the various physical and behavioural signs of stress and disease. A guide to likely signs is provided by the United States Department of the Interior (1984). See Table 3.7 below.

Table 3.7 Typical Signs of Disease

<u>Behavioural Signs</u>	<u>Disease Type</u>
* Failure to feed.	Most diseases.
* Swimming weakly, lazily, erratically or in spirals.	Most diseases.
* Scratching, flashing or rubbing against objects in the pond.	External parasites.
* Twitching, darting, convulsions.	Toxins, nutritional disease, external parasites.
* Failure to flee when exposed to fright stimuli.	Low oxygen, metabolic factors, most diseases.
* Crowding or gathering in vegetation, shallow water or at the water inlet, hiding to avoid light.	Most diseases, toxins, low oxygen.
* 'Topping' or 'piping' at water surface, floating head-up, moribund or dying.	Low oxygen, toxins, external parasites, bacteria.
<u>Physical Signs</u>	
* Dead or dying fish.	Most diseases.
* Open lesions or sores, bloody or reddened areas.	Bacteria, bacteria secondary to parasite infections, external parasites, toxins.
* Gaping mouths.	Low oxygen, diseased gills.
* Scale loss.	Milk scale disease, external parasites, fighting, predation, rough handling.
* Pale, eroded, puffy, bloody, brown gills, or gill covers flared.	Anaemia, vitamin deficiency, gill disease, environmental stress, toxins, external parasites, Branchiomyces (fungus), Flexibacter columnaris (bacterium).
* Bleached skin colour.	Vitamin E deficiency, low oxygen.
* Popeye, stargazing.	Bacterial dropsy, brain flukes, gas bubble disease, malnutrition, environmental contaminants.
* Bloated belly.	Bacteremia, flukes, Ligula (tapeworm).
* Excess mucus, sloughing of skin, scratches on body.	External parasites, fungus, fighting, predation.
* Spinal curvature.	Vitamin C deficiency, pesticides, genetic deformities.
* Folded fins or tail, pectoral fins pointed forward.	Toxins, many diseases.
* Nodules, pustules, white spots.	Myxosporidian cysts, larval trematodes, Ich, yellow grub, larval nematodes.
* Fluid in body cavity (cloudy, bloody or clear).	Bacterial dropsy, malnutrition.
* Bloody internal organs.	Bacteria, virus, vitamin A or B deficiency.
* White fungus patches.	External fungus, 'Epistylis' (protozoan).
* Frayed fins or tail, eroded tail.	External parasites, chemical contaminants.
* Emaciation, reduced growth.	Diseases causing reduced feed intake, malnutrition, intestinal worms, vitamin deficiency.
* Air bubbles under skin.	Gas bubble disease.
* Cloudy eyes.	Eye flukes, nutritional deficiency.
* Red spots near base of fins.	Larval 'Lernaea' (copepod), external parasites, bacteria.
* Grey, chalky white, or dull opaque yellowish ovaries or eggs in golden shiners.	'Pleistophora ovariae' (protozoan).
* Ruptured abdomen.	Toxic algae (in fry), 'Ligula' (cestode), white grub (trematode).
* Dirty grey or yellow lesions.	Bacteria, external parasites, external fungi.
* Foul smelling lesions.	'Edwardsiellatarda' (bacterium).
* Hole-in-the-head.	'Edwardsiella ictaluri' (bacterium).
* Brown blood.	Nitrite toxicity.

Source: U.S. Department of the Interior (1984).

While disease can occur despite precautions, sound management practices will generally be

rewarded with healthy fish (Stickney, 1979). Wherever possible treatment with drugs and chemicals should be minimised, so as to avoid the development of dependency. According to Stickney, these are an additional source of stress, because the amounts of these substances often required will approximate levels fatally toxic to fish. A balance between fatal toxicity and eradication of the pathogenic organisms should be found.

Essentially, the key to successful treatment will be early detection and correct diagnosis (Stickney, 1979). However, as Pillay (1990) states, eradication requires a programme by which infected stocks are removed, re-infection is prevented, stress is reduced and optimal conditions are regained. Chemotherapy or the use of therapeutants will generally only give temporary domination of a pathogen.

Undoubtedly, prevention involving the adoption of sound husbandry practices and the avoidance of pathogens is the best treatment. Bryant et al (1980) suggest several preventative points:

- a) maintenance of a relatively disease-free water supply;
 - i) screening pond inlets to bar wild fish;
 - ii) obtaining stock from a reputable supplier;
- b) proper hygiene;
 - i) pond and equipment disinfection;
- c) the quarantine of all newly purchased stock.

Disease is a concern not only for the fish being cultured however. The hazards to public health can also be serious, especially in tropical areas. The existence of water-borne diseases such as Bilharzia (schistosomiasis)¹⁹ and mosquito-borne diseases such as Malaria,²⁰ are the most hazardous and will usually necessitate the adoption of specific preventative measures. Pagoda ponds and fish ponds can become breeding grounds for malaria-carrying mosquitoes if not properly managed. Pond farms built on low-lying, swampy areas are favourable areas for mosquito breeding. Accordingly, if the risk of mosquito breeding is to be minimised ponds must be constructed with proper drainage facilities and the water surface kept clean of vegetation to allow water movement by the wind and fish. Pillay (1990) states that in particular ponds which are constructed above the surrounding ground level should:

- a) be at least 0.61 metres deep;
- b) have dykes with steep sides on the inside to avoid shallow margins;
- c) be kept weed free;
- d) have proper drainage channels to control seepage;
- e) be protected from cattle, as their hoof prints on the embankments are notorious breeding grounds for mosquitoes;
- f) be well stocked, since most fish species will feed on mosquito larvae and the algal vegetation sheltering them.

Some fish species (for example, the tilapia species) have been found to be useful in controlling mosquito larvae. Hickling (1962) reports that *T. mossambica* cleared all larvae from fish tanks in Malacca.

19 Bilharzia is a particular problem in some regions of the African continent. It is not a problem in Cambodia.

20 The malarial carrying mosquito is common where areas of still water are available for larval rearing.

In the case of bilharziasis, the water is contaminated by infected people, and environmental conditions suitable for the growth of snails, a necessary intermediate host (Pillay, 1990). Prevention may accordingly be achieved by avoiding the use of contaminated water and controlling the snail populations. Again, according to Pillay, there are three methods available for controlling snails:

- a) introducing snail-feeding fish;
- b) integrating fish with ducks, as ducks feed on snails and algal vegetation;
- c) periodic draining, drying and liming of ponds.

As Table 3.7 suggests the range of fish diseases is large. Table 3.8 therefore, provides a list of those which are commonly referred to concerning warm water fish species. For each disease listed the likely symptoms, possible treatments and preventative measures available are noted.

Table 3.8 Some Common Warm Water Pond Diseases

Diseases	Symptoms	Treatment and Prevention
<u>Viral</u>		
* Epizootic Ulcerative Syndrome (EUS)	Early lesions usually single or multiple, development of large shallow ulcers with hemorrhagic or necrotic base, lesions generally on dorso-lateral body surface, in snakehead erosion of head and jaws likely.	Low rate of recovery, destroy affected fish.
* Lymphocystis	Verrucose lesions on skin and fins.	Eliminate diseased fish, disinfect facilities, derive stock from free populations.
* Infectious Dropsy	Fluid accumulation in body cavity, scale protrusion.	Avoid carrier fish, reduce environmental stress, good husbandry and nutrition.
<u>Bacterial</u>		
* Furunculosis	Blisters on skin, protruding eyes, fluid in body cavity and oedematous organs.	Slaked lime in drained pond, medicated feeds.
* Columnaris	Discoloured grey patches in dorsal fin area, lesions exposing underlying muscle tissue, lesions prominent in mouth and head and are yellow and cratered.	Good husbandry and nutrition, avoid exposure to disease, disinfect water supply, reduce population density and water temp, Coper sulphate 33ppm for 20 minutes.
* Gill Rot	Pale colouration of gill filaments, sloughing and accumulation of excess slime, inflamed and eroded gill covers.	Bleaching powder containing 30% available chlorine at 4kg/ha.
* Edwardsiellosis	Gas filled lesions in muscle tissue of mature fish.	Avoid environmental stress, improve husbandry and nutrition, use antibacterial's.
* Fin and Tail Rot	Margins of fish become necrotic and slough away.	Improve water quality, reduce stocking density, good nutrition, antibacterial drugs.
<u>Fungal</u>		
* Saprolegniasis	Cutaneous infection of skin or gills, hemorrhage, blindness.	Good sanitation, malachite green treatment, potassium permanganate treatment, common salt.

- | | | | |
|---|------------------------------------|---|---|
| * | Gill Fungus
(Branchiomyces sp.) | Common in presence of abundant decaying organic matter. | Prevent pollution, introduce cool water, stop artificial feeding, add lime. |
|---|------------------------------------|---|---|

Protozoan

- | | | | |
|---|------------------------------|---|--|
| * | Ichthyophthiriasis | Small whitish cysts (1mm) on skin, gills and fins. | Destroy carrier fish, disinfect water and equipment, malachite green (0.1ppm/15ppm formalin). |
| * | Ichtyobodosis
(Costiasis) | Dull spots on the sides, grayish film by increased secretion of mucus, erosion of tissue between rays of fins. | Quality nutrition, disinfect spawning ponds with quicklime, eliminate carrier fish, formalin, malachite green, potassium permanganate. |
| * | Trichodiniasis | Dull body with thin, whitish film of mucus, fish become restless. | Disinfect fish and pond, potassium permanganate. |
| * | Sporozoa (Pox disease) | Large numbers of milk-white cysts on various regions of the body. Cysts on gills impair breathing. Weakness, emaciation, falling off of scales. | Intra peritoneal injection with 1ml of a 1% solution of arsenic compound, arycil. |

Trematodes

- | | | | |
|---|--|---|--|
| * | Deplostomiasis
(Black-spot disease) | Small black nodules (1-5mm across). Occurs in lens of eyes. | Dip treatment in 3:100,000 picric acid for 1 hour; Di-n-butyl tin oxide at 250mg/kg. |
| * | Gyrodactylosis | Fading of colours, drooping of scales, peeling skin. | Dip treatment in 5% common salt solution or 1:5,000 formalin for 5 minutes, or 2ml of 25% ammonia solution/litre of water for 30-60 seconds. |
| * | Dactylogyrosis | Gill damage, gills covered in mucus, restless. | Dip treatment in 2ml of 25% ammonia solution/litre for 30-60 seconds. |

Cestodes

- | | | | |
|---|---------------------|---|----------------------------------|
| * | Ligula intestinalis | Swollen belly, belly eventually ruptures. | Treat as for Black-spot disease. |
|---|---------------------|---|----------------------------------|

Copepods

- | | | | |
|---|-------------------------------------|--|---|
| * | Argulosis | Younger fish more susceptible. Inflamed wounds secreting mucus oedema & hemorrhages. Loss of scales. | Separate younger fish, isolate infected fish, dry and disinfect pond after harvest, place sticks in pond bottom to attract Argulosis eggs & then remove, introduce frogs to eat parasites, Bromex at 0.12ppm or dip baths of 1ml lysol/5 litres of water for 5-15 seconds or 1g of potassium permanganate/1 litre water for 40 seconds. |
| * | Lernaeosis
(Anchor worm disease) | Ulcers with bright red or grayish margins, parasitic fibrous nodules, parasite can also penetrate the liver. | Control during free-living larval stage of parasite with 0.12-0.15 Bromex repeating 3 times at 7 day intervals. |

Source: Pillay (1990); Brock (1986); Santhanam et al (1987); U.S. Department of the Interior (9184); Sarig (1979); Gopalakrishnan (1968); Bardach et al (1972); Frerichs et al (1990).

3.13 ALGAL BLOOM, WEED AND PREDATOR CONTROL

The control of weeds is important not only for controlling mosquito populations. Although aquatic plants are useful for maintaining water quality, and providing shelter and substrates for food organisms, if permitted to grow uncontrolled they can significantly inhibit pond management.

In fact, Pillay (1990) states that weed infestation in the undrainable, tropical ponds of Southeast Asia can assume 'very severe proportions', the consequences being that light penetration of the water is inhibited, photosynthesis and oxygen production reduced and the volume of dead and decaying vegetation increased. As a result, oxygen depletion and eventually anoxia will occur. Also the dead and decaying vegetation will add to the soil and water's fertility, promoting further weed growth. This in turn will increase the demand for pond nutrients and reduce the volume available for plankton growth, required for fish food. Furthermore, those weeds rooted in the pond bed will tend to trap silt and organic matter around their roots, causing excessive siltation and difficulty in harvesting with nets. (Pruginin, 1968; Pillay, 1990).

Before examining weed growth control, it may be useful to consider how growth might be prevented. For this, a knowledge of the causes of weed infestation is important. Water clarity can have a major effect here, because clearer water allows sufficient sunlight to reach the pond bed for submerged weeds to become established. It is therefore imperative that fertilisation be regular in order to maintain the growth of phytoplankton (Lawrence, 1968).

This can be a particular problem in newly filled ponds because of the time involved in establishing phytoplankton. If a pond has very shallow marginal areas, has a fluctuating water level, or becomes silted, weed growth will also be stimulated. This will not only affect the pond environment, but, as previously discussed, increase the danger of malarial incubation.

Finally, connection with sources of infestation, floods, and or drainage from fertile land areas, will undoubtedly prompt the introduction and establishment of weeds (Philipose, 1968). These factors, jointly or severally, are responsible for weed infestation, and as such should be eliminated by the proper utilisation and year-round maintenance of the pond.

In considering control of weed and algal infestations, it is useful to note various weed types, classified as follows:

- a) Algal weeds;
 - i) filamentous algae (e.g. *Spirogyra*, *Pithophora*);
 - ii) algal blooms (e.g. *Microcystis*, *Anabaena*);
- b) Floating weeds (e.g. *Eichhornia*, *Pistia*, *Azolla*);
- c) Emergent weeds (e.g. *Nymphaea*, *Myriophyllum*);
- d) Submerged weeds (e.g. *Ceratophyllum*, *Hydrilla*);
- e) Marginal weeds (e.g. *Typha*, *Marsilia*, *Jussiaea*).

(Lawrence, 1968; Pillay, 1990; Santhanam et al, 1987).

There are generally five methods available for weed control; management, manual, mechanical, chemical, and biological. Table 3.9 provides a brief overview of how these are applied.

Table 3.9 Summary of Methods of Weed Control

Control Method	Weed Type				
	Algal fil	Floating bloom	Emergent	Submerged	Marginal
<u>Management</u>					
1 Deepening marginal shelves					*
2 Burning			*		*
3 Grazing, ploughing in			*		*
4 Artificial turbidity				*	
5 Draining & desilting		*			
6 Erecting barriers		*			
7 Flooding			*		*
<u>Manual</u>					
1 Uprooting, cutting			*	*	*
2 Netting		*			
3 Log weeders				*	
4 Hand drawn bottom rakes, bamboo poles, broom forks, sickles etc.				*	
5 Agitation	*				
<u>Mechanical</u>					
1 Drag line excavators, weed buckets, chinese rake etc.			*	*	*
2 Allen motor grass cutter.			*	*	*
3 Weed launch etc.			*	*	*
<u>Chemical</u>					
1 Shading with dyes or cowdung	*				
2 2,4-D ester			*	*	*
3 2,4-D (amine salt)		*	*	*	
4 Diquat		*		*	
5 Copper Sulphate and Simazine	*	*		*	
6 Anhydrous ammonia		*		*	
7 Sodium arsenite	*			*	

<u>Biological</u>					
1	Grass carp: fingerlings adults		*		*
2	Silver barb	*	*		*
3	Tilapia: mossambica rendalii zillii nilotica	*			*
4	Common carp (uprooting)	*		*	*
5	Ducks & geese				*
6	Shading: water lettuce salvinia				*

Note: * = Control method able to control weed type category.

Source: Pillay (1990); Santhanam et al (1987); Philipose (1968); Lawrence (1968); Blackburn (1968); Hickling (1962).

In selecting a method, it is necessary to consider the type and density of the weed infestation, nature of the farm, cost, species of fish being cultured, and the most appropriate time for treatment (Pillay, 1990). According to Pillay, by ascertaining when the weed is likely to be most vulnerable (i.e. during intensive production of reproductive units), control can be most effective.

Naturally, in small-scale, low-cost aquaculture, cost will be a major constraint, particularly in the use of herbicides. If these are used, particular care must be taken in the method and timing of their application, because most are also lethal to cultured animals. In some cases the accumulation of herbicides in the pond bed is a problem. For example, sodium arsenite build-up on bed fauna can be harmful to the food chain (Pruginin, 1968). Dead plant matter must still be removed manually to avoid oxygen depletion as it decays. While Table 3.9 shows the categories of weeds on which various herbicides are effective, it must be noted that their efficacy will also vary according to the specific weed species concerned.

Utilising management strategies appropriate to particular situations is important. In this, biological control is likely to be the most effective. Selecting fish species able to consume unwanted weeds is in short most advantageous. However, as Pillay (1990) indicates, it is important to realise that biological control, despite its potential, can be difficult to implement.

The feeding habits of aquatic herbivores will vary at different stages of life, high fish densities are often needed to exert effective control and, if artificial feeds are used, the effectiveness of biological control may be reduced. Shading submerged weeds by producing phytoplankton blooms with inorganic fertilisers may be effective in some cases. But in Southeast Asia, where sunlight is intensive for long periods, light penetration may still be adequate to allow excessive weed growth.

Control of predators, weed fish and pests is also important. Apart from competing for food and space, these can prey on fry and fingerlings. Water beetles, bugs, dragonfly nymphs, weed fish, frogs (and tadpoles), snakes, crocodiles and birds can all pose problems. Water

management practices such as periodic pond draining and preparing for new stock, are useful in controlling predatory fish and, according to Pillay (1990), oil emulsions are effective in controlling insect larvae and frogs.

Birds, however, are a more difficult concern and, as Pillay (1990) outlines, have been the subject of much ingenious attention. In Southeast Asia, for example, lines with bright-coloured pieces of cloth or metal attached are strung across nursery ponds between poles to frighten the birds.

Fencing and clearing dense vegetation from pond embankments will generally prevent the entry of frogs, snakes, crocodiles, alligators and lizards. Preventing the entry of weed fish is simply achieved by filtering the water at the pond's intake. There are numerous simple, easily constructed devices available for this. Some examples suitable for small-scale ponds in Southeast Asia are noted by Chakroff (1976) as follows:

- a) a saran fibre filter mounted in a wooden box;
- b) a nylon mesh bag hanging into the pond water;
- c) a sand/gravel/stone pit; or
- d) a wire screen mounted into a concrete/brick monk.

3.14 CONCLUSION

The range of pond culture systems, their attributes, methods of integration, and constraints are clearly diverse. What is applicable in any given situation will be largely dependent on a farmer's requirements, environment and resources available. In selecting an appropriate aquaculture system and method of integration which is appropriate, the range of site information required can be summarised as:

- a) farm size (small or large scale);
- b) the role which the aquaculture enterprise is to play within the total farming system (the dominant farm activity or complementary to other more important activities);
- c) resource availability (for example; fluctuations in availability throughout the year, adequate water of the required quality, water retention capacity of the soil, waste type available for fertilisation or supplementary feed);
- d) required output of the aquaculture system (i.e. kilogrammes of fish);

Of primary importance in small-scale aquaculture if integration is to be effective is that the selected systems complement the farmer's current and primary means of production. These systems will need to have the capacity to utilise available waste and water resources within the environmental, social and production constraints of the farming systems into which they are to be integrated.

However, in order to allow conclusions to be made on how small-scale aquaculture can be appropriately used in the Cambodian situation a case study and the results of research conducted *in situ* is provided in the following chapters. This study considers in detail one project which is assisting the development of integrated pond and rice/fish culture among small-scale farmers in the Kandal province of Cambodia.

The following two Chapters provide an overview of the project and the baseline analysis programme it conducted in its first year of implementation. Arising from this baseline analysis programme was strategic environmental and socioeconomic information. The project will use this information as a basis for the establishment of farm-based trials. These trials will facilitate the farmer refinement of appropriate aquaculture and integration methodologies

which will be later promoted by the project's farmer based extension programme. Here however, the research permits the formulation of appropriate conclusions on the potential which integrated aquaculture has for aiding the improvement of fish availability to the rural population, and further, to ascertain its value as a means to sustainable rural development in Cambodia. These conclusions are provided in the final chapter, chapter seven.

CHAPTER FOUR

THE SCALE PROJECT: A MEANS TO SUSTAINABLE RURAL DEVELOPMENT IN CAMBODIA

4.1 INTRODUCTION

Having discussed the various attributes of aquaculture, its integration and its role in sustainable rural development, we can now focus on a specific project.

The SCALE project is endeavouring to refine an appropriate methodology for the sustainable implementation of IAQS for small-scale farmers. It is focused not only on the integration of aquaculture with traditional farming systems in Cambodia, but also on the establishment and facilitation of a farmer-led process of development. As such, it is an example of how integrated aquaculture can contribute to the implementation of a sustainable process of rural development.

After nearly two years of planning, its first phase (primarily the conduct of a baseline analysis programme) began in early November 1991.

This chapter will introduce the SCALE project, its objectives, rationale and strategy for development. The following chapters will discuss the baseline analysis, some of the results produced and the influence they are likely to have on the project. Recommendations for the future shape and form of the project are also considered.

4.2 THE IDENTIFICATION AND FORMULATION OF SCALE

The SCALE project (SAO Cambodia Integrated Aquaculture on Low Expenditure) is a project formulated by SAO to assist the Cambodian Government to arrest the decline in its fisheries production. Throughout the 1960s and 1970s production from the once-abundant natural inland fisheries continuously declined and has since struggled to return to little more than half what it was in the early 1960s. This has dramatically reduced the population's consumption of fish, the most important source of protein in Cambodia. The rural poor (subsistence households) are the sector of the population most affected by the decline in fisheries production and are therefore targeted by SCALE.

Accordingly, SCALE aims to initiate a process of small-scale integrated aquaculture development (utilising various methods of integrated pond culture) designed to complement the traditional farming systems of the subsistence farm family.

Officially the SCALE project is a joint venture in Cambodia between the National Fisheries Department, the Department of Agriculture in Kandal province (where SCALE is located) and SAO (a United Kingdom based NGO). However, an additional and integral aspect of the SCALE partnership is the participation of the rural communities of Kandal province. Throughout the project's development, their positive and increasing involvement (as their managerial capacity develops) is integral to the development of the SCALE IAQS. For this reason the first three years of the project have a heavy emphasis on baseline analysis and farm-based trials.

Formulation of SCALE began in 1989, when SAO was invited to discuss with the Cambodian Government potential opportunities for SAO to assist in the country's reconstruction and development.

A project identification mission was conducted in October 1989. SAO discussed with the Cambodian Ministry of Agriculture and Fisheries Department (a department of the Ministry) the general status of the Cambodian fisheries, the Fisheries Department's development plans, and matters in which they sought external assistance.

The Fisheries Department proved to have three general strategies designed to arrest the decline in production from the natural fisheries:

- a) replanting flooded forest areas to re-establish fish nursery grounds;
- b) dredging the Tonle Sap (Great Lake in Central Cambodia) to assist the restoration of fish migration patterns;
- c) developing aquaculture to augment production from the natural fisheries.

Over the next two years, SAO made numerous visits to Cambodia to obtain information for the preparation of an appropriate project proposal. The Fisheries Department was the main government body involved in this process. Once the Fisheries Department had identified Kandal province as the optimal project location, the Kandal Department of Agriculture and the Kandal Provincial Committee became involved.

Care was taken to conceive a project suited to the needs of the rural community and the local environment in Kandal. Another major objective throughout this process was to propose a project, relevant to the goals of the Fisheries Management in Cambodia, which is simple and has the capacity to become locally sustainable.

During the planning of SCALE, survey work was considered necessary before a comprehensive development strategy could be designed. In particular, the socioeconomic environment of SCALE, is likely to be the key to the project's success. Moreover, ignorance of the current rural environment together with SCALE's intention to initiate the development of pond culture, (which has been largely unpractised by the Cambodian farmer), meant that an analysis of the rural community and environment was vital. A complete review of the baseline analysis programme formulated to address these issues is discussed in Chapter five.

4.3 PROJECT RATIONALE

Although small-scale farmers were specifically targeted in the formulation of SCALE, numerous consequent considerations arose. The more important of these include:

- a) To what extent should the project become involved in training?
- b) How intensive/technical should a project with small-scale farmers be?
- c) To what extent should the selected project involve experimentation?
- d) Should the project be based on the demonstration of new/appropriate farming techniques or should it involve a more participatory approach whereby the farmers assist in refining the techniques themselves?

4.3.1 Development Constraints and Opportunities

Of basic importance in the consideration of these issues are the numerous limitations to operating in rural Cambodia. After years of war and social disruption, movement and communications are very difficult. Secondly, the political climate is still far from stable and thirdly, the ability of the local government to actively and practically participate is limited.

Since late 1989 the political situation has changed significantly. In late 1989 the Vietnamese army withdrew from Cambodia and peace negotiations began between the four main political factions. During 1991, an agreement and ceasefire were negotiated, with a peace accord

(Paris Peace Accords) being signed in October of that year. Early in 1992, the United Nations Transitional Authority in Cambodia ("UNTAC") arrived and began preparations for holding national elections sponsored by the United Nations. Although not all the Cambodian factions cooperated fully, and some actively disrupted preparations for the elections, potential exists for an international effort in the reconstruction and rehabilitation of the country. This should provide a substantially improved climate for the establishment of a development project in Cambodia's rural sector.

Further, towards the end of 1989 the State of Cambodia government ("SOC") began to liberalise its economy. This brought economic freedom to the people, with the privatisation of land and property which followed allowing farmers to begin operating in their own right. Consequently the interest of farmers in improving their status and participating in development was renewed. This is evidenced in the fisheries sector by the rapid increase in the number of farmers experimenting with fish culture, particularly in Kandal. While the managerial capacity of the rural population was poor, the economic liberalisation provided them with the impetus to reassert control over their own destinies.

To what extent however, does the managerial capacity of the rural community permit its involvement in the development process likely to be promoted by the project? Would a project involving the rural community and provincial administration have the potential for sustainability? These questions are undoubtedly significant and should be seriously considered in the design and implementation of any project.

The need for assistance in the fisheries sector is clear. The annual production of the capture freshwater fisheries was little more than half what it was in the 1960s, despite a significant effort to re-establish the fisheries' historically prolific production since the fall of the Democratic Kampuchea ("DK") Government in 1979.

The Fisheries Department believes that, due to the degradation of spawning grounds and the siltation of the country's major waterways, production is unlikely to improve significantly beyond the current level (see Table 1.2). They believe that an alternative emphasis on developing freshwater aquaculture is necessary if the fisheries sector's production is to improve. The development of aquaculture therefore features as one of the Fisheries Department's main strategies in their five year plans.

This development need is highlighted by the importance of freshwater fish in the Cambodian diet. Moreover, the dramatic decrease in fisheries production together with an equally dramatic increase in population since the 1960s, means that fish as a source of protein must be frequently substituted with other meats. Further, it has become very expensive, inflating in price at a rate faster than that of inflation.²¹ This poses particular problems, as recent surveys have revealed that a high proportion of the rural population buy almost all of the fish which they consume. This problem is further compounded by other meats (poultry, pork and beef) being expensive also, and accordingly, not always an option for the rural poor.

4.3.2 Development Strategy

The development strategy of SCALE ("The SCALE philosophy") has a strong emphasis on increasing participation of the rural community in all aspects of the project. It is believed that efforts to facilitate the long-term sustainability of SCALE are worthless unless the local community can determine the desired direction of the development process. SCALE requires that this process should become centred in the local community.

²¹ The price of fish rose at a rate of 547 percent over the first ten months of 1992, while the average increase in commodity prices was 300 percent (CDRI, Oct 1992).

Having established the desirability of an aquaculture project, the key requirement is to facilitate the local development of appropriate, sustainable IAQS. The SCALE philosophy holds that the attainment of this high ideal lies in:

- a) the IAQS being integrated with the present traditional farming systems existent in Kandal;
- b) the farmers themselves not only participating in the development of the IAQS, but also through the use of farmer owned and operated farm-based trials ("FBTs"), directing IAQS evolution;
- c) the farmer to farmer communication of successes in the development of the IAQS. The wider implementation of SCALE should be led by a cross pollination of the development process rather than a top down implantation from a removed SCALE Management;
- d) the effective, on-going training of local staff who are competent, qualified, and committed to working with the farmer;
- e) an improvement in the managerial capacity of the local population.

While a bottom-up (or grass-roots) strategy in development has been mentioned frequently in development theory over recent years (for example, Chambers, 1983; Swift, 1988), SCALE believes that this should be realised, whatever the obstacles. If not, the long-term objectives of the project will not be achieved. Practically, farmers will be much more likely to participate in, and promote, the development process of the project if they consider they have an investment in its evolution.

The technical options adopted by the SCALE project reflect the above concerns. Essentially, two options confronted SAO in the formulation of the project. First, that it could be intensive and demonstration based, or secondly, that it could be simple and farm-based. In considering the first option, it was thought that seeking to transfer intensive aquaculture methodologies to small and poor farmers knowing only their traditional farming systems, was not appropriate. It would also involve significant demonstration and technical support, and a high degree of farmer aptitude and willingness to work. Furthermore, it would not facilitate the active participation and investment of the farmer in the development process as discussed above.

The second option appeared more appropriate to the prevailing socioeconomic environment. This option ensures the farmers are involved in developing the IAQS, whereas relying on demonstration from a large, intensive farm to transfer a new technology to a poorly developed rural community like Kandal, is both technically and socioeconomically not feasible.

The prospects for developing simple and appropriate IAQS, while they may lack the production capacity of more intensive systems, are much greater. Further, the IAQS, when refined, are intended to complement and enhance the existing traditional farming systems, not replace them. The traditional farming systems presently employed by the farmer will necessarily continue to dominate.

In respect of the sustainability of the IAQS, it is important to consider the impact of the development process initiated on the total farming system, not just the specific aquaculture application itself. The integration of aquaculture does not benefit fish alone, but the total farming system to which it is related (for example, garden and field crops, waste disposal). Further, an aquaculture application has an impact on wider farming activity in respect to the water, organic waste, labour and financial resources required. Sustainability therefore should be measured by the degree to which total farm production is improved and can be maintained. In this way, aquaculture contributes with other farm activities to the sustainability of the total farming system and the improvement in the well-being of the farm household.

Financial and risk concerns also influenced the selection of the simple, farm-based approach. For the farmer, IAQS must be developed which are appropriate, not only according to technical and social conditions, but financial also. The rural poor do not have the means to take risks. The SCALE baseline analysis revealed that most people are unwilling to borrow capital, the risk being too great. Their prime concern is ensuring their daily survival. This does not mean that farmers are unwilling to try new ideas or develop their farming systems, indeed survey results speak to the contrary, but only within the capacity of their present resources.

Financial concerns are also important regarding the capital intensiveness of SCALE. Sustainability is important not only at the farmer level, but also in the operation of the overall project. This is particularly important in the establishment of the SCALE Development Centre ("DC") in Kandal and the extension programme associated with the project.

The DC includes the construction of a medium-sized fish hatchery, capable of supplying Kandal with its future fish seed requirements. The technology used there must lead to self-sufficiency, whether eventually operated by the provincial authorities, the private sector (i.e. a collective), or some other rural institution. This, together with the managerial capacity of its operators, will necessarily dictate the level of technology it is able to employ. It has therefore been designed using gravity drainage and simple spawning techniques.

In summary, SCALE has set a strategy which is community (farmer) based. The development of the introduced IAQS is led by farmers and the fate of these IAQS is decided by farmers. SCALE's responsibility is to make sure this happens, not to dictate how it happens. The hatchery, while not operating at the farmer level, has similar requirements including simplicity, ease of maintenance, and potential for financial viability.

4.3.3 The Scale of SCALE

SAO's mandate from the Ministry of Agriculture is to assist Kandal Province to develop IAQS appropriate to both the small-scale farmer and the province.

Given the range of farming activities in Kandal, this is a formidable task. It has required the selection of project areas representative of the various existing landuse types. The main objective of the landuse appraisal conducted at the initiation of the project was to select these areas.

Although the project areas help to keep the project to a manageable size, the logistics of operating in a number of areas simultaneously involves significant managerial skill in the initial project phases.

After the first year of baseline work, the pilot programme was established. Twelve FBTs have been established in two of the five major project areas. A further fifteen will be established in the remaining three major project areas in the second year of the pilot programme.²² These FBTs constitute Phase II and III of SCALE. IAQS appropriate to the major landuse types and agro-ecosystems in Kandal will in this way be developed and the mandate fulfilled.

The other major factor influencing the size of SCALE is the fish hatchery being constructed at the DC (see Sections 4.4.1.2 and 4.4.3.1).

SCALE is divided into five main phases, and has an initial life of six years, in which time it will have achieved the initiation of IAQS development throughout Kandal. At the end of the

²² There are five main and two strategic project areas. See chapter six for a complete description of the project areas.

six years the implementation need not be complete, but should have advanced sufficiently to allow the gradual withdrawal of SAO and the eventual hand-over of the project to the local authorities.

To achieve this, the SCALE Management includes two expatriate staff for the baseline year and three thereafter. Local staff number eleven. Secondly, a carefully planned training programme is designed to improve local managerial capacity and provide adequately trained people to direct the increasing local control of the project. This programme involves concentrated annual training courses of up to one month, numerous on-site seminars and, as appropriate, further training overseas. Staff, suitably trained, will then manage the extension programme, facilitating the implementation of the IAQS throughout Kandal.

4.4 THE PROJECT

4.4.1 The Five Key Features of SCALE

There are five major features of SCALE. Each is complementary and crucial to overall success. They are as follows:

- a) Baseline analysis;
- b) The Pilot programme;
- c) The Development Centre;
- d) The training programme;
- e) The extension programme.

The baseline analysis is discussed in detail in Chapter five. A summary of the other four aspects of SCALE is given below.

4.4.1.1 Pilot Programme

Analysis of the baseline survey will enable appropriate IAQS to be introduced to a selected group of pilot farmer sites (FBTs) within each of the project areas. With the support of SCALE (SAO expatriates and Cambodian field staff working with the project), farmers will conduct local trials using these IAQS. Results will be used progressively to refine the IAQS. Full account will be taken of sociocultural and socioeconomic factors, as well as technical criteria (both aquacultural and agricultural), in determining the success of the trials and any consequent variations of approach or improvement to strategies. The pilot sites will be operated and managed as any other village site.

The objectives of the FBT strategy are:

- a) ultimate refinement of IAQS and strategies for implementation under varying resource availabilities, and environmental, socioeconomic and cultural conditions and attitudes;
- b) establishment of models, in realistic settings, of some potential methods available to farmers for the integration of fish culture into their own systems;
- c) establishment of the credibility of the concept in recipient communities;
- d) initiation of the planting of the SCALE development process into the rural community;
- e) provision of a facility for Cambodian staff to integrate their training with (and make it applicable to) an authentic socioeconomic environment.

FBTs are the key to the SCALE development strategy becoming centred in the rural community. While SCALE intends to provide comprehensive support to these trials, the

farmer will retain overall control. The trial is to be owned and managed entirely by the farmer. Otherwise the farmer will not feel responsible for the trial's successes and failures. Ownership, in an economic and a developmental sense, is crucial to fulfil the goal of 'people's participation'.

The risk in placing the control of the FBTs in the farmer's hands is that they may not adhere to SCALE advice and fail to produce the answers which SCALE seeks. However, if SCALE were to retain control, the results produced would not necessarily accurately represent the true socioeconomic position of the farmer. An IAQS can only be considered appropriate and successful after it has been thoroughly exposed to all the dynamics of local socioeconomic conditions. This can in turn only be adequately achieved if the farmer is permitted to take the proposed IAQS and implement it as he/she deems appropriate.

SCALE's role here is to facilitate the provision of constant technical support and advice, especially in the first year of trial implementation. If such assistance is well received and the advice actioned, it may be considered appropriate. If not, the nature of the support may be inappropriate or the technical advice beyond the farmer's comprehension. SCALE will need continually to review the receipt of its support, to ensure that it suits the socioeconomic conditions of the farmer. In this way SCALE may facilitate the success of the farmer's implementation of the trial.

In addition, SCALE will be continually monitoring activity and progress. This will assist SCALE in reviewing its support, in ascertaining the suitability of the IAQS in question, and in making any necessary modifications.

If the pilot programme and FBTs prove successful, not only technically but also in the sense that the farmers become committed to the development process and begin to display some independence, it is intended that the development process will continue and expand throughout Kandal by a method of 'cross-pollination' (farmer based extension).

While SCALE must facilitate the wider implementation of the development process, it will seek to do this by encouraging the FBT farmers to drive the expansion. Thus, the wider implementation of the defined IAQS will occur through farmers communicating and demonstrating their already well established successes. Up to 55 new farmers will become involved in each of the two years following the completion of the FBTs.

To support the pilot programme and the FBTs, it is important that the SCALE field staff are well trained and equipped. Accordingly, these staff have been involved in an ongoing training programme which for the first year (during the baseline analysis) has focussed on socioeconomic analysis. This has included on-site training, a comprehensive one month training programme, and conducting field work for each of the surveys. They have been involved in planning, formulating, and conducting the surveys and subsequent analysis. In June 1993 the second annual training programme was held. It had the express purpose of preparing the staff for the pilot programme and involved an introduction to integrated aquaculture and farm-based trial methodologies (see Appendix 4.1).

In equipping the field staff it will also be important to ensure that they can easily service the number of FBTs each is assigned. See Appendix 4.2 for an indication of the staff requirements for the FBTs.

4.4.1.2 The Development Centre

The SCALE DC is viewed as a sub-project. This does not mean that it is detached from the other features of SCALE, but rather that it can be easily identified as a distinct entity. It is integral to the support of the SCALE programme and essential in the achievement of

numerous objectives such as:

- a) containing the fish hatchery, proven essential for the future supply of fish seed to Kandal.²³
- b) providing a training centre for the SCALE field staff;
- c) providing a centre for future extension activity;
- d) facilitating the participation of the local authorities and community in all aspects of the project;
- e) refining IAQS (in a limited fish raising system) by testing and adapting techniques to Kandal. The major benefit of this will be the advancement of the field staff's practical knowledge of aquaculture ("learning by doing"). This will enhance their credibility with local farmers and contribute significantly to their confidence and competence as extension workers.

While the above DC functions are essential to the implementation of the SCALE programme, they are not intended to dominate the focus of SCALE in the rural community. They are instead to support SCALE's on-farm development process. The hatchery will ensure the availability of fish seed to the farmer, and the training (in theory and practice) and extension functions will help build the managerial capacity of the field staff, future extension workers, and the rural community.

The hatchery is a technologically simple design, (including a gravity pond drainage system), which is essential to its ongoing management and maintenance if it is eventually to come under local control. The training component of the DC is essential in facilitating the development of the requisite expertise and commitment for hatchery operations.

Fish species chosen for the first year's production (1993) are capable of natural pond spawning. This will allow simplicity in the first year of operation, a test year, while still providing adequate fry for the first year of the pilot programme. The species selected at this stage are Nile tilapia, common carp and silver barb. In the subsequent years further species will be produced, which will likely involve the introduction of induced spawning techniques. While this involves a higher level of technology, it has the potential to be a sustainable technology with adequate training and support in the first years of practice. Induced spawning is currently practiced at the Chang Chamreas Research Station ("CCRS"), several kilometres north of Phnom Penh.

4.4.1.3 The SCALE Training Programme

Development of local managerial capacity through the comprehensive training of field staff and extension workers in all aspects of the SCALE integrated aquaculture strategy and development philosophy is crucial to the successful implementation of the project. Currently the managerial ability of the local community is low, requiring significant development through training, confidence building, and empowerment of the rural population. However, the actual level of local managerial ability is probably more advanced than it presently appears, being partially obscured by the current climate of political uncertainty.

The SCALE training programme is therefore comprehensive (including both weekly training days and intensive annual training courses) and designed to meet the ongoing requirements of SCALE. Of particular importance is the confirmation of the existence of adequate local

²³ Cambodia currently has a significant shortage of fish seed. Any surplus which the SCALE hatchery might produce will contribute to meeting shortages in other parts of Cambodia.

FAO findings assert that new hatchery facilities must be established in strategically located provinces and that provincial level hatcheries should be a 'sustainable technology' in Cambodia (FAO, 1990).

skills and managerial ability to sustain the project's management, the hatchery and the extension programme after the scheduled withdrawal of SAO from SCALE (possibly during 1997 and 1998, depending on local capacity to assume control).

The current field staff training programme plan can be viewed in Appendix 4.1.

After completion of each of the annual training programmes, a training manual documenting the sessions conducted will be produced. This will allow the trainees and others to refer back to the course content for refreshment. It will also be available for further use, either by SAO, Cambodian institutions or other agencies.

Appropriate explanatory and training materials for the extension programme will be designed (or adapted from materials used in other countries) and produced for the extension officers' use in training activities, promoting IAQS to farmers and monitoring and supporting farmer activity.²⁴

Further, English language tuition will be provided as necessary for those whose function requires essential reference to technical English literature, those who are required to establish working relationships with English-speaking advisers and those being considered for overseas scholarships.

In addition to these SCALE training programmes, it is intended that suitable field staff be provided with the opportunity for further training overseas. This is most likely to occur in neighbouring Asian countries, and could involve short courses (one to six months) or longer programmes such as masters degrees. The objective is to send at least one person each year to pursue such study.

4.4.1.4 The SCALE Extension Programme

In order to facilitate the introduction of proven IAQS, first to farmers in the SCALE project areas and then throughout Kandal, a comprehensive extension programme will be required.

After completion of the pilot programme extension officers will promote the concepts and benefits of integrated aquaculture to potential beneficiaries, train, advise and assist those who decide on an implementation. They will also provide the link to the SCALE team for continuing support and problem resolution.

4.4.2 The SCALE Beneficiaries

The design and focus of the project is intended to harmonise with the resource base and socioeconomic situation of the large proportion of small-scale poor farmers in Kandal. Accordingly, SCALE has been deliberately designed to incorporate low expenditure technology which complements the traditional farming methods these farmers are familiar with.

In contrast to the more widespread effect of a general community development project, it should be recognised that SCALE's focus on the promotion of IAQS means it will not fulfil the needs of all poor, small-scale farmers. Some such farmers will have other more pressing needs. For example, a farmer's need to have access to a reliable, potable water supply may be more urgent. In this situation, SCALE's close working relationship with other NGOs could allow such a need to be met through non-SCALE resources.

²⁴ For example, the training materials of the BAFRU Unit at the Institute of Aquaculture, University of Stirling in Scotland, may be available. With adaptation to fit the Cambodian cultural and linguistic context, they could be readily utilised.

Effectively, SCALE will only be available to a very small proportion of the Kandal rural community during the pilot programme and the initial stages of the wider implementation. The problem will therefore not be finding enough, suitable farmers to participate, but rather selecting farmers from a potentially large portion of the rural population.

After the first five years, the spread of the SCALE development process will become more rapid and its impact therefore greater. However, during the initial period of implementation it is not expected that SCALE will have a significant effect on the nutrition and protein intake of the rural population as a whole. Such an effect is a long term goal as the SCALE development process matures.

4.4.2.1 Benefit to Women

The SCALE philosophy incorporates an equality and equal opportunity policy in respect to gender.

While Khmer culture has traditionally given priority to men, women are very active in the management of farm activity and family business. The large number of women as a proportion of Cambodia's population and their traditional involvement in agriculture and fisheries should ensure that a significant proportion of the project's benefits accrue to women. With discretion and due respect to culture, the SCALE training programme encourages its Cambodian field staff to give equal opportunity to women who could benefit and participate in the project.

4.4.3 Works and General Facilities

4.4.3.1 The Development Centre and Hatchery Facilities

Construction of the fish hatchery has been divided into four stages, over four dry seasons. The first year's works involved the construction of a flood wall (approximately 900 metres long) along two sides of the 10 hectare DC site (see Appendix 4.3) including the installation of the gravity drainage system for the site (see Appendix 4.4). Being almost three metres high, it is designed to protect against heavy monsoon flooding. In 1991, one such flood occurred and was locally described as a "30 year flood". The flood wall, had it then been constructed, would have been sufficiently high to restrain this flood.

The final design and location of the flood wall was discussed with the Kandal Department of Agriculture and the Kandal Provincial Committee. The decision for the adoption of this design was made on-site by the SCALE Management, including a resident civil engineer in consultation with Robert H. Cuthbertsons & Partners, Consulting Engineers, of Edinburgh, who have been responsible for drawing the embankment plans. The hatchery design (specifications, layout, water supply and drainage facilities) were selected by the SCALE Management with the plans being drawn by the resident engineer (see Appendix 4.5).

The first year's construction programme used a combination of manual labour and supporting machinery. The labour force was paid in rice from the World Food Programme's ("WFP") Food for Work programme.

Due to difficulties in managing large gangs of workers (200 to 300 people) and repeated machinery breakdowns the embankment was not fully completed in 1992. It was however, raised to a height of approximately two metres which was adequate to hold back the 1992 monsoon flood.

The embankment was completed in the 1993 dry season and the reservoir, water supply and filtration system constructed. It had been intended to begin pond construction also in order

to permit a limited breeding programme to commence in the 1993 monsoon season. Unfortunately this was not achieved, due to the local contractor having difficulty working to the required specifications. Pond construction will therefore begin in the 1994 dry season. The fingerlings which were to have been produced for stocking the 1993 FBTs have instead been procured from the government hatchery, CCRS.

It is desired that the first year of hatchery operation (now to be 1994) will be low scale and simplistic (using species capable of natural pond spawning, see section 4.4.1.2.). Each year thereafter, further ponds will be constructed sufficient to permit the increase of production by about 25 percent per annum until the hatchery is finally complete and in full production. The hatchery design caters for a total of 40 fish ponds including eight brood ponds of 1,000m² each and 32 fingerling ponds of 800m² each.

At full production the hatchery should produce approximately six million eight centimetre fingerlings of four or five different species. Not all of these species will be capable of natural pond spawning which will therefore necessitate the use of artificial spawning techniques. The required facilities for artificial spawning will be designed and constructed only after the first year of hatchery and FBT production is completed.

In addition to the information provided by the baseline analysis, the results from the FBTs first production season will be of particular assistance in selecting the additional species for spawning and therefore the spawning facilities required. For the purpose of budgeting, the Chinese circular spawning tank system has been chosen. However there are numerous variations of this and other systems which are equally viable and will be considered at the appropriate time. Some alternative systems are simpler and less expensive. For example, the use of breeding hapas.

It will be necessary for the hatchery and selection of fish species to be flexible and able to respond to changing conditions and requirements within the rural community. One example is the potential future development of farmers becoming involved in nursing fry. If this becomes feasible the hatchery will be required to focus more on the provision of fry as opposed to fingerlings.

4.4.3.2 On-Farm Investment

The distinguishing feature of on-farm investment in the SCALE programme is that it will be carried out by the farmers on their own farms and at their own expense, with SCALE making credit available and arranging for required work where necessary. Where credit is necessary this will not necessarily be supplied by SCALE, but may come from other established rural credit programmes.

Particular forms of financial support which SCALE may need to facilitate are assistance for the initial construction required by the farmer and in subsidy of the cost of fingerlings to farmers in their first year or two of production. For on-farm construction, there is potential for further WFP assistance through their Food for Work programme. However, whatever support SCALE may be required to provide, the SCALE development strategy seeks to avoid providing handouts to farmers, but rather, seeks to facilitate their decision to invest in development. This is crucial if they are to fully own their development and move towards independence without a constant reliance on SCALE.

For each farmer, the required investment in construction and operating costs will be dependent on their existing resources and the technical requirements of the IAQS to be used. In terms of construction, the most which is likely to be necessary is the digging of a pond or the amendment of the layout of a rice paddy to raise the bunds and dig refuge trenches for the fish. SCALE will provide expert advice in the siting and design of ponds and the layout

of rice paddies, to obtain the optimal implementation of the IAQS.

4.4.4 Supporting Services

4.4.4.1 Extension

On an annual basis, the extension programme will facilitate the selection of, and support to, those farmers who will become involved with SCALE. All potential candidates for participation in the wider implementation will be assisted by extension officers to assess their situation and ascertain whether they are in a position to undertake the integration of an IAQS with their existing farming system. These officers will also facilitate the monitoring and on-going refinement of farmers' implementation on IAQS.

In addition to providing support to farmers, the team of extension officers will also be required to facilitate and support the development of the farmer-based extension process. The small group of FBT farmers only will be involved at first, but as more farmers become familiar and successful in implementing IAQS, the potential impact on farmer involvement in the extension process will grow.

Once the farmers selected for each year's wider implementation have been identified the extension officers will assist them in deciding how best to develop their existing farming system through the adoption of fish culture. Together, they (SCALE and the farmer) will select an appropriate IAQS, proven in the FBTs, and refine it as required to ensure that it is appropriate to the farmer's situation and local environment (physical and socioeconomic).

With each year's production a farmer's reliance on SCALE should decrease. Technical and economic independence should be possible after three years. This therefore means that, together with the increasing effectiveness of farmer involvement in the extension process, the annual increase in farmers implementing IAQS will not require a requisite increase in the number of extension officers required. The current schedule for farmer implementation suggests that 17 extension officers will be the maximum required.

Questions and factors for consideration in the selection of farmers to proceed with an implementation of integrated aquaculture will include:

- a) Why does the farmer want to grow fish?
- b) What will the farmer gain from growing fish?
- c) How can the new technology be adapted and transferred to the particular circumstances of the farmer?
- d) Who will benefit from the wider farmer implementation, and will the stated objectives of the project be achieved? For example, will the quality of living/nutrition of the poor in any given community be improved? If not, are the net benefits foreseen sufficient to justify implementation?
- e) Land tenure and ownership rights and responsibilities;
- f) Institutional facilities available in the local community and their effectiveness. Will any institutional facilities need to be established?
- g) The availability to farmers/villages of the required resources. If SCALE is to assist with their provision, how will the creation of dependency be avoided?
- h) Satisfaction of environmental and technical criteria on the proposed site for a successful implementation;
- i) Attitudes to, and willingness to accept new ideas. Degree of motivation and enthusiasm the farmers have for integration of new systems with their traditional methods;
- j) Whether the establishment of farmer clubs are appropriate and desired by those concerned. How can farmers be encouraged to interact and share their

- successes and failures to assist in improving their farming techniques;
- k) Monitoring the overall impact of the wider farmer implementation. The extent to which the benefits are being distributed for the provision of the local community's subsistence needs, especially the poorest. For example, are those farmers producing fish producing sufficient to allow marketing of excess production at a price which makes it readily available to the rural population?
- l) The extent to which the farmers have already decided or are capable of establishing:
 - i) their plan of authority for operation and control;
 - ii) their resource requirements ie. what they have available and how they can procure what must be obtained off-farm;
 - iii) their plan for implementation of the appropriate IAQS and how they intend to integrate it with their existing farming system;
 - iv) the method of marketing surplus produce.

As with the FBTs, the technical support required by farmers initially will be significant. However, with each year's production the farmers' reliance on SCALE will decrease. After three years of production a farmer should be capable of technical and economic independence.

The extension programme will therefore, require the capacity to maintain not only the support requirements of the new farmers coming on line each year (55 in each of the first two years after the completion of the pilot programme), but the requirements (decreasing) of these farmers for the first three years of their production. The extension programme will also facilitate the ongoing monitoring of SCALE.

To maintain this extension programme, it will be necessary to mobilise each of the extension workers on a motorcycle. They will be based at the DC, where the already established building has been designed to cater for their requirements. The SCALE training programme will provide necessary training (see Appendix 4.1). As new extension workers are required, they will also be able to receive on-site training by being apprenticed to a senior field staff member capable of introducing them to the requirements of the job.

To sustain the number of farmer implementations planned it will be necessary to train about eight extension workers ready for the first year of the pilot programme (1993). For the first year of the wider implementation (two years later) thirteen such workers will be required, and fifteen the following year. Refer to Appendix 4.2 for a detailed breakdown of calculations on staffing requirement. The eleven field staff already working for SCALE will be able to meet the extension requirements for the pilot programme.

4.4.4.2 Farmer Clubs

Another support facility which SCALE intends to establish are farmers' clubs. There could be considerable value in initiating a farmer support network, first for those involved in the pilot programme but subsequently for all who become involved in the SCALE development process. In other provinces some NGOs (World Vision International in Kampong Speu and Church World Service in Svay Rieng) have reported successful establishment of farmers' clubs. These could well be the most effective means of ensuring farmers communicate and share ideas. If successful, they could also greatly facilitate and even secure the placement of the SCALE development process in the rural community.

Such farmer meetings on a regular basis have proven very successful at advancing farming methods in numerous developed countries (notably New Zealand). Their apparently

successful establishment in Cambodia would suggest that they could be a useful strategy in rural development here. During the pilot programme, FBT farmers in each project area, and others who are interested, will be encouraged to communicate and interact. This will test the viability of starting farmer clubs in Kandal and provide a foundation for their formal establishment if considered feasible.

4.5 CONCLUSION

This case study is one example of an appropriate procedure for utilising integrated aquaculture in rural development.

The contribution which integrated aquaculture can make to achieving sustainable farming systems and sustainable rural development generally is dependent on the extent to which the physical and socioeconomic environment of the impact area is subjected to considerable baseline analysis prior to implementation.

The SCALE baseline analysis has proved indispensable in providing the required information on the physical and socioeconomic environment of Kandal Province. This information is now contributing to the drafting of the first IAQS which the already selected FBT farmers will implement. While some of these farmers will fail to produce the desired results, each will be of significant value in testing the potential of the IAQS, which although technically proven, have not been exposed to the unique physical and socioeconomic conditions characteristic of the SCALE project area.

In summary, the key features of SCALE may be listed thus:

- a) joint venturing in a development programme between local authorities and a foreign NGO partner;
- b) the apprehension and amelioration of a significant decline in inland fisheries production and, consequently dietary protein availability;
- c) establishment of low cost effective aquacultural technology in a rural heartland;
- d) comparatively simple integration of the technology with traditional farming systems so as to utilise on-farm resources;
- e) a development strategy based on intensive survey analysis and thereby geared toward simple, rapid and effective project implementation, specifically and appropriately targeted;
- f) sustainability of the above process achieved by introduction of the rural community into the project management at an early stage with a view toward rapid takeover.

CHAPTER FIVE

THE SCALE BASELINE ANALYSIS PROGRAMME

5.1 INTRODUCTION

Successful implementation of the integrated aquaculture development programme and its long-term sustainability are both dependent on a thorough understanding of the local socioeconomic and physical environment. With particular reference to Cambodia, two decades of war, oppression and isolation from the international community had brought about enormous changes in the rural community. SCALE Management was aware of its comparative ignorance of the socioeconomic environment and therefore adequate time was set aside at the outset of the implementation phase (Phase 1) to conduct a baseline analysis.

This baseline analysis, started in November 1991, was a comprehensive survey programme designed to obtain detailed socioeconomic and physical data. This data would provide the project management with greater insight in the conditions of the rural communities which would be important to define the IAQS and FBTs as well as provide a database for future reference.

The baseline programme, its objectives, purpose and procedure are discussed below. The results of the programme will be presented and discussed in chapter six.

5.2 THE BASELINE PROGRAMME

The baseline survey consists of five stages.

- a) The provincial level landuse appraisal was designed to ascertain the various landuses throughout the province and assist in the selection of key project areas. These project areas are the focus of the SCALE survey work (discussed in this chapter) and pilot programme (see Chapter four).
- b) The commune/village level survey provided the first socioeconomic, environmental, and technical information at the village level. It also provided the framework into which information obtained at the farmer level could be placed.
- c) The pilot farmer level survey was conducted as a trial run to the major baseline farmer survey to ensure that the methodology for the baseline survey would yield the desired results.
- d) The baseline survey examined a stratified sample of farmers (according to the socioeconomic categories of poor, average and good) from within the five main project areas. The selection was taken using a random selection of the villages surveyed in the commune/village level survey.
- e) The benefit-cost analysis of the project, included the DC hatchery, the FBTs of the pilot programme and an estimated number of farmer implementations over a total of twenty years.

5.2.1 Preparing for The Analysis

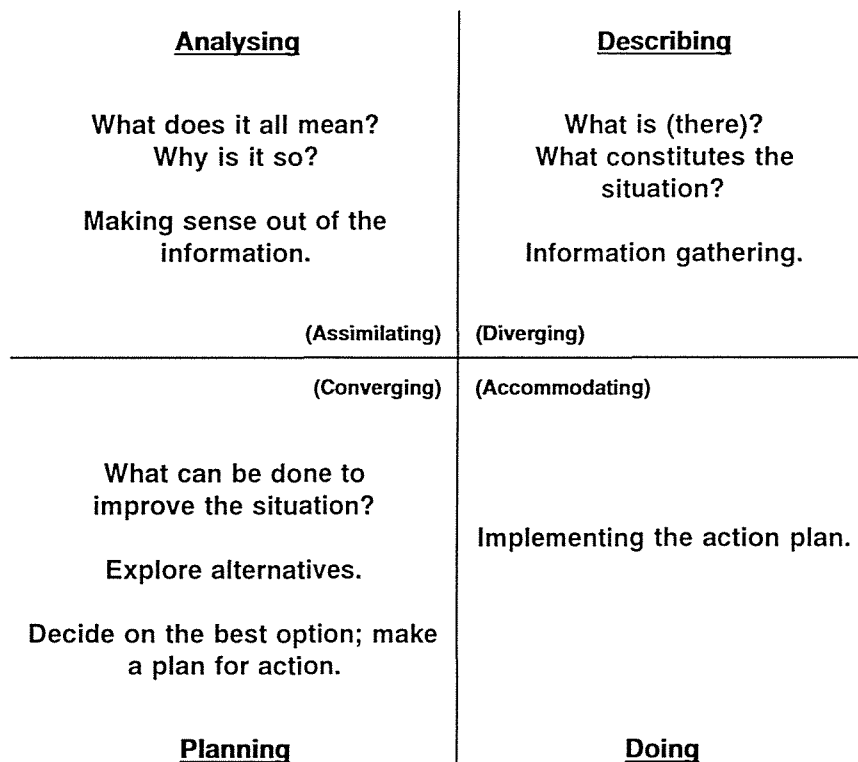
In the preparation of the baseline programme, some important basic principles had to be clearly defined and understood. This was particularly important for the SCALE field staff's attempts to grasp the objectives of the analysis and deciding how they might assist SCALE in its implementation.

The following discussion considers some of the features of the baseline programme which required careful definition and consideration.

5.2.1.1 Socioeconomic Analysis

Socioeconomic analysis is an examination of the mechanisms by which people plan, organise themselves, and make decisions as individuals, families, and community members. Such analysis also seeks to apprehend the forces that influence people to adopt or reject development. Figure 5.1 depicts a possible methodology for socioeconomic analysis.

Figure 5.1 Situation Improvement Methodology



(Dowall and Bolke, 1993)

Analysis of this nature is usually undertaken prior to the introduction of a new development project, in order to test a population's response to government policy, or generally to discover how people organise themselves. For SCALE, however, it was undertaken as the first phase of implementation, to provide the required foundation for the preparation of the second phase involving the selection and establishment of the FBTs.

The analysis was conducted as part of the project's implementation because the difficulties of the Cambodian political situation prevented it forming part of the project's formulation. To ensure that the analysis was able to fully influence the final shape of SCALE a major appraisal was scheduled for the end of the project's first phase. At this stage the entire development strategy of SCALE was to be reviewed.

In the course of the analysis it was important to distinguish between the use of primary and secondary information and to acknowledge the value of the secondary material in supporting the primary collected through survey. Much statistical data and information is available from the various Cambodian government departments or from UNTAC as it establishes its database

for conducting the 1993 election. For example, information about the average rainfall in Cambodia for the last twenty years, the annual rice yield since 1980, or the number of households in each village, is called secondary information because it has been previously collected and is available for general use.

Primary information, of course, is the goal of the surveys undertaken in the baseline analysis. In the case of the SCALE analysis it is to be obtained from the farmer, and the leadership of the village, commune and district. The collection of this kind of information can be categorised in two ways.

a) Hard (quantitative) data

Hard data, as in most surveys, is important in the SCALE baseline analysis, for providing the necessary foundational information. It is information which once obtained, may be tested as to its veracity and/or replicated by others.

b) Soft (qualitative) data

Soft data has a similarly important role, in identifying the individual farmer's desires, feelings, perception of his or her problems, behaviour, and reaction to the concept of cultivating fish. The soft data can also reveal:

- i) how and with whom the farmers communicate;
- ii) beliefs, values and norms;
- iii) attitudes to change;
- iv) awareness and interest in new technology;
- v) economic situation;
- vi) and their role in the community and its decision-making processes.

Soft data cannot always be verified as hard data can. It is difficult to verify objectively, yet it is knowledge that will enable a determination as to whether the project is likely to be supported or rejected by the local people. For a more detailed analysis on the use of hard and soft data in the Cambodian situation, see Dowall and Bolke (1993).

The baseline analysis required the collection of both hard and soft data. While hard data was required to provide an information framework and was more important in the landuse appraisal and village survey, the soft data in many respects was more strategic, opening a window into farmers' thoughts and understanding of their situation. It became particularly important in the farmer-level survey.

The quality of the hard data collated was found to be particularly dependent on how questions were constructed and interpreted. Working in a different language and cultural context is always a problem in surveying, and this case was no exception. The collation of soft data was more dependent on the interviewers' ability to induce respondents to communicate. Accordingly, the soft data was more likely to produce information which would not usually have been anticipated.

In the rural environment, properly-collected soft data requires an insight into the mind and thought patterns of the farmer, and prompting him or her to divulge that which would not otherwise be forth-coming if direct and/or closed questions were asked.

Accordingly in gathering information and analysing problems, appropriate methods had to be used. While the gathering of hard data is more straight forward and suitable to the use of traditional survey techniques, gathering soft data in this situation required a different and creative procedure.

Some methods were informal - visiting and talking to farmers, familiarising and empathising, asking open questions, listening and learning. These techniques assist in obtaining a greater appreciation of (for example, their social system, their beliefs, their fears, and their goals) and sensitivity to the farmers' situation.

More formal methods were also used, such as:

- a) semi-structured interviews;
- b) focused group discussions;
- c) rapid rural appraisals;
- d) attitude surveys;
- e) delphi surveys;
- f) local consensus data surveys.

The first three of these are particularly useful for understanding and analysing the current situation and were therefore used as part of the SCALE baseline analysis.

Having stated the foregoing as the basis for the analysis procedure, it is now possible to state the ultimate purpose and summarise the objectives of the surveying.

5.2.2 The Research Purpose

The essential purpose of the analysis is to evaluate the socioeconomic environment in which the concept of integrated aquaculture is proposed to be promoted and the consequent influence or effect that this environment will have on the selection of appropriate methodologies for its integration with traditional farming systems.

Accordingly, the analysis should provide information which is:

- a) descriptive;
 - i) describes the existing situation;
 - ii) states facts (hard data) quantitatively;
 - iii) through the collation of both quantitative and qualitative (soft data) information, identifies how aquaculture can address people's needs and problems within their cultural and socioeconomic contexts;
- b) explanatory;
 - i) to analyse relationships between descriptive facts;
 - ii) to understand the composition of the rural community, its traditional farming routine, activities, problems, and culture;
 - iii) to identify the causes of problems and the possible effect they might have on the project;
- c) predictive/evaluative;
 - i) to predict how aquaculture can assist the small-scale farmer and what strategies and techniques might be most appropriate, given local socioeconomic and physical limitations;
 - ii) to examine the merits of integrating fish culture with traditional farming systems;
 - iii) to predict the possible outcomes of farmer adoption of integrated fish culture.

The decision alternatives to be evaluated involve:

- a) the socioeconomic feasibility of introducing fish culture to traditional farming

- practice;
- b) the definition of which IAQS are appropriate for introduction to the FBTs in Kandal.

The criteria for selecting alternatives are:

- a) social acceptability;
- b) economic feasibility;
- c) compatibility with existing/traditional farm activities;
- d) income generating capacity or relieving of existing farm/household costs;
- e) potential to increase the protein intake of poor people;
- f) potential to increase the availability of fish for subsistence consumption and/or sale (available to the poorer sector of society).

5.3 THE LANDUSE APPRAISAL (22 November to 20 December 1991)

The landuse appraisal was important in that it, for several reasons, provided an initial impression of the physical environment in Kandal. This was to be very important in determining the project location able to meet SCALE's mandate of selecting and adapting appropriate methodologies of integrated aquaculture for implementation throughout the province.

It was further important that this introductory insight into the local environment did not become overly involved. Concentrated survey work could be more appropriately applied once the specific areas within the province where SCALE would focus its efforts had been selected. The key objective of the landuse appraisal was therefore the collation of sufficient information for the definition of project areas.

5.3.1 Framework of Analysis

5.3.1.1 Identification of the Agro-ecosystems Present

If the integrated aquaculture strategies developed by SCALE are to be appropriate for the various farming systems practiced in the Kandal province, the agro-ecosystems and landuse types should be identified. Each of the eleven districts within Kandal were therefore studied and their major landuse characteristics and types identified. This district information could then be compiled to show the location of, and area contained in, each landuse in the total province.

5.3.1.2 Definition of Project Areas

This permitted the definition of "project areas", with each representing one major landuse. They would become the focus for the remainder of the SCALE baseline programme, and thereafter, the implementation of the pilot programme's farm-based trials.

The important feature of the project areas is that they enabled the collection of information, and the definition of strategies, relevant to the characteristics of the farming systems they contain.

While the above two objectives were primary and central to the survey, there were two secondary objectives important to the future workings of SCALE; public relations and field staff training.

5.3.1.3 Public Relations

Local government structures in Cambodia currently appear both hierarchical and widely influential. Not only is local authority approval necessary for project work in any local area, but without its consent and referral, people are very hesitant to assist. The landuse appraisal provided the ideal opportunity to gauge local government response to the philosophy of SCALE and to seek participation in the project. This in turn facilitated communication with commune and village leaders in the village survey.

5.3.1.4 Field Staff Training

Three Cambodian field staff assisted SCALE from its inception. All were graduates of the Phnom Penh Chamcar Daung Agricultural Institute ("CDAI"). SCALE Management decided, however, that a six week training period would be necessary as an introduction to SCALE and its philosophy. The landuse appraisal provided an ideal opportunity for the field staff to practise some of the survey techniques that they were learning in their training and which they would be using extensively in the future.

It is realised that inexperience of the field staff in conducting this type of analysis increased the likelihood of inaccuracy of results. However, they were supervised throughout the analysis. In the first two weeks of field work, they were supervised on every visit to the districts and later, in respect of unspecified visits detailed, careful briefings and debriefings were conducted.

5.3.1.5 Procedure for Data Collection and Analysis

Four stages of data collection and analysis were involved:

- a) Key Informant Interviews - with the District Leadership. Where possible, these entailed discussions of approximately two hours with the District Chief, Vice-Chief and Director of Agriculture. These people were not always available, but on such occasions the interviews were attended by appointed deputies;
- b) District Maps - drawn to locate each commune, then supplemented with a key to indicate the major and secondary landuses within each commune;
- c) Cross-sections - subsequent to the key informant interviews to facilitate identification of the various landuse characteristics discussed with the district leadership. Each cross-section was located specifically to highlight each of the major landuse types discussed;
- d) Comparison - of the statistics gathered at the district level with those obtained provincially.

As much as was possible the statistical information sought from each district was kept consistent. This ensured that it could be readily compiled in the creation of the wider picture of the province. However, general qualitative information was also important. To this end the meetings with the district leadership were conducted as informal discussions, to allow the extra information to be gathered. This added to the understanding of the background situation of each district and to the final selection of the project areas.

From initial planning to completion of field work, the landuse appraisal took a total of four weeks to complete. One week was used for preparation of the field staff and gaining the approval to move freely through the districts, and three weeks were dedicated to field work.

Usually a complete day was allotted to a district, but for those districts located in the extremities of the province, greater travelling time was required. Two trips to each district

were required; the first for interviewing and the second in order to conduct the cross-section. After each interview was completed the field staff would return to the Phnom Penh office to collate their information and prepare a district map in preparation for their return to conduct the cross-section.

5.3.1.6 Categorisation of Data Collected

- a) Demographic statistics;
- b) Srok (district) level landuse statistics;
- c) Delineation of major landuse areas on the Srok map and their interrelationship;
- d) Major/secondary landuse by Khum (commune);
- e) Aquaculture activity.

5.4 THE VILLAGE SURVEY (February / March 1992)

The landuse appraisal having defined seven project areas, the purpose of the village survey was to bring the baseline analysis closer to the final analysis, that of the farmer/household level. Its key objective was the collection of information from a selection of villages within the project areas.

This would then provide a framework into which the information from the farmer/household analysis could be placed. It would also provide useful information for the design and development of the farmer/household level analysis.

It was not possible, however, to bypass the commune leadership and target the village leadership. Therefore, in order to reach village leadership the survey had to be designed to include a certain amount of discussion with the commune leadership as well. Fortunately, this meant that the quality of the data gathered was higher than that which might have been obtained through a single visit to the village leadership. The village leadership did not always have the required information readily available or in accurate form. For each village surveyed therefore, the village survey gathered information from the leadership of both the commune and village.

5.4.1 Field Staff Survey Training and Participation in Preparation

Having completed their introduction to survey work the SCALE field staff were arguably better equipped to participate in the village survey. Their involvement at all levels of planning and decision making was heavily emphasised. As with the landuse appraisal, this meant that more time had to be committed to preparation. This, however, was not only helpful for the field staff, but also ensured that all aspects of preparation were thoroughly considered by SCALE Management.

The field staff's involvement in the survey preparation followed the following general procedure:

- a) discuss together (field staff and SCALE directors);
- b) training session on relevant topics conducted by SCALE director;
- c) plan together;
- d) field staff plan and prepare written notes;
- e) discuss together;
- f) field staff review notes;
- g) SCALE director prepares draft;
- h) field staff test in the field under SCALE director supervision;

- i) revise together;
- j) prepare final draft of survey.

5.4.2 Framework of Analysis

As the village survey was conducted with the commune and village leadership, the establishment of a framework of information on the village, rather than a detailed understanding of the farmers' situation, was obtained. The collection of hard rather than soft data was the focus. It was still considered more appropriate, however, to use an informal discussion interview method as opposed to a formal questionnaire. This was due to the high likelihood of a questionnaire being misunderstood, due to the need for translation to and from Khmer.

It was preferable therefore, to provide the field staff with a consistent method of recording the information obtained, rather than a series of specific questions. To achieve this, 'data sheets' were prepared (for an example of these data sheets, see Appendix 5.1). If any extra information was forthcoming, it could be noted at the foot of each data sheet.

Avoiding the traditional questionnaire also meant that the survey was simpler to prepare, since it was not necessary to ensure that every question was accurately worded and culturally appropriate. In the course of their informal discussions the field staff were also able to obtain other qualitative information which a traditional questionnaire could not have yielded.

The data sheets could also be designed for simplicity and ease of completion. If used in the context of an informal discussion, they had to allow the interviewer to concentrate fully on his/her interaction with the respondent, not the completion of the data sheets.

The data sheets were first prepared together with the field staff in English, and then translated into Khmer. This allowed the staff to record the information in their own language. While English alone could have been used, this would have created an increased margin for error and misunderstanding. The survey's data sheets, therefore, were translated into Khmer and, when completed, translated back to English for analysis.

Once the data sheets had been prepared, the survey was then tested in three villages to ascertain the relevance of the subject areas under question, and whether there was any room for improvement in layout. These trials were also important in allowing the field staff to practise the techniques of conducting informal interviews.

With the exception of some minor changes necessary in the layout of the data sheets, and some fine-tuning in the field staff's discussion/interview techniques, the survey was then considered ready for implementation.

5.4.2.1 Subject Areas of the Data Sheets

- | | |
|---|---|
| a) basic demographic data; | h) livestock; |
| b) literacy and education; | i) aquaculture; |
| c) land ownership; | j) natural resources; |
| d) incidence of seasonal migration; | k) socio-cultural; |
| e) cropping; | l) economic; |
| f) other development projects in the village; | m) institutional arrangements; |
| g) public health; | n) communications; |
| | o) major problems; |
| | p) field worker's assessment of the community spirit. |

5.4.2.2 Village Selection

Of the seven project areas defined by the landuse appraisal, the selection of villages to be included in the village survey was restricted to five. The other two areas (referred to as being strategic) were not included, since they could be considered at a later date when there was less pressure on the baseline analysis schedule.²⁵ It was also decided that the selection of the villages should be done on a random basis using probability sampling.

The ultimate purpose of sampling is to select elements from a population in such a way as to ensure that descriptions of them will be representative of the total population. Probability sampling increases the likelihood of achieving this aim, and further, allows for estimating the likely degree of success (Babbie, 1989). A simple definition of probability sampling might be:

Probability sampling is when each respondent in the sample has a known and equal chance of being included in the sample and they are selected randomly.

This compares to non-probability sampling:

Non-probability sampling is when there is no way of estimating the exact probability each respondent has of being in the sample, or of estimating the margin of error.

For a more detailed analysis of probability and other sampling methodologies, see Gardner (1976) and Babbie (1989).

Why was it important to select villages at random? If SCALE is primarily to assist the poor farmer, why not just select those villages which are predominantly poor? If this was done, however, it would require sufficient knowledge of the location of the poor. Moreover, it would assume an accurate definition of "poor". With the survey work pending, these would certainly have been premature assumptions. It therefore seemed more appropriate to ensure that all villages within each project area were given an equal chance of selection.

This process could then be maintained throughout the remainder of the survey, with every respondent having had equal opportunity for involvement. The selection of the SCALE project areas had ensured that landuse had been adequately represented. Therefore, it was important also to ensure that the socioeconomic environment was also adequately represented.

As the project areas are defined by the communes they contain, the villages held within their borders are easily identified. Thus, by taking a sample of villages at random, each had a known and equal chance of being included.

After each village was identified by name a list of each project area's villages was compiled and entered on to the Quattro Pro computer spreadsheet. The list could then be randomly mixed by assigning each a random number and sorting them into descending order. From this random combination, the first 25 percent of the villages were taken. Over the five project areas being surveyed this gave a total number of 69 villages for inclusion in the survey.

A 25 percent selection was chosen as it meant that the total number of villages selected was sufficient to ensure the sample was representative of each project area's physical and socioeconomic environment. Had the percentage been lower it would have been unlikely to have made the village sample any more representative and would have unnecessarily

²⁵ The characteristics of the project areas are discussed in chapter six. The two strategic areas referred to here are strategic due to their political significance and provision of existing integrated aquaculture examples implemented by some farmers.

extended the survey. Secondly, as the survey was being conducted with the village and commune leadership, the likelihood of there being a 100 percent response rate was high. This proved to be correct.

5.4.2.3 The Discussion (interview)

The optimal number of field staff to be used in each interview session would have been three; one person to lead the interview, one to record and one to observe and relieve as necessary. Unfortunately this was not possible as there were only three field staff available and time for the field work was limited. However, the fact that the interviewing was conducted with both the commune and village leadership meant that to a certain extent the field staff could still work together as a team.

The procedure followed had all three field staff travelling to communes and working in a team with the commune leadership. The staff would then separate. The two more experienced staff would go to separate villages. The less experienced third member joined one of the others for the first two weeks. Once confident, she then operated alone also. This method proved successful and was sustained for the duration of the survey field work.

The important aspect of this methodology was keeping the collection of the information consistent. Of course, this is not strictly possible unless only one operator is used. However, by keeping all three staff together for interviewing the commune leadership, or alternatively, ensuring that only those who had been to the commune conducted the interviews with the villages of that commune, meant that an acceptable level of consistency was maintained.

5.5 THE FARMER SURVEY

Having obtained a framework of information for each of the villages, it was possible to meet and survey individual farmers. This required a change, or development, in the methodology used from a hard systems approach (village survey) to a soft systems information methodology. This move proved particularly difficult for the field staff to grasp.

The cultural adjustment which they had to make, being educated and predominantly from the city, seemed little less than that required of the SCALE expatriates when relating to local farmers. Consequently, considerable time was invested in explaining the concept of, and reason for, soft data collection. It was simpler for the field staff to think in terms of the concrete and quantifiable features of a farmer's activities. For example, to ask how much monsoon season rice a farmer grows will return a direct and quantifiable answer. However, to pursue the thoughts of how a farmer perceives his or her situation and how it might be improved will return an answer which is not quantifiable, but rather based on opinions and impressions.

In an effort to improve the understanding and skills of the field staff, further training in the form of an informal workshop, and later, (in preparation for the complete baseline farmer survey) a full month's training course in socioeconomic analysis were provided. Further, pre-testing the survey with a pilot survey gave the staff the opportunity to put their theoretical training into practice.

5.5.1 Framework of Analysis

The farmer survey represented a move from the administrative level of the commune and village to the farmer and was the point at which an understanding of the farmers' socioeconomic situation could genuinely begin to develop. It was therefore most important

that this survey successfully unlock the thoughts of each respondent.

The first issue arising in the preparation of the survey was whether the previously used data sheets for recording information were appropriate. With individual farmers now being the focus of attention and the collection of qualitative data being important, it had to be decided whether the data sheet methodology of recording information could be applied in the pilot and baseline surveys.

In answering this question, the main problem was to find the most appropriate way of recording this 'soft' information. It had to be remembered that the collection of information would, generally be restricted to the discussion the field staff would have with the farmer and his or her family. That being the case, the data sheets' capacity to provide a simple and quick method of recording information as it was provided seemed to offer the most appropriate method of recording. If the layout did not fit the qualitative information which surfaced, it could be easily noted separately. The alternative, the use of a more formal questionnaire, would have been restrictive and likely to inhibit the recording of information which did not neatly fit the answers sought by the questions asked.

New data sheets were therefore compiled, the subject areas of which are noted below:

- | | | | |
|----|---------------------------------------|----|---------------------------------|
| a) | family details; | j) | marketing; |
| b) | education; | k) | farm income and
expenditure; |
| c) | land tenure; | l) | household investment; |
| d) | agriculture (crops and
livestock); | m) | credit; |
| e) | farm waste; | n) | local sources of
assistance; |
| f) | water; | o) | religion; |
| g) | aquaculture; | p) | social situation. |
| h) | capture fisheries; | | |
| i) | fish consumption; | | |

In the process of compiling the data sheets, a training seminar, specifically focused on the use of soft systems analysis, was provided for the field staff. This assisted greatly in extending their thinking beyond the simple terms of quantifiable information. They were then able to consider the farmer's perspective, and how they could assist the farmer to share information. The data sheets that were produced therefore showed a development in the field staff's thinking as much as in document content and layout.

Once the data sheets were prepared and the training complete a comprehensive pilot survey was conducted to test data sheet accuracy and household selection methodology. This facilitated the refining of the farmer survey, the discussion technique and the method of household stratification most appropriate.

5.5.2 The Pilot Survey (May / June 1992)

While the pilot survey was a pre-test of the survey and the methodology used, the information it supplied was also valuable to the baseline programme. The review and appraisal of the SCALE project, conducted before the completion of the full farmer survey, referred to the information it provided. The pilot survey therefore, while important in providing a comprehensive test of the data sheets, interview/discussion procedure, and respondent selection, was important for building on the framework of information already collected by the village survey.

5.5.2.1 Pilot Survey Respondent Selection

As it is necessary to ensure that the IAQS developed are appropriate to the various farming systems and socioeconomic conditions found in Kandal, it was important that a good cross-section of households were obtained. To this end the pilot survey was required not only to test and refine the categories and nature of the information to be collected, but also to ascertain the best method for stratifying and selecting farmer households.

Accordingly, four households within each village were selected from four socioeconomic categories: poor, poor/average, average/wealthy, and wealthy.²⁶ This was done by physically traversing the village with the village chief and using his assistance to positively select one household in each strata. This proved to be easily done and also served the valuable purpose of including the village chief in the process.

The villages themselves were selected on the same basis as for the village selection in the village survey. This time a random selection of twenty percent of the villages surveyed in the village survey was taken. This gave a manageable number of sixteen villages.

5.5.2.2 The Household Discussion

Generally the discussions (interviews) with each farm household took one hour. These were conducted by the three field staff working as one team, with one leading the discussion, one recording the information, and the third observing and assisting where necessary. It was hoped that this team approach would increase the level of accuracy attained. One day was spent in each village, with two households being surveyed in the morning and two in the afternoon. The sixteen villages were therefore covered in two weeks.

5.5.3 The Farmer Survey (September to December 1992)

The pilot survey provided a useful test of the data sheets, promoting numerous additions and changes. However, the method of stratifying and selecting the household respondents required improvement. Although it was adequate for the pilot survey, it was believed inappropriate for application on a larger scale. The scope for error and bias was considered too high. For example:

- a) while the selection of the villages within each project area was random, that of the household respondents was not. Respondent selection was therefore subject to bias on the part of the village chief's preference;
- b) the criterion for ascertaining a household's placement within the four strata was also based on the village chief's opinion and so was not necessarily consistent, especially between villages.

An involved method of stratification and selection was therefore designed.

5.5.3.1 Stratification of Households

While the pilot survey had been conducted within each village, it was found that this restricted achieving a representative selection of households within each project area as a whole. Although it guaranteed a fixed number of household respondents in each surveyed village, the large variation in the household populations of the villages resulted in the

²⁶ Each of these strata are relative to the socioeconomic environment of the village. Wealthy does not necessarily denote an economic position equivalent to "wealthy" in an urban environment such as the provincial centre or Phnom Penh. Later, in the farmer survey, the divisions between the strata were more appropriately ascertained with the use of specific social indicators.

selection ratio not being constant. As local landuse and socioeconomic characteristics should be represented by the SCALE project areas, rather than the villages within those areas, it was necessary to stratify and select households by project area rather than village. Although the ratio of selected households varied in terms of village population, this allowed the sampling ratio within each project area to be constant.

While the pilot survey used four strata, results indicated that the original poor/average and average/good were similar. They were therefore combined to make one category called Average. The three strata adopted were called: Poor, Average, and Good.

For the purpose of conducting the stratification both primary and secondary social indicators were used. These can be viewed in Appendix 5.2. The primary indicators were based on the type and condition of each household's house and the material goods owned. The secondary indicators were based on the geographic location (in relation to community facilities such as local markets and roads), water availability and fruit crops grown of each household. The indicators were all tested and refined in trial villages prior to their being utilised in the formal stratification.

In the analysis of a household, each indicator was assigned a score according to its status, i.e:

Poor = 1 point Average = 2 points Good = 3 points

The primary indicators were then weighted to allow for their relative importance by totaling the indicator scores of the primary and secondary categories separately and dividing the secondary total by two. By adding the two category totals together the household's final score and socioeconomic stratum could be determined.

These can be interpreted as follows:

Poor household	Score = 8.0 - 12.5
Average household	Score = 13.0 - 16.5
Good household	Score = 17.0 - 24.0

For an example of the recording sheet used see Appendix 5.3.

The stratification process was conducted during September 1992 and involved a brief three to four minute meeting with a representative of each household under the supervision of the village chief.

5.5.3.2 Household Selection

The stratification was conducted in a random selection of 40 villages from the village survey (50 percent) within the five main project areas. This gave a total of 40 villages across all the project areas.

The total number of households documented in each project area is listed below.

a)	Project area 1	1840 households
b)	Project area 2	368 households
c)	Project area 3	2315 households
d)	Project area 4	751 households
e)	Project area 5	529 households
	Total	<u>5803</u> Households

Five percent of the households were then proportionally selected from each project area and from within each stratum to provide a total survey population of 293 households.

Sample size (5 percent)	<u>293 Households</u>
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5.5.3.3 Discussion methodology

It had become apparent during the course of the pilot survey that despite the work which had been committed to designing the data sheets so as to elicit the required soft information from the farmer, they alone would be inadequate. A new, and what became referred to in SCALE as a more "holistic" approach, was developed.

This involved the use of the informal farmer discussion using data sheets followed by group discussions. The group discussions brought together the farmers which had been surveyed in each village. The same field staff who surveyed the farmers led the discussion and used it as a means by which the farmers could freely discuss their situation and how integrated aquaculture may be appropriately applied to it.

Three teams of three field staff conducted the survey. Each project area was surveyed in turn, with each team working in separate villages. Each team completed two household discussions per day. At the end of each day the team was required to complete a daily report on their conclusions and observations for the day.

When the household discussions for a village had been completed, the farmers (heads of household) were brought together for the group discussion. In this way further soft (qualitative) information could be obtained to complement that provided by the individual household discussions.

Unfortunately the deteriorating economic climate and the dry 1992 monsoon season resulted in many households being preoccupied with off-farm employment or business activity. The request to come away to a village meeting was therefore unpopular, and required the discussions to be postponed until later in the dry season.

5.6 ECONOMIC ANALYSIS

A review and appraisal of the SCALE project was conducted in October 1992. While the farmer survey was not completed by this stage, the information provided by the landuse appraisal, village and pilot surveys was considered adequate for its completion. The farmer survey to follow would provide the detailed information required for deciding the final design and implementation strategy of the IAQS to be used in the pilot programme. Part of this review and appraisal included an economic analysis.

5.6.1 Framework of Analysis

The economic analysis was designed as a simple benefit-cost analysis ("BCA") of the project and included all features of the project. This required the making of numerous assumptions concerning the system types to be used and the production levels likely to be attained in the DC hatchery, FBTs and farmer implementations over the twenty year period of the analysis. This however, was based on realistic estimations according to the project's objectives and what was considered feasible as a result of the survey work completed.

While the BCA and associated notes can be viewed in Appendices 6.5, 6.6 and 6.7, the following is a brief description of the parameters involved in the analysis:

a)	DC Hatchery:		
	i)	construction programme	1992-1995
	ii)	fingerling production; ²⁷	
		1993	0.5 million
		1994	2.0 million
		1995	4.0 million
		1996	6.0 million
	iii)	artificial spawning facility constructed in 1994;	
b)	FBTs for refining the IAQS:		
	i)	1993	14
	ii)	1994	28
c)	wider farmer implementation of IAQS:		
	i)	1995	55
	ii)	1996	55
	iii)	thereafter, 30 new sites per year;	
d)	eight IAQS designs:		
	i)	rice/fish	(N.tilapia/C.carp polyculture);
	ii)	rice fish	(C.carp monoculture);
	iii)	pig/fish	(N.tilapia monoculture);
	iv)	pig/fish	(N.tilapia/C.carp/snakehead polyculture);
	v)	duck/fish	(N.tilapia/Chinese carp polyculture);
	vi)	duck/fish	(N.tilapia monoculture);
	vii)	fish	(polyculture);
	viii)	cattle/fish	(N.tilapia/carp polyculture);
e)	FBT support programme		1993 and 1994
f)	Training programme		annual

5.7 CONCLUSION

While the SCALE baseline analysis programme uses a variety of survey and analysis techniques, it has been specifically tailored to the situation of the SCALE project. Its design was kept flexible throughout to ensure that it was capable of amendment according to information (socioeconomic in particular) as it arose. Although the basic procedure, purpose and objectives of the programme as a whole remained as originally designed, some procedural features of each survey were changed as required. Some of the more significant changes included:

- a) the inclusion of the commune leadership in the village survey interviews;
- b) a change in the focus of the farmer survey from individual villages to project areas;
- c) development of the household stratification for the farmer survey;
- d) adoption of the holistic discussion technique for the farmer survey, including individual household discussions and village group discussions.

These changes have all contributed to the quality of the survey work and the baseline

²⁷ The analysis was conducted prior to the required revision of the DC hatchery breeding programme for 1993 (see Section 4.4.3.1.). The planned (limited) hatchery income and expenditure for 1993 therefore remains in the analysis as originally planned.

programme. However, it is intended that this analysis be only a beginning and that through continual project monitoring, the database of information and knowledge on the project area, its physical and socioeconomic environment, will grow and become more comprehensive.

CHAPTER SIX

RESULTS AND FINDINGS OF THE SCALE BASELINE ANALYSIS

6.1 INTRODUCTION

The comprehensive baseline analysis programme has produced a large volume of information. The following sequence and analysis of the information, increasing detail with each successive survey, is useful in supporting the case for integrated aquaculture and SCALE's development strategies.

The purpose of this chapter is to report some of the findings of the baseline programme and provide an analysis which may influence the establishment of integrated aquaculture as a means to sustainable rural development in Cambodia. This will be done by firstly presenting the results of the SCALE landuse appraisal, village and farmer surveys. Secondly, it will include a financial analysis of two IAQS to indicate their financial viability, and potential for farmer implementation. Finally, the economic analysis of SCALE will also be presented to show the project's economic potential.

6.2 THE LANDUSE APPRAISAL

6.2.1 District Receptiveness

The leaders in each district showed genuine interest in the SCALE project and its basic philosophy. Information was made available and assistance freely given during the cross-sectional analysis.

The opportunity was taken to state clearly the intentions of the project and to disseminate one of the major SCALE premises, 'to help farmers to help themselves'. It was evident that the SCALE interpretation of this was somewhat different from the Cambodian interpretation. It became important to state firmly that SCALE was based on supporting the local farming community to develop their own methods and strategies, not on handouts and directives which are unlikely to be appropriate. This approach was received with interest; time however, will be needed to indicate how readily it will be accepted.

6.2.2 District statistics

The statistics gathered fall into demographic and landuse categories (see Tables 6.1, 6.2, 6.3). While all these statistics are not crucial to the definition of the various agro-ecosystems in Kandal, they are very helpful in gaining an overall appreciation of the province. Where the districts did not have the required information on hand it was obtained from the Provincial office.

In most cases the districts were found to have a detailed record of statistics and a good appreciation of the overall status of their area. The district and provincial statistics did not always match, but were usually comparable. Table 6.1 reviews the distribution of the population by district. In every case the percentage of females is slightly greater than that of males. The highest this disparity reaches however, is 58 percent.

Table 6.1 Demographic Statistics (1991)

District Name	Population			Number of Communes	Number of Villages
	Provincial Total	District Total	Percent Female		
Mok Kum Pul	62,210	60,675	54	11	55
Takhmau	31,747	33,453	51	6	19
Khsach Kandal	90,476	90,269	52	18	93
Phnom Penh	66,585	64,797	53	16	307
Po Neah Leu	62,312	60,559	55	14	141
Koh Thom	113,887		58	11	92
Kandal Stung	45,422	60,589	53	23	155
Kien Svay	94,579	100,000	54	12	46
Leuk Dek	32,394	33,035	54	7	24
Saang	131,051	142,486	51	16	119
Luvea Em	46,803	46,803	55	15	45
Total	787,784	806,453		149	1,096

Note: Population totals for each of the districts were collected both at the Provincial and District levels. The statistics for only one district (Luvea Em) equate. All the collected figures have therefore been listed in an effort to give the best possible estimate.

The above percentages of women in each district are an estimate using available statistics from both the Provincial and District offices.

Table 6.2 shows the land area of each district and area available for potential and actual agricultural purposes.

6.2.3 Major Rice Ecosystems

As expected the appraisal highlighted the importance of rice in Kandal. The two major ecosystems found to be important are the Rainfed Lowland Rice ("RLR") and the Dry Season Rice ecosystems.²⁸ These ecosystems provide the framework into which all the major landuse types of Kandal fit. For a brief background on the major rice ecosystems found in Cambodia see Appendix 6.1

²⁸ In order to be consistent with local terminology these rice ecosystems are also referred to as Monsoon rice and Dry season rice.

Table 6.2 Status of Landuse - 1989

District Names	Land Area (ha)	Agricultural Land (ha)		Potential Agricultural Land
		Total including waterspread	Waterspread	
Mok Kom Pul	27,500	10,026	3,539	10,041
Takhmau	3,178	1,470	-	56
Khsach Kandal	35,254	19,905	1,083	2,185
Phnom Penh	29,603	10,546	25	431
Po Neah Leu	31,655	10,140	5,531	1,146
Koh Thom	50,304	15,769	570	4,583
Kandal Stung	25,041	13,076	18	3,634
Kien Svay	38,211	10,988	1,444	5,634
Leuk Dek	37,436	10,717	-	22,756
Saang	51,500	26,664	1,984	3,486
Luvea Em	26,899	9,129	1,279	8,723
Total	360,040	138,430	15,473	62,675

Note: a) All the Land area figures were collected at the District level and have been found to equate well with those available at the Provincial Office.

b) All figures for agricultural land were collected at the District level. With the exception of the following, they equate well with those available at the Provincial office.

Leuk Dek	8,049 ha
Po Neah Leu	16,093 ha
Phnom Penh	11,883 ha

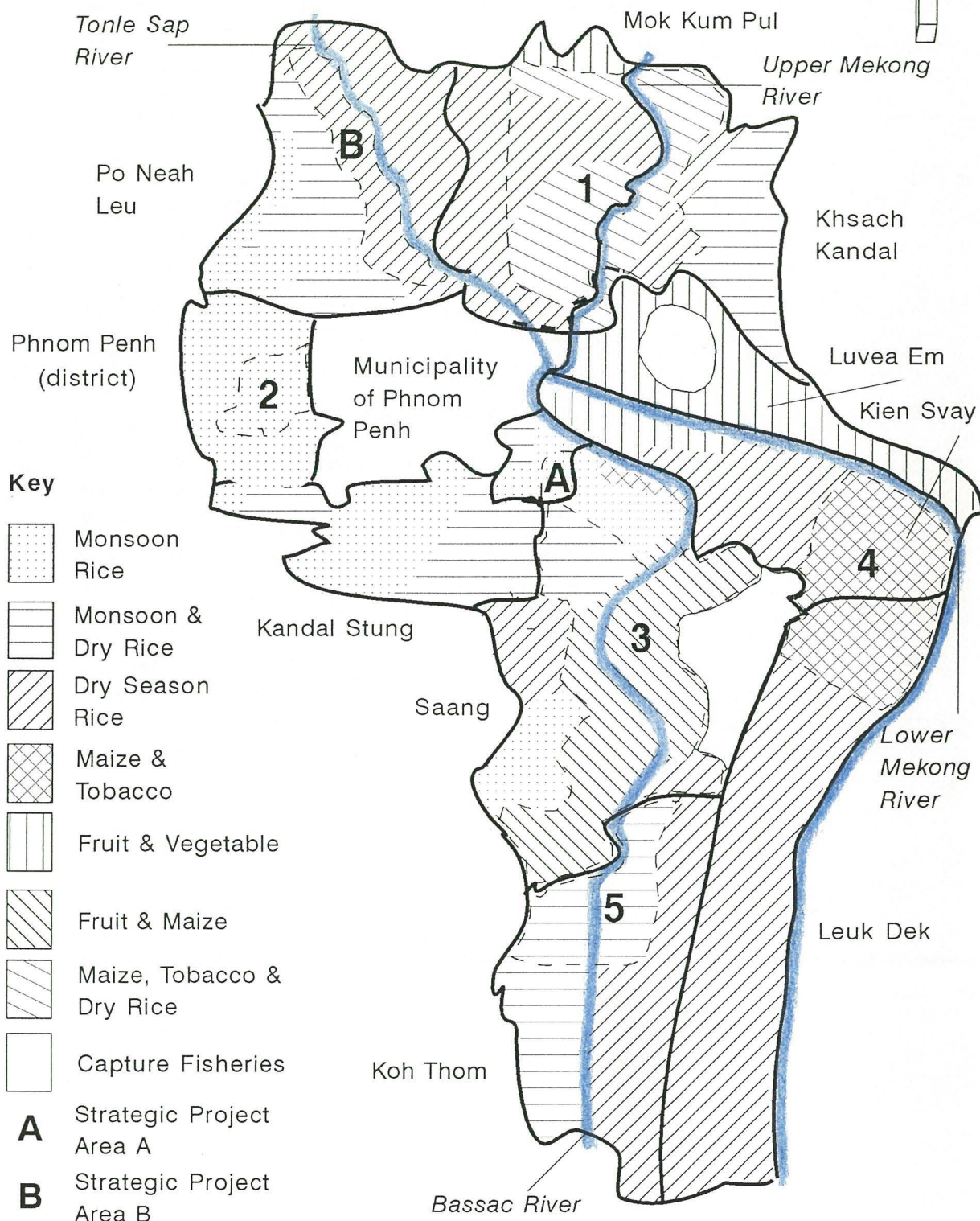
c) Potential Agricultural Land is equivalent to waste land which could be redeveloped for agricultural purposes. A significant area of southeastern Koh Thom has recently been redeveloped out of scrub as it was unproductive as either flooded forest or cultivatable land.

d) Waterspread area represents the area under water in the dry season. All figures were obtained from the Provincial Office.

Table 6.3 shows the quantity of monsoon and dry season rice which is grown in each district. Although not necessarily the primary crop in every district, as Figure 6.1 shows, their importance to the province as a whole make it desirable to take specific note of the hectares involved. The status of secondary crops are also shown, as in some cases (for example, Khsach Kandal and Saang districts) they utilise a significant land area.

Figure 6.1

Major Landuse & Project Areas Kandal Province



No's 1-5 Main Project Areas

Table 6.3 Crops

District	Monsoon Rice (ha)	Dry Rice (ha)	Secondary Crops (ha)
Mok Kum Pul	628	3,500	1800
Takhmau	750	300	200
Khsach Kandal	14,302	3,800	18,882
Phnom Penh	11,160	300	552
Po Neah Leu	8,190	4,205	1,531
Koh Thom	4,074	7,000	5,000
Kandal Stung	12,267	290	477
Kien Svay	1,000	400	2,300
Leuk Dek	656	6,292	4,400
Saang	8,500	6,000	22,820
Luvea Em	4,633	4,300	2,200
Total	66,160	36,387	60,162

Note: Secondary crop figures do not necessarily reflect their being secondary to the stated monsoon or dry season rice figures, rather they are secondary to the primary crop(s) in each district, which may or may not be monsoon or dry season rice. These statistics do not indicate that monsoon rice or dry season rice are the primary crops in every case.

Repeatedly it was found that dry season rice was not rotated on the same land with monsoon season rice, although both crops could easily be grown by the same farmers. In the few cases where dry season rice followed monsoon season rice, it was usually attributable to the severe 1991 flood which destroyed many of the provinces' crops late in the 1991 monsoon season. This flood is referred to by most as a "30 year" flood and was the result of heavier than usual rains in the Upper Mekong catchment.

Most of the districts affected by the flood were supplied with dry season rice seed to replant the monsoon rice areas which were destroyed. Unfortunately, in those areas which are not adjacent to a year round water supply, this replanting was later hit by drought and suffered severe water stress. In many cases the crop failed completely (for example, Khsach Kandal). This atypical situation has meant that at the time of the appraisal the area planted out in dry season rice was much greater than usual. We attempted to ensure that the statistics collected on landuse represent a normal year.

The flood also damaged some of the irrigation structures in Kandal rendering them inoperable until major restoration works are done. The irrigation structures in Kandal Stung in particular were severely damaged.

Furthermore, as is noted by Delvert (1961), it was found that the dry season rice areas are usually some distance from the villages, at the perimeter of their monsoon season growing areas. Often the dry season rice could be found in areas where the monsoon season flood was receding, or even around large reservoirs or lakes which recede during the dry season. The lake to the south and southeast of the SCALE Development Centre in the Saang district

provides a typical example of a flood recession crop area.

6.2.4 Other Landuse Categories

There are other important landuse categories in Kandal in addition to rice. The following include the major crops for which statistics are available and as defined by the district leadership:

- a) maize;
- b) tobacco;
- c) fruit;
- d) vegetables;
- e) green/mung beans;
- f) sweet potato;
- g) sugar palm;
- h) fish.

As with monsoon and dry season rice, in most cases the crops are not rotated. Generally, land is committed to one crop and then left until replanting in the following year. It was also found that little pattern could be defined in the relationship between primary and secondary landuses. This verifies the finding that crops are neither rotated nor related. That which is grown in a particular area does not necessarily influence that which is grown immediately adjacent.

For a cartographical summary of the major landuses throughout Kandal see Figure 6.1 and for a description of the various landuses in each of the SCALE project areas, see Appendix 6.2.

Statistics procured from the Ministry of Agriculture Agronomy Department vary greatly in the yields of secondary crops from year to year (see Table 6.4). It is not known how reliable they are. They do indicate however, that of those for which statistics are provided in Kandal, maize, tobacco, vegetables and green/mung beans are the most common. No statistics were available for fruit, or sugar palm, which SCALE's land use appraisal also showed to be common. In every case the tonnage returned in the 1991-1992 growing season was lower than the previous two seasons. The extensive flooding in September and October of 1991, immediately followed by a prolonged dry season, may have contributed to this decline.

6.2.5 Assessment of Aquaculture

Although aquaculture does not feature as a major landuse in any of the districts, the opportunity was taken to make a preliminary investigation into the extent of aquaculture activity in the province.

As with the major landuses the incidence of aquaculture was recorded according to the judgement of the district leadership. Further observation was made while conducting the crossections and travel throughout the district.

The traditional practice of cage culture was found to be particularly common in three districts and present to a limited extent in a further five. Snakehead was the major species used, however, in two districts *Pungasius (Pungasius sutchii)* also featured.

Table 6.4 Secondary Crop Yields for Kandal

Crop	1989/90 Forecast	1989/90 Actual	1990/91 Forecast	1990/91 Actual	1991/92 Forecast	1991/92 Actual
Maize	17000	16165	20000	13994	4000	1134
Yam	500	925	500	461		283
Sweet Potatoe	1150	1010	1150	897	960	625
Vegetable	3500	3845	3500	3902	200	980
Green/Mung Bean	8500	2750	8500	3331	1400	3043
Peanuts	1250	380	1250	719	750	1116
Soya Beans	300	10	300			
Sesame Seed	1200	1440	1200	1338		
Sugar Cane	1400	1450	1400	1935	600	772
Cotton	0	4	0	0		
Tobacco	3850	3850	3850	4445	4200	3605

Source: Agronomy Department, Ministry of Agriculture, Cambodia

Pond culture was found to be less common, although it was clear that in some districts experimentation with various culture methods is increasing. Some ponds were found in all districts, although in some cases only one or two were involved. Takhmau and Po Neah Leu, in particular, have numerous farmer ponds, quite a number of which have been established recently. The major species used are, pangasius, carp (grass carp, common carp) and tilapia (*Oreochromis spp*). Pond culture in Po Neah Leu is significantly advanced in the Prek Taten and Po Neah Leu communes. Here ponds with numerous methods of integration can be viewed from national route 5. Integration with pigs, ducks and nightsoil all feature. For a breakdown of the prevalence of cage and pond culture by district see Tables 6.5 and 6.6.

In the course of the appraisal numerous issues were frequently observed as posing problems for the natural development of aquaculture. The more significant of these were a competition for water in some areas, a limited supply of on-farm resources, an expensive and scarce supply of fish seed, and a high percentage of existing fish ponds with water either too turbid or too fertile.

The supply of fish seed is said to be inadequate nationwide and will only be addressed with the development of seed producing centres (such as that included in the SCALE project, see Chapter 4) and the possible long term potential for the introduction of farmers to the nursing of fry. Pond management problems will be overcome with time as farmers become more familiar with the management requirements of integrated aquaculture applications. The difficulties associated with water availability and on-farm resources are more complex and were addressed in more detail by the farmer survey, the results of which can be viewed in section 6.4.

Table 6.5 The Incidence of Pond Culture

District	Major Species	Ponds Many	Ponds Few
Khsach Kandal	Tilapia		**
Takhmau	Pangasius/Carps		**
Kien Svay	Pangasius/Carps		**
Phnom Penh	Pangasius/Carps/ Tilapia	**	
Kandal Stung	Pangasius/Carps Tilapia/Indigenous sp.		**
Saang	Pangasius		**
Leuk Dek	Pangasius		**
Koh Thom	Pangasius/Carps		**
Mok Kum Pul	Pangasius		**
Lovea Em	Pangasius/Tilapia		**
Po Neah Leu	Pangasius/Tilapia		**

Table 6.6 The Incidence of Cage Culture

District	Major Species	Cages (Many)	Cages (Few)
Khsach Kandal	Snakehead/ Pangasius	**	
Takhmau		None	
Kien Svay	Snakehead		**
Phnom Penh		None	
Kandal Stung		None	
Saang	Snakehead/ Pangasius		**
Leuk Dek	Snakehead		**
Koh Thom	Snakehead		**
Mok Kum Pul	Snakehead		**
Lovea Em	Snakehead	**	
Po Neah Leu	Snakehead	**	

Note: The categorization of ponds into many or few is a direct reference to the district leadership's interpretation. Clearly there is room for inconsistency in judgement. For a preliminary introduction however, these results are adequate.

These issues all suggest that simple applications designed according to the environmental and socioeconomic constraints facing small, resource-poor farmers who lack technical knowledge of integrated aquaculture, will be required if aquaculture is to develop further.

6.3 VILLAGE SURVEY

The information obtained from the village was intended to provide a general insight to the farming activities and socioeconomic situation of the villages included in the sample. The survey was required to provide a general introduction to the village environment. Three main objectives were involved as follows:

- a) to provide more specific detail on the farming system information gathered in the landuse appraisal;
- b) to provide a general understanding of the socioeconomic conditions of village life which may influence farmer capacity to undertake integrated aquaculture;
- c) to develop a rapport with the commune and village authorities which would help facilitate access to, and the confidence of, the farmers for the farmer survey to follow.

The farming system information and general understanding of village conditions provided a framework of understanding which the farmer survey was able to analyse in more detail. This information was instrumental in formulating the farmer survey. The importance of the third objective became increasingly apparent as the important role of the commune and village chiefs was discovered. They were frequently found to have substantial authority and influence over village life. Had these people (i.e. chiefs) not been included in the survey, their confidence in the potential benefits of the survey would not have been cultivated. This would have made many people reluctant to participate in the farmer survey to follow, with access to them in some cases possibly even being denied. The village survey therefore not only provided useful introductory information but ensured farmers were able to participate freely in the farmer survey.

The village survey information has been compiled into a series of village summaries. As an example, one of these is appended as Appendix 6.3.

6.4 FARMER SURVEY

The information produced by the farmer survey is very diverse, ranging from general demographic data of the farm family to current fish consumption trends. Only those results with direct relevance to integrated aquaculture will be commented on in what follows.

Substantial constraints were experienced in conducting the survey which has had the effect of compromising the quality of many of the results. Some of these constraints are noted below and should be kept in mind when viewing the results.

First, despite all of the field staff being either technical college (Prek Leap Agricultural College, "PLAC") or university (CDAI) graduates and the provision of significant theoretical and practical training specific to survey and communication techniques, the ability of the field staff to carefully and consistently document their findings using the data sheets was poor. It had been hoped that their consistent participation in the formulation of these data sheets from their conception would have ensured a higher standard of reporting. Unfortunately however, they appeared to lack the required discipline to ensure that the recording of the information obtained in their discussions with farmers was complete.

The second constraint was found to lie with the respondents themselves. Farmers were notorious for answering questions inconsistently, or even changing their answers if asked for clarification. Further, their desire to receive help often caused respondents not to disclose an accurate account of their resources. For example, farmers with a number of cattle often misrepresented the true number owned. This made the collection of accurate information particularly difficult for the field staff and did not encourage a high standard of reporting.

While these constraints increase the survey's potential for error, it should be recognised that they are typical of the social environment. As such, they also require consideration (together with the survey results) in the formulation of conclusions concerning development strategies, what makes an IAQS appropriate, and the overall feasibility for the use of integrated aquaculture in the development of Cambodia's rural sector.

Despite the potential for compromising the quality of the results the importance of the SCALE field staff being intimately involved throughout the survey's preparation, conduction and analysis, is strategic to establishing a participatory process of development. To deny their participation would compromise efforts to extend the local communities' capacity to plan, implement and manage the course of their own rural development. Their role therefore is strategic to the attainment of sustainability.

For the purpose of presenting the results they have been grouped into numerous categories. In most cases they are expressed graphically. Each category of results is presented and discussed in turn. Conclusions are made where appropriate.

6.4.1 Results of the Socioeconomic Stratification of the Survey Area

Figure 6.2 presents the distribution of survey households with a poor, average and good socioeconomic classification (see Section 5.5.3.1). project area 2 is shown to have the greatest proportion of poor households. By looking at Figures 6.20 to 6.24 with 6.2 a direct correlation between the distance to and the type of the nearest water source, and the socioeconomic status of the households can be seen. Figure 6.21 (project area 2) has the greatest proportion of households (75.1 percent) of any project area requiring families to go over 100 metres to obtain water. 18.8 percent of these households must go more than 500 meters and 6.3 percent over 1000 meters. Figure 6.25 shows that the majority of households in project area 2 rely on rainfed village ponds for their water. The nearest naturally occurring permanent water body is to the northeast of the project area approximately 10 kilometers away (see Figure 6.1).

Conversely, those project areas where the proportion of poor households is smaller than project area 2, have a greater proportion of households with a closer and more permanent water source. It can therefore be concluded that a reliable and available water source is an important determinant in the socioeconomic status of households.

Further, tied to the availability of water is the range of farm and subsistence activities which are feasible. Accordingly, the villages in project area 2 are small, scattered and almost solely reliant on monsoon season rice and sugar palm for their household's subsistence requirements (see Figures 6.7 to 6.13).²⁹

6.4.2 Demographic Data

The composition of each household was obtained to ascertain average family size and the proportion of single parent households in the project areas. While this is interesting general

²⁹ Unfortunately sugar palm is not reflected in the results as it was considered by the field staff and farmers as off-farm income as opposed to a farm crop. Sugar palm trees are scattered sporadically over the landscape, thus preventing households from quantifying the area of their land given to its production.

knowledge, it is of more specific interest here as it indicates the average household size which farm production must support and the amount of labour which can be expected to be provided from within the household.

Table 6.7 shows the average family size ranges between 5.4 and 6.3 people and Figure 6.3 shows that in most cases the number of children per family is four or less. Households with more than four children consist of approximately 30-40 percent of the households surveyed. The average number of children per household ranges between 3.5 and 4.2 over the five project areas (see Table 6.7).

Given that Cambodia's current growth rate is as high as 2.8 percent (World Bank, 1992) the percentage of households with five or more children under the age of 15 is not high (see Table 6.7). Conversely, the percentage of households where at least one of the children is 15 years or older is substantial. This is particularly useful in that it shows that a high proportion of households have children which can contribute to farming activity on a full time basis (see Figure 6.4). This is not to suggest that younger children do not contribute to farm labour, for it is generally children younger than 15 years which are given the task of caring for the animals.

The status of household parents also provides some interesting information, though predictable given the last twenty five years of war. Figure 6.5 shows a high number of widows are the head of households. This indicates that a significant proportion of the farmers in the project area with whom the SCALE project will be working are women. Particular care will be required to ensure that they are not disadvantaged or excluded from the opportunity to participate in the project's development initiatives. In their favour is the cultural tendency for women to be the decision makers in the household. However, the group discussions held with farmers in some of the project areas would indicate that they effectively remain subservient to men in Cambodian society. While women happily participated in the group discussions, they always submitted to the men whose opinions dominated.

Literacy levels also gave an interesting insight into survey households. This was considered useful as literacy is an indication of the degree of education which the households had received and therefore a determinant in the methods of extension which might be appropriate for the SCALE project to use. For example, if a large number of households are poor readers then the use of written extension material will be limited.

Table 6.7 Family Data

	Average Family Size	Average Number of Children per Family	Percentage of Households with 5 or More Children Under 15 Years
Project Area 1	5.5	3.6	15
Project Area 2	5.4	3.5	6
Project Area 3	6.1	4.2	5
Project Area 4	5.6	3.9	15
Project Area 5	6.3	4.1	21

Figure 6.2

Household Socioeconomic Status

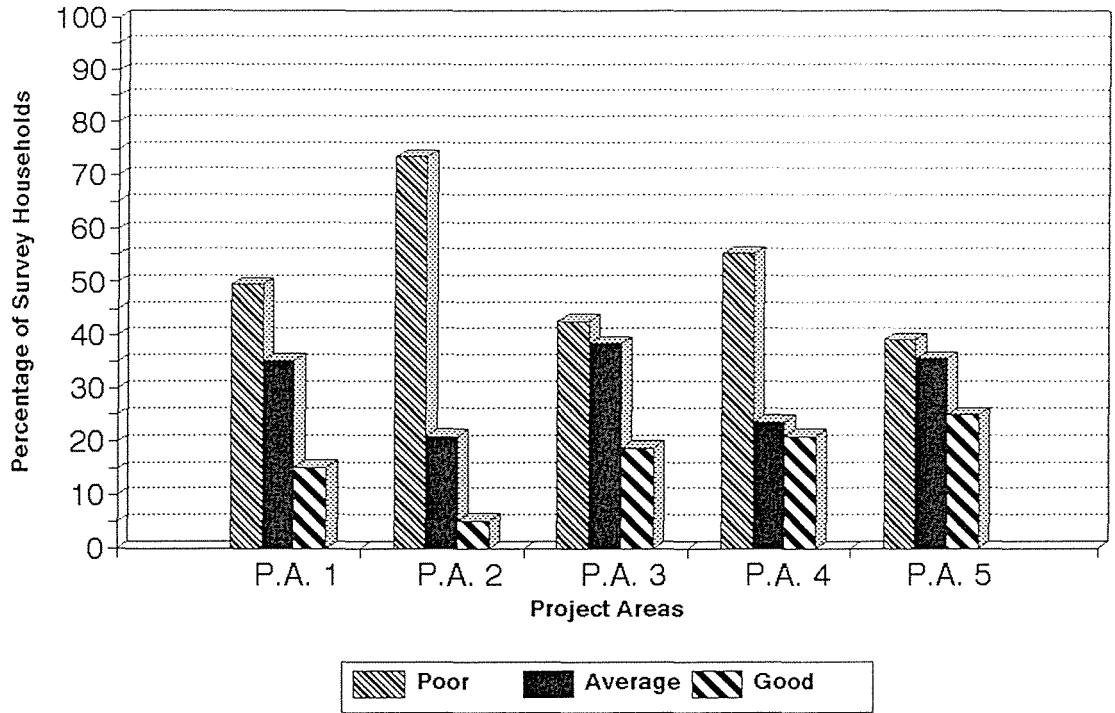


Figure 6.3

Composition of Household Children

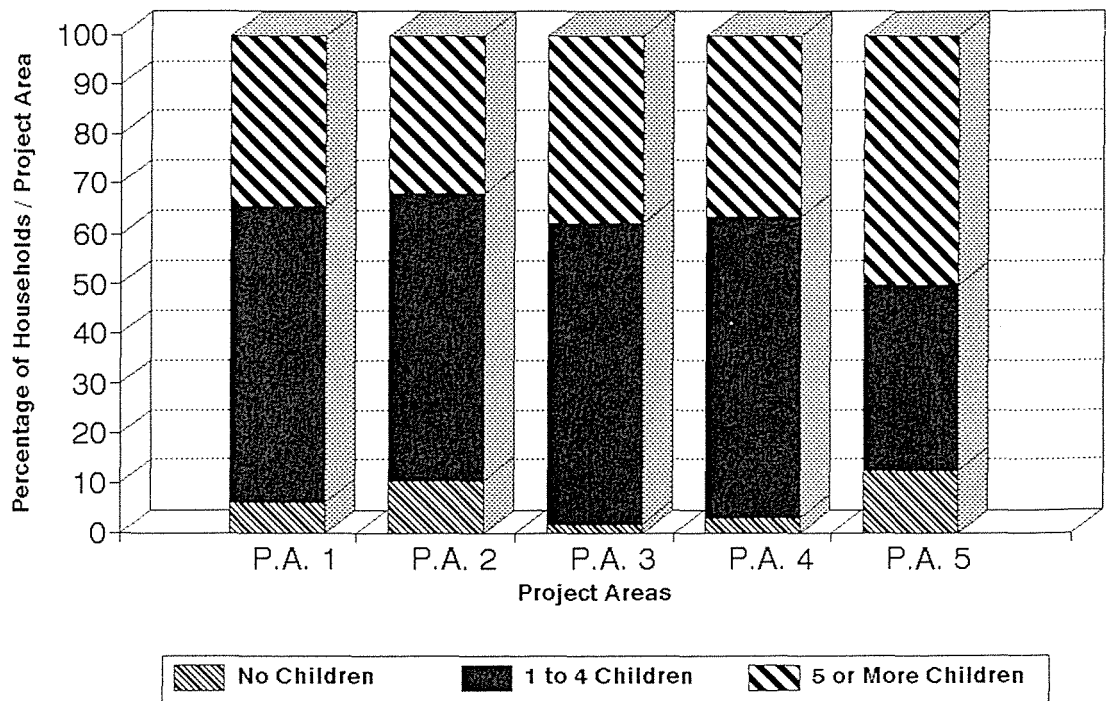


Figure 6.4

Proportion of Households with Children 15 Years Old and Over

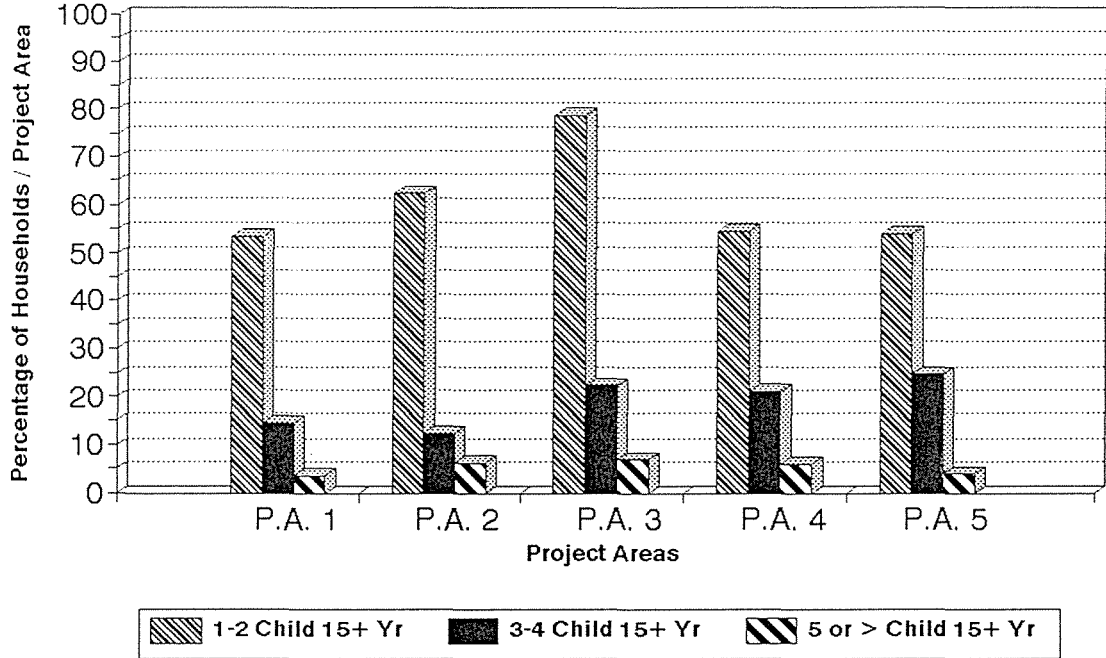
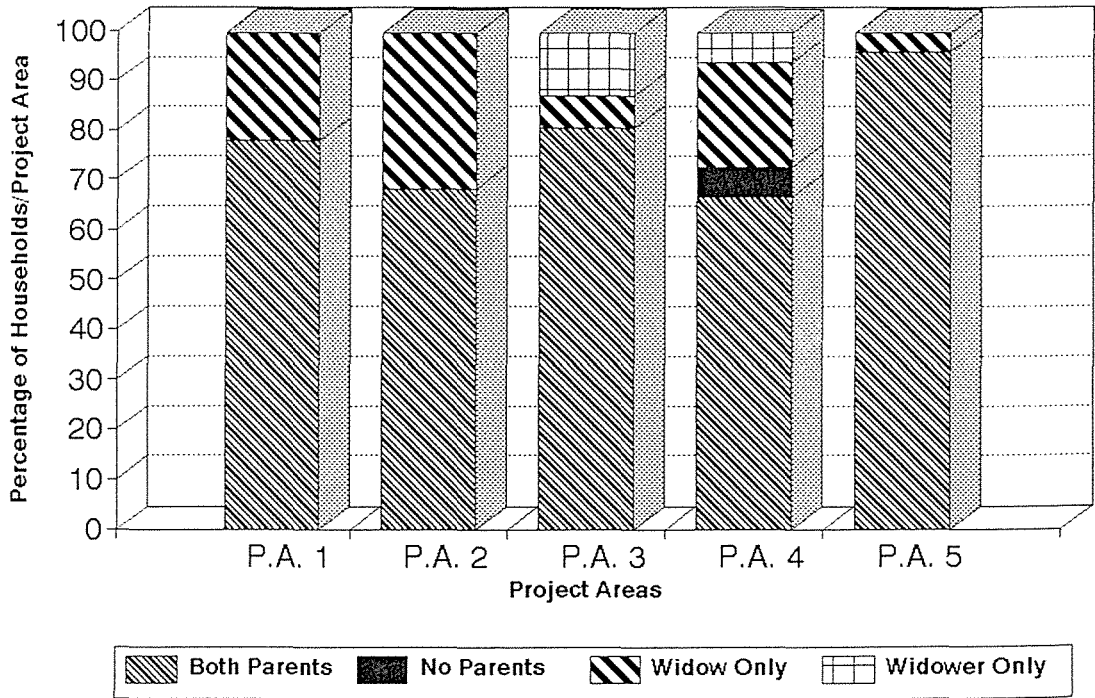


Figure 6.5

Status of Household Parents



The results show that not all households have occupants that can read or write. Figure 6.6 shows that in project area 2 the percentage of households with at least one person who can read or write is as low as 79 percent. The other areas are not so poor and range between 89 and 97 percent. When the literacy of the head of households is considered the percentages are even lower. While project area 5 head of households produce the best read and write return (79 percent), project area 2 produces the lowest (58 percent). Households with the head and at least one other occupant able to read and write are even fewer. Project areas 1 and 2 are as low as 52 and 53 percent respectively.

In all cases of the literacy analysis project area 2 features the worst, which would indicate that more care will be required there in assisting farmers in a way which they will comprehend. It may be that particular emphasis will be required on pictorial and practical presentations of new ideas.

6.4.3 Crop Patterns Within and Across the Five Project Areas

Data concerning current farm activities formed the next part of the survey. While general landuse types have already been provided by the landuse appraisal, the purpose of collecting the data at the household level was to provide an another insight to the farm activities within each project area.

The household landuse trends shown in Figure 6.7 reflect all those households growing any of the listed crops. Whether these crops are of major or minor economic importance was difficult to determine due to household to household variations in the proportional area used by any given crop within the total farming system. Figure 6.8 attempts to indicate major versus minor rice crops by drawing a distinction between monsoon and dry season rice according to the relative area given to each. This was calculated by assuming that a given rice crop type (for example, monsoon rice) was major if the area designated to it in the year of the survey was greater than that given to another rice crop type (for example, dry rice).

Because of this difficulty in drawing conclusions between major and minor farm crops the survey sought to ascertain which crops the household head considered to be major according to the economic or social benefits provided by the crop to the household.

Figure 6.9, therefore, reflects those crops of major social importance and Figure 6.10 those crops of major economic importance. In every case rice is considered to be the most important with maize, tobacco and plantation (mainly consisting of vegetables and sugar cane) in project areas 3, 4 and 5 being the only other crops of any significance. The social importance of rice is shown to be comparable to its economic importance in all project areas with the exception of project area 5, where its economic importance is significantly more than its social importance. While the social importance of maize in project area 5 is equal to that of rice, economically its importance is marginal compared to that of rice.

Unfortunately the information returned from the survey in respect to major social and economic crops was not adequate to make a distinction between dry season and monsoon season rice.

When these results are compared to the landuse map (Figure 6.1) obtained from the landuse appraisal there appear to be some discrepancies. In project area 4, in contrast to the landuse map, the occurrence of maize and tobacco is shown by the farmer survey to be marginal and in project area 5 (a dual monsoon and dry season rice area) the occurrence of monsoon season rice is half that of dry season rice. After a closer look at the villages where the randomly selected farmers are located and at the landuse in neighbouring villages, these discrepancies appear to be attributable to the farmer survey sample (randomly selected) including some farmers who were an exception to the norm in the project area as a whole.

Figure 6.6

Household Read/Write Capability

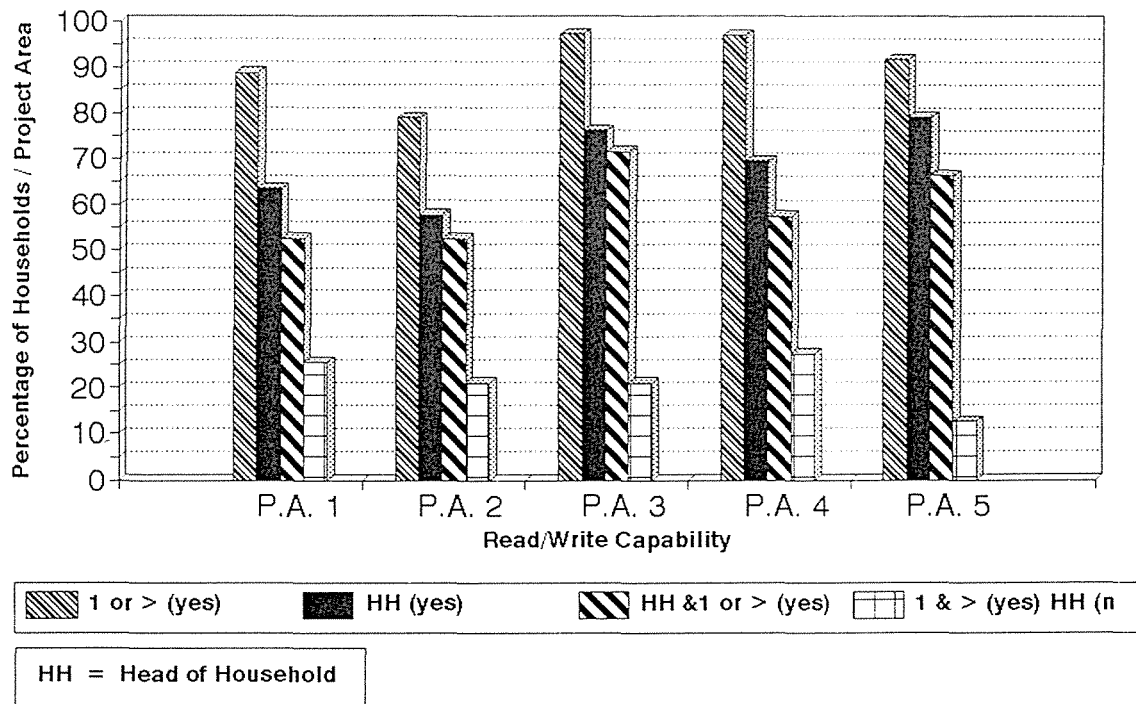


Figure 6.7

Household Landuse by Project Area

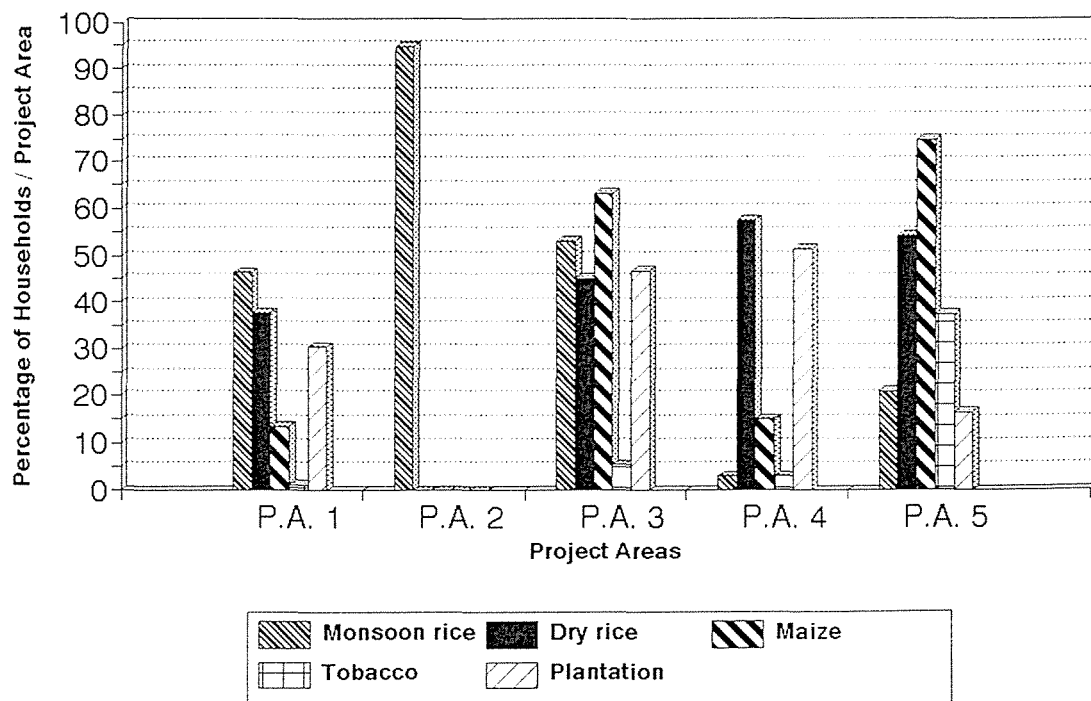


Figure 6.8

Major Rice Crops by Project Area

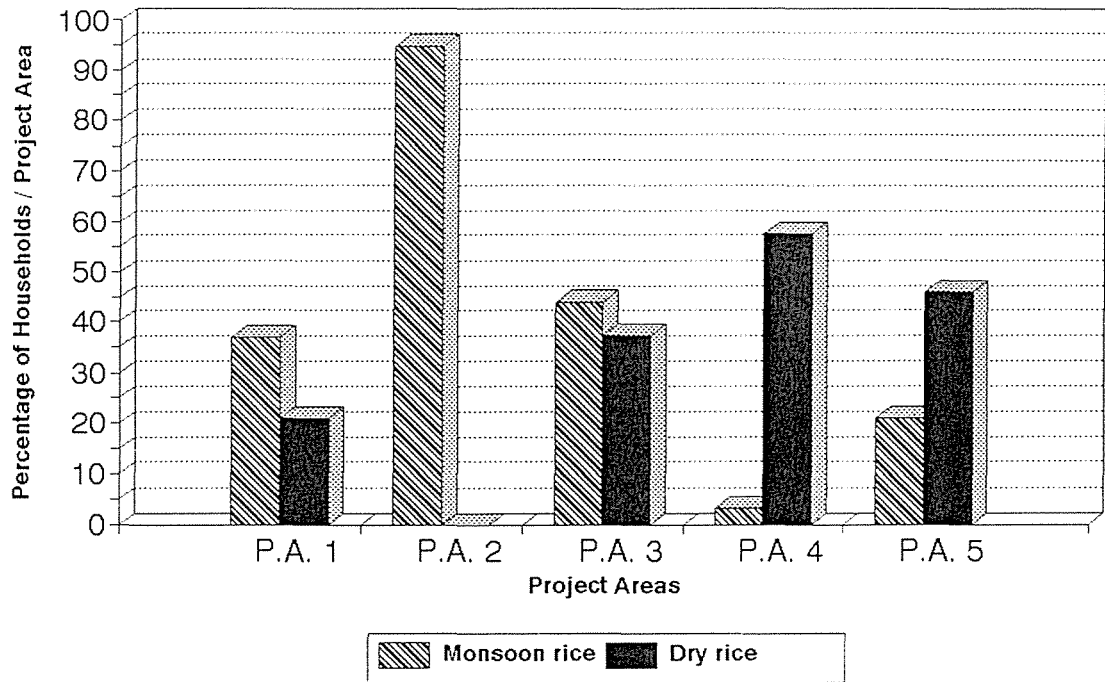
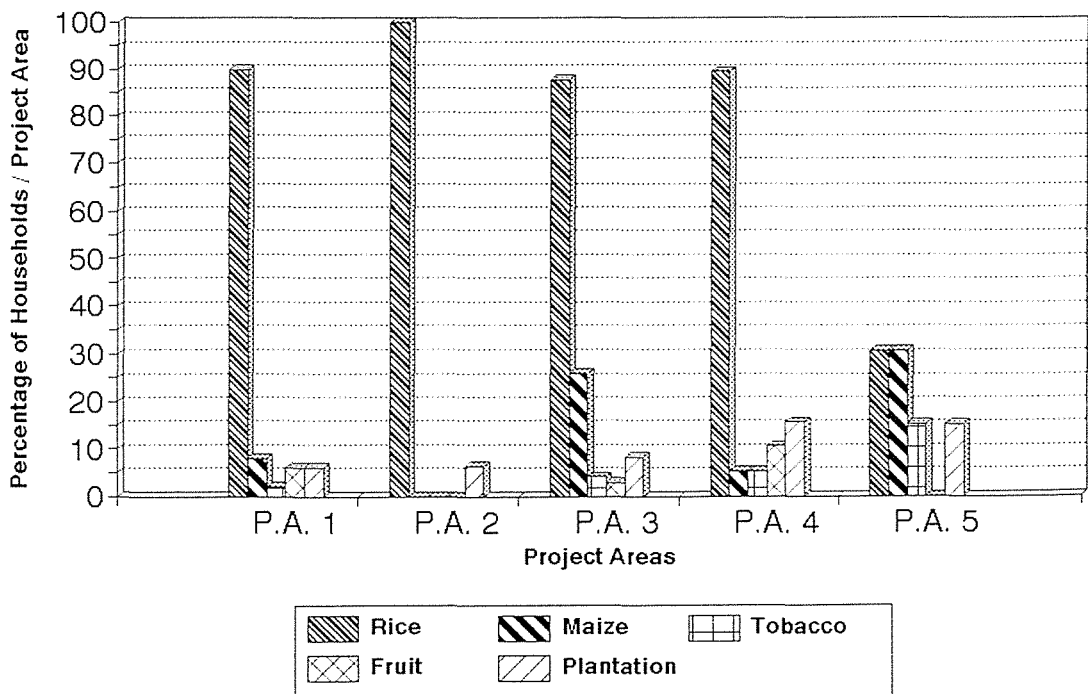


Figure 6.9

Major Social Crops by Project Area



This therefore suggests that a direct comparison between the landuse designations of the five project areas and the current landuse of the households in the farmer survey cannot be made. The results however, will become more balanced as the landuse information of further farmers joining the project are added to the database and so remain useful.

The value of the landuse information is to indicate the current farming activities which are likely to influence the selection of appropriate methods of integrated aquaculture (IAQS). For example, in project area 2 monsoon season rice is definitely the predominant crop (see Figures 6.7 to 6.10). Further, the group discussions conducted with the respondents in project areas 2 and 3 showed that the monsoon rice in project area 2 is a transplanted crop as opposed to the monsoon rice in project area 3 (where monsoon rice is also common see Figure 6.8) which is generally a broadcast crop. For the following reasons this indicates that project area 2 has potential for the development of a rice/fish aquaculture system.

- a) the well defined paddy of transplanted monsoon rice is easily adapted to contain fish;
- b) the water depth of monsoon rice is adequate for fish if a portion of the paddy is sacrificed for use as a refuge area (e.g. a one metre wide and a half metre deep ditch around the outside of the paddy);

The broadcast monsoon rice of project area 3 however, is not suitable for rice/fish as well defined paddies are not used for broadcast rice, prohibiting the containment of the fish.

Integration with vegetable and maize crops is also likely to have potential (see Figure 6.7). With the exception of project area 2 both occur in all areas. In these locations ponds stocked with herbivorous fish able to be reared on plant material, especially waste vegetables, can be used.

A further feature of household cropping patterns which the survey sought to investigate, was the percentage of household crops used for subsistence purposes as opposed to being marketed. Figure 6.11 shows the percentage of each project area's households which are using all of their crops for subsistence, Figure's 6.12 and 6.13 consider each crop type in turn.

Figure 6.11 suggests that the number of households using all their crops for subsistence is substantial. Figure 6.12 in showing the trends in the use of industrial crops suggests that in each of the project areas where tobacco features the number of households who grow tobacco and maize and maintain 100 percent of the harvest for family use is high. Surprisingly however, the total harvest of plantation crops (which include all vegetable crops), is shown by a comparatively small number of households to be retained for subsistence use (see Figure 6.12).

Rice crops, which are the major economic crops in every project area (see Figure 6.10), are shown by Figure 6.13 to be particularly important for household subsistence requirements. The proportion of households retaining all of their rice crop for family consumption is very high. This verifies the importance of rice as the main staple in the local diet and that the majority of the rural population are engaged in a subsistence lifestyle.

These results are of further interest in that they indicate that rural households undertaking the integration of aquaculture with their current subsistence farming activities will probably do so primarily to enhance their subsistence lifestyle. While some of the production from aquaculture development may well be marketed, it is likely that this will be either that which is excess to household requirements, or as a means of procuring preferred fish species or alternative foods. The extent to which this occurs however, will be dependent on the resources available to the household. The more resource rich a household is, the more likely they are to desire a financial return by marketing their fish harvest.

Figure 6.10

Major Economic Crops by Project Area

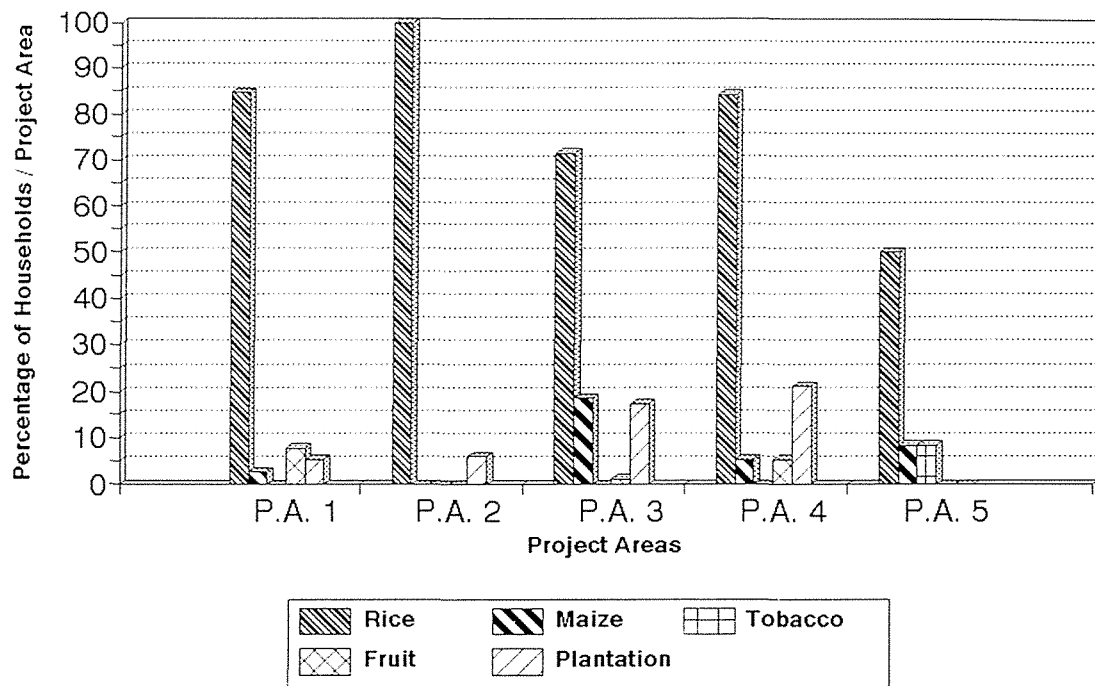


Figure 6.11

Households Using All of their Crops for Subsistence

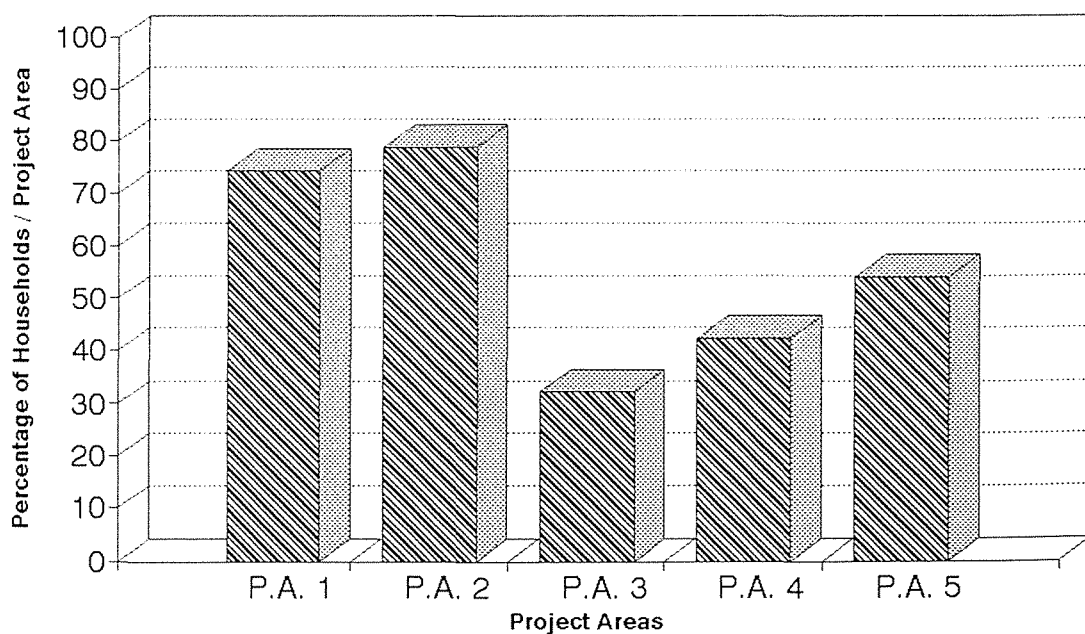


Figure 6.12

**Industrial Crop Growing Households
Using All their Crops for Subsistence**

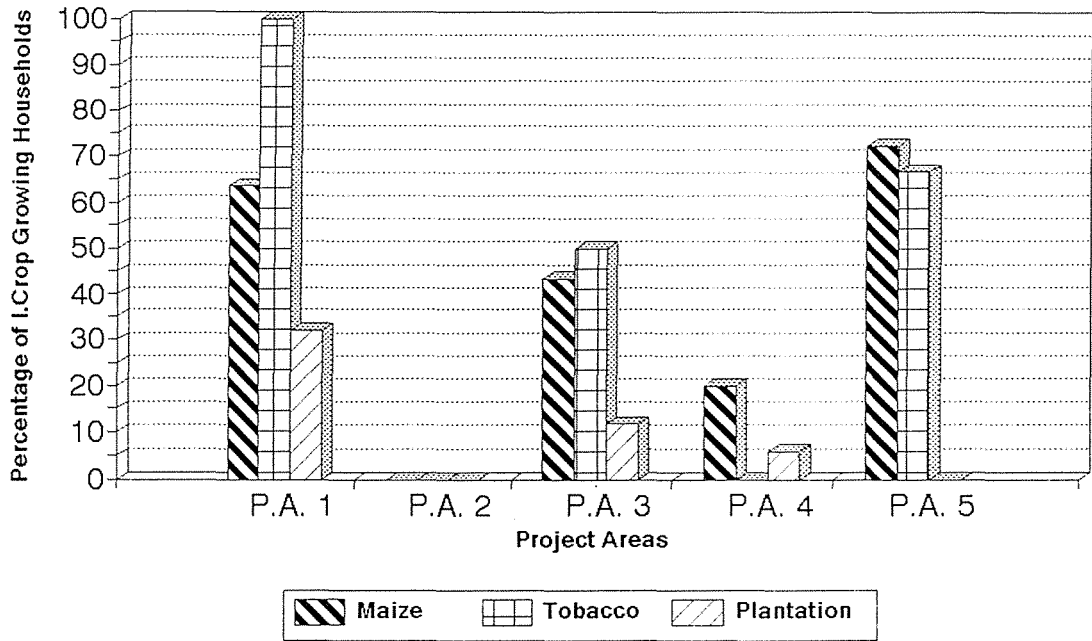
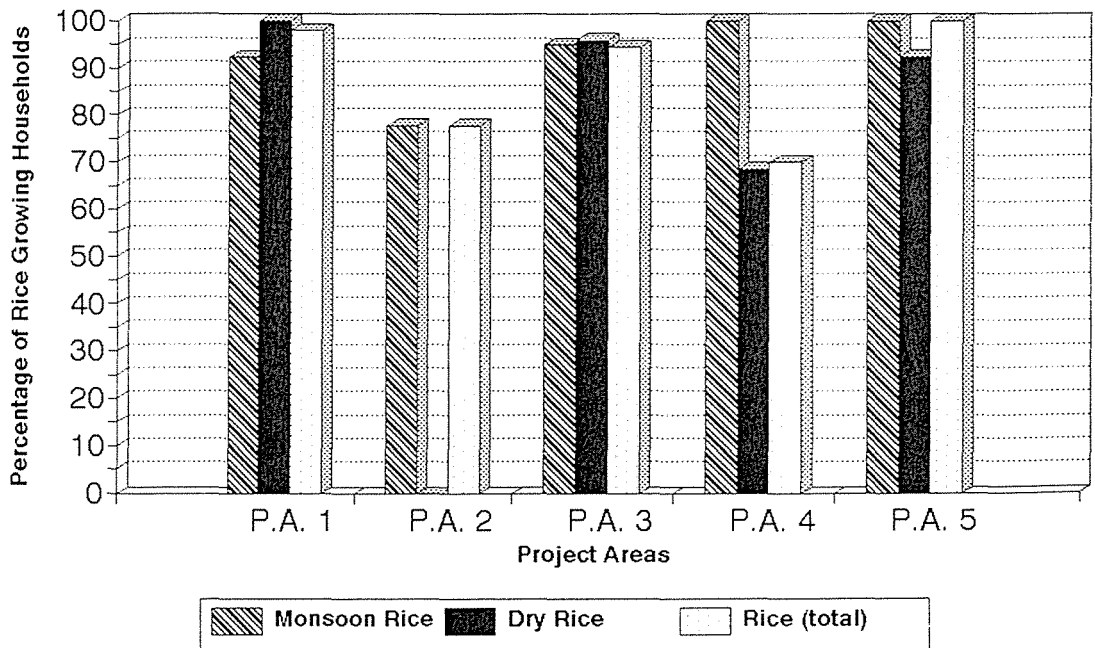


Figure 6.13

**Rice Growing Households Using
All of their Rice Crop for Subsistence**



6.4.4 The Importance of Animals to The Farm Household

Figures 6.14 to 6.19 show the contribution which animals make to the surveyed households. Figure 6.14 indicates that most households have animals. However, the number of households with cattle (Figure 6.15) vary significantly between project areas, with project area 2 having almost 80 percent and project area 1 having little more than 30 percent. However, in all the project areas the majority of those households rearing cattle have two or more. This is likely to be due to two cows being more efficient for work requirements than one. Ascertaining what the various species of cattle are was not considered necessary for the purposes of this survey.

The number of water buffalo is very low. In fact all project areas, with the exception of project area 1, are shown to have no buffalo. This is consistent with the Kandal province traditionally being perceived as a cattle rearing area. Generally provinces in Cambodia reflect a single concentration of either buffalo or cattle, seldom are large numbers of both seen in the same locality.

The survey also determined what was considered to be the major purposes for households rearing cattle. Figure 6.18 reflects that subsistence (work and/or breeding for replacement) consist of a little more than half of the stated household rearing purposes. Project area 2 is the exception, with 72 percent of their cattle rearing households using their cattle for subsistence.

In contrast to the prevalence of cattle, pigs and poultry are shown to be of lesser importance. Figures 6.16 and 6.17 indicate that the number of households in all project areas with either pigs or poultry are less than those with cattle. With the exception of project area 4, 60 percent of the households in this project area have poultry compared to 42 percent with cattle.

Finally, Figure 6.19 shows some results of particular interest in respect to household preferences in the consumption of their animals. All project areas reflect a significant reluctance to consume household reared animals. Only project area 2 shows the number of households willing to consume their animals to be greater than those who are not. Unfortunately the information returned by the survey data was not clear. While the survey sought the household consumption preference for each animal type owned, the results were not always consistent or complete. An assumption has therefore been made that if a household is willing to consume any one of the various animal types owned, that this indicates willingness to consume all of the animals being reared.

This apparent reluctance to consume animals may indicate that the same can be expected for household reared fish. This would therefore suggest that a substantial proportion of the reared fish will be marketed. The group discussions held in conjunction with the survey however, indicated that in many cases the households wanting to sell their fish would do so in order to buy other fish with the proceeds. For some this was because of their preference for wild fish over pond reared fish. In time, if the development of small scale aquaculture is successful, the potential market impact may require further investigation.

Figures 6.19 and 6.18 further endorse this conclusion. While a substantial proportion of the households rearing cattle, according to Figure 6.18, do so for the purpose of marketing, a substantial proportion of all households, according to Figure 6.19, are unwilling to consume household reared animals of any kind.

Finally, the data on project area 2 allows the conclusion that the households in its area may be an exception. First, as stated already, Figure 6.18 shows that the subsistence use of cattle is high compared to other areas. Second, the proportion of households willing to consume their animals exceeds those that are not (48 percent compared to 25 percent). While this does

Figure 6.14

Households Which Own Animals

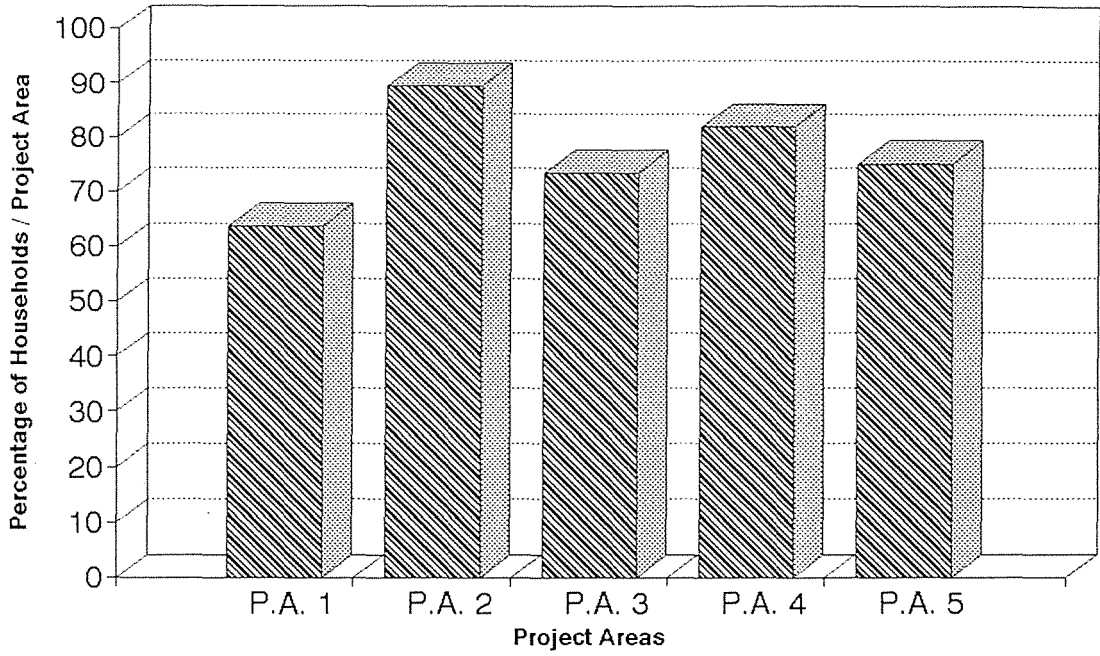


Figure 6.15

Households With Cattle

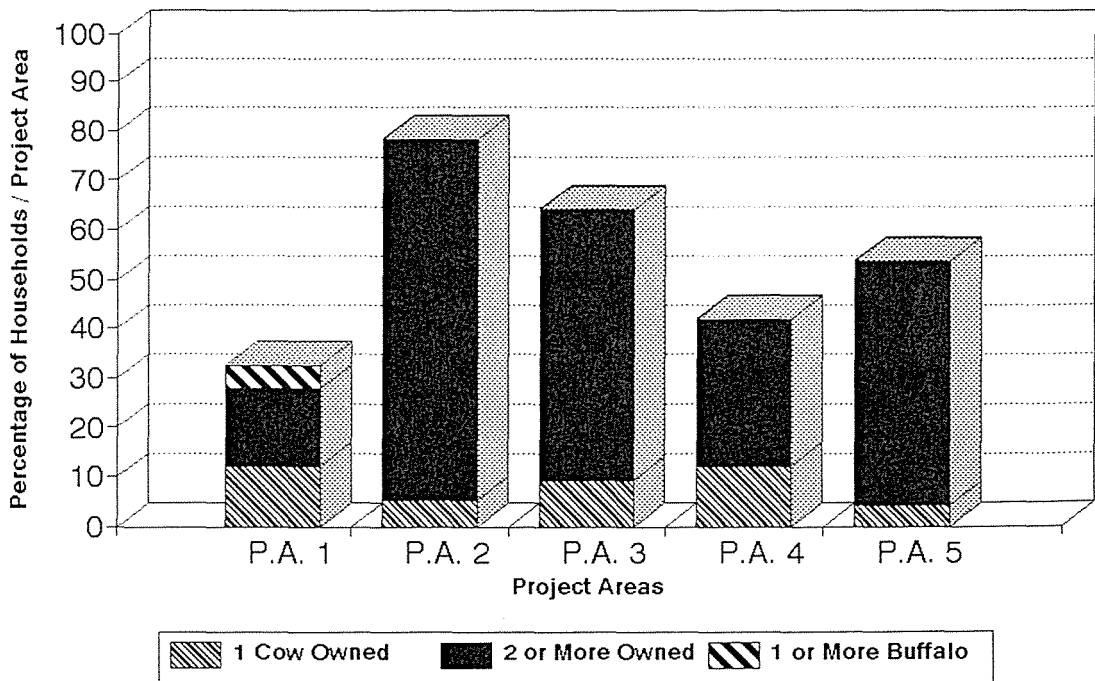


Figure 6.16

Households With Pigs

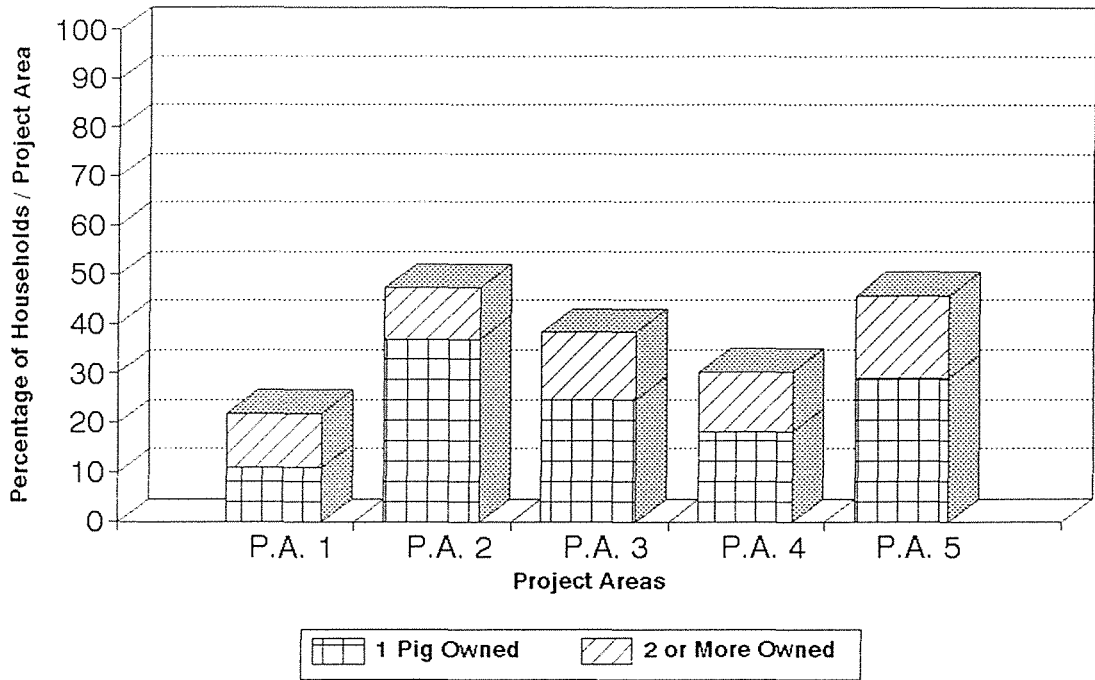


Figure 6.17

Households With Poultry

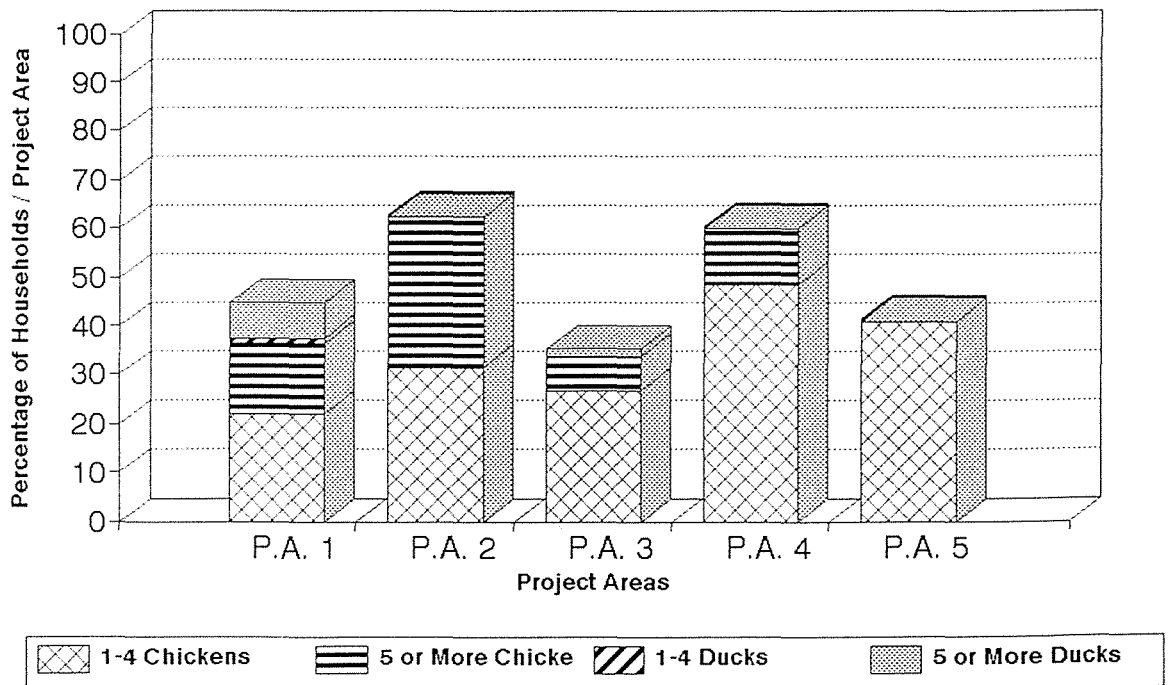


Figure 6.18

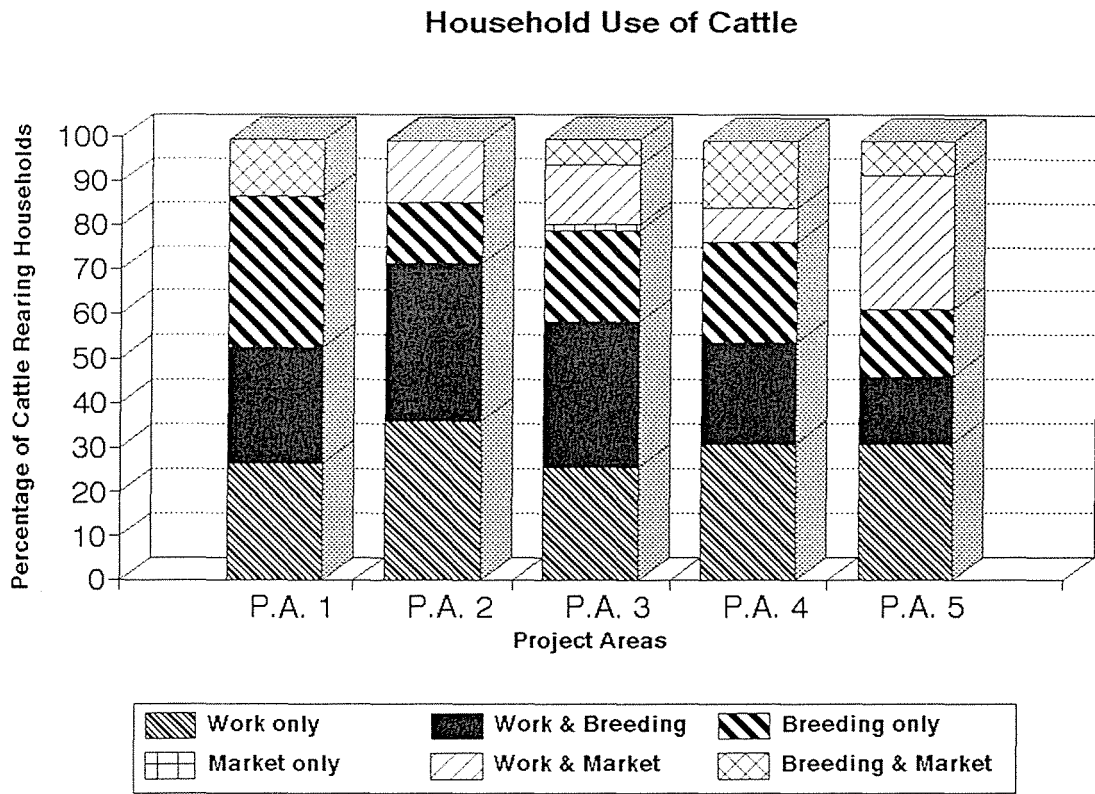
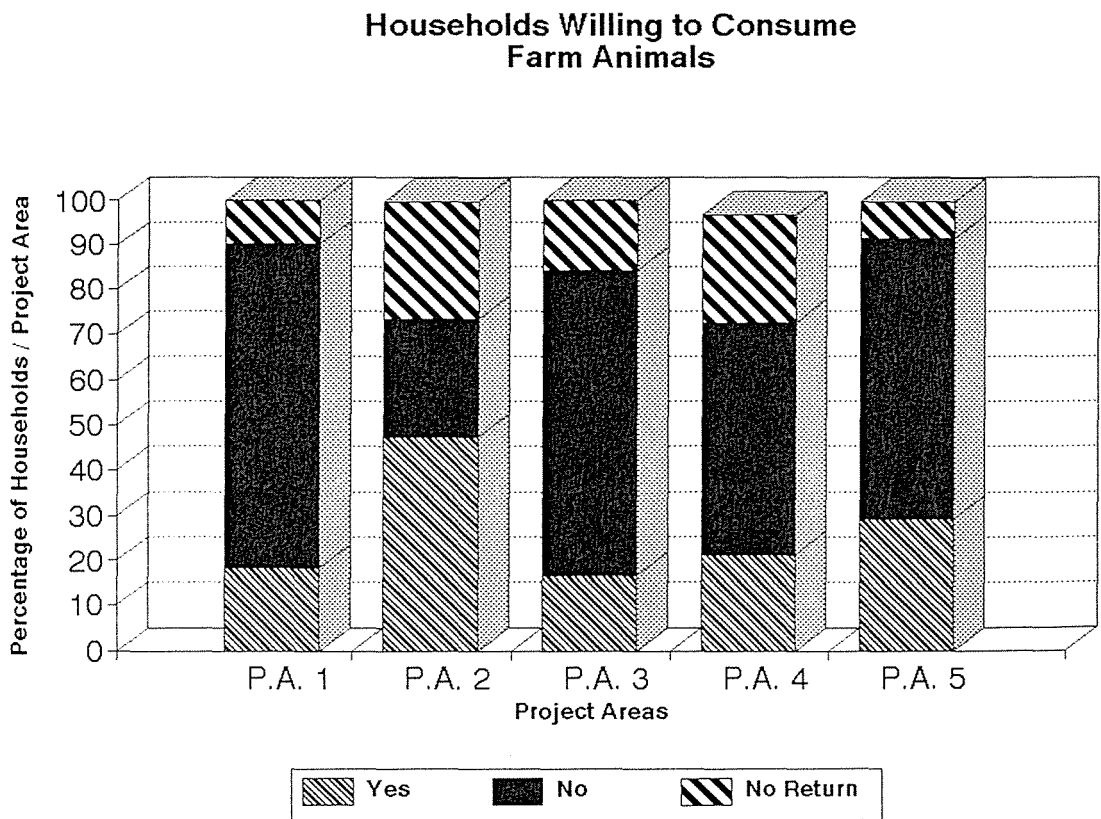


Figure 6.19



not necessarily indicate that the households in project area 2 are poorer (the proportion of households with animals, especially cattle is as high here as all the other areas), it does suggest that subsistence requirements are of much greater importance. While cattle are retained predominantly as draft animals, pigs and poultry are reared for household consumption (although the figures are not complete enough to fully support this conclusion). Further, if the purpose of the area's crops are reconsidered (Figure 6.11), crops are predominantly retained for subsistence. The proportion of households in project area 2 using all their crops for subsistence is greater than all other areas.

6.4.4.1 The Use of Animal Waste on the Farm

An important contribution which animals can make in the integration of aquaculture with traditional farming practices is to provide organic waste for the fertilisation of fish ponds. If adequate fertiliser, whether organic or inorganic is provided plankton growth in the pond can be enhanced. If a pond's fertility is adequate this can substantially reduce the need to provide supplemental feeds for the fish. While the quality of organic waste varies greatly, most animal manures can be used. The quality of cattle manure is poor compared to that of pigs, however, Figures 6.15 and 6.16 would suggest that it is likely to be more available.

The survey therefore, sought to ascertain the current degree to which on-farm animal waste is used as a fertiliser for either crop or garden production. Unfortunately the quality of the information returned was poor and so the reliability of the results is not good. Some conclusions however, can be made.

Table 6.8 shows the total number of households with either cows or pigs who currently collect their animal waste and use it for the fertilisation of either their gardens, crops or both.³⁰ The proportion of households using their manure is relatively high and would suggest that farmers who rear either pigs, cattle, or both do not have much manure available for use by fish. In project areas 1, 2 and 3 the most common use of animal manure is shown to be for the fertilisation of crops. In project areas 4 and 5 manure it is used on both crops and gardens.

Table 6.8 Trends in the Use of Animal Manure

Trends in the Use of Animal Manure						
	Percent Households With Cows/Pigs	Percent C/P owning Respondents	Percent Respondents Collect all/some manure	Percent Using Manure for Garden	Percent Using Manure for Crops	Percent Using Manure for Garden & Crops
Project Area 1	43	94	70	9	57	22
Project Area 2	79	87	100	0	62	8
Project Area 3	71	94	83	2	72	27
Project Area 4	58	84	69	45	45	9
Project Area 5	75	100	72	0	31	46

³⁰ As poultry usually roam freely and the collection of its manure therefore difficult it has not been included in these results.

During the group discussions farmers were asked again if they currently use their animal manure for fertiliser. Although the response was rather mixed, the proportion of farmers currently using their manure for fertiliser was also high.

Household willingness to grow fish using animal waste was addressed in more detail by the group discussions and is considered further in Section 6.4.10 below.

6.4.5 The Availability of Water

A reliable water source is a crucial requirement if aquaculture initiatives are to be successful. Much of the Kandal province is very low lying (as low as ten metres above sea level) and consists of much of the Mekong, Tonle Sap and Bassac river flood plains, but the region's water management is very poor. While many areas of the province suffer from too much water during the monsoon season and an inability to control it for the gain of the local farmers, many areas suffer from a lack of water in the dry season. Many irrigation and water control structures are damaged and inoperable.

The SCALE survey therefore sought to determine the predominant water source type used by households and their distance from the house. An attempt was also made to quantify the difficulty which households have in procuring adequate water during the dry season months. Unfortunately this proved difficult to do and the results returned are insufficiently reliable for inclusion in this analysis.

The five pie charts provided by Figures 6.20 to 6.24 divide the distance between household and water source into five categories. In all areas, with the exception of project area 5, it can be seen that at least half of the households must go between 100 and 500 metres to their water source. A significant proportion must go further than 500 meters and some further than 1000 meters. For households having more than one source of water available, only the closest is reflected here.

Figure 6.25 shows the six water source types and the degree of their importance according to the proportion of households utilising them in each of the project areas. With the exception of project area 2 for which ponds are the major source of water, all project areas rely predominantly on the local river for their water. This does not suggest that all the household respondents are located in villages adjacent to rivers. As Figures 6.20 to 6.24 show some households must travel in excess of one kilometer to obtain their water.

The significant distance which many households must go would suggest that some households may prefer to construct a pond for domestic and irrigation requirements. In this situation constructing a pond specifically for the use of producing fish may not be so attractive. Where this is the case there may be some value in promoting the ability of using ponds for both irrigation requirements and fish. This however, will be dependent on the water retention capacity of the soil.

Figure 6.20

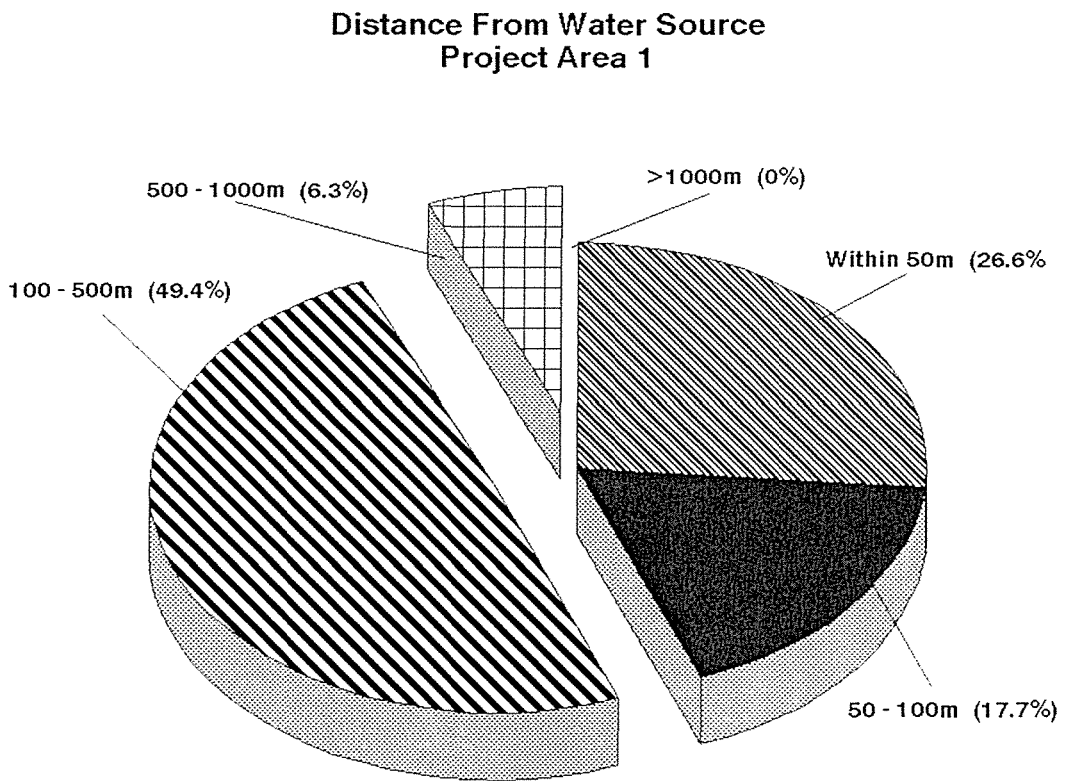


Figure 6.21

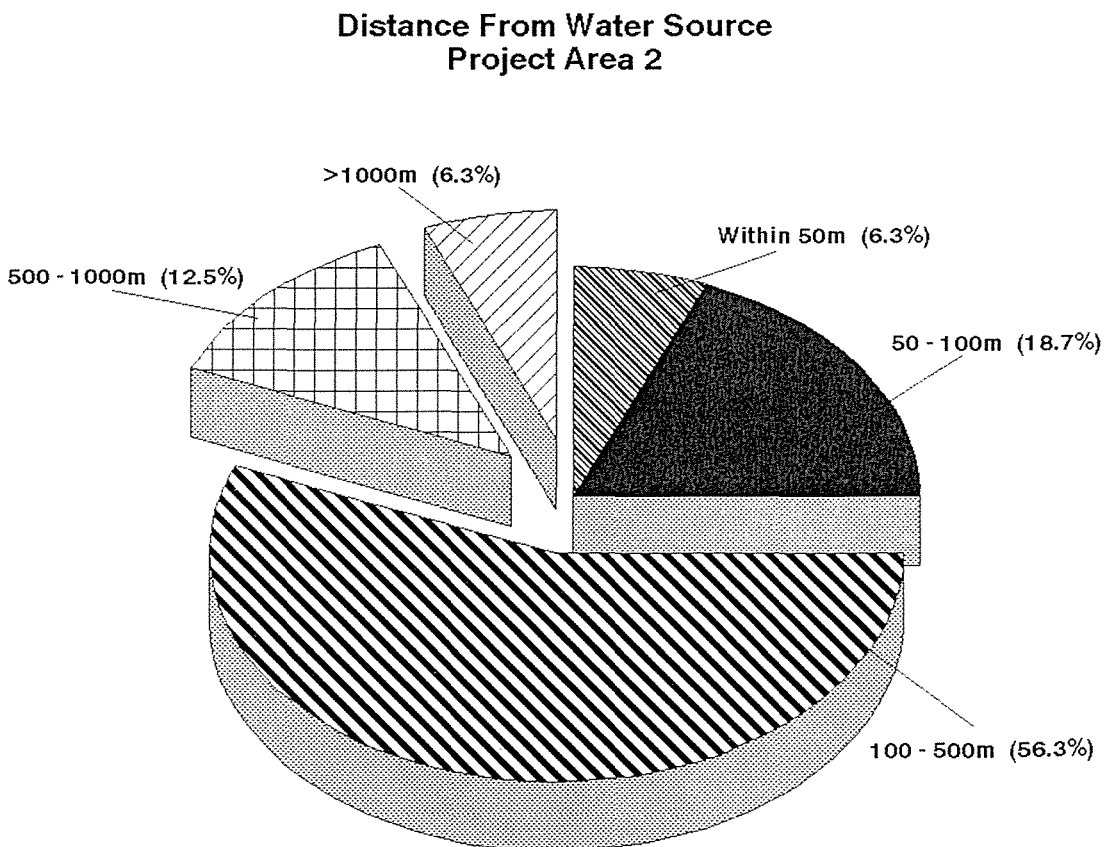


Figure 6.22

Distance From Water Source
Project Area 3

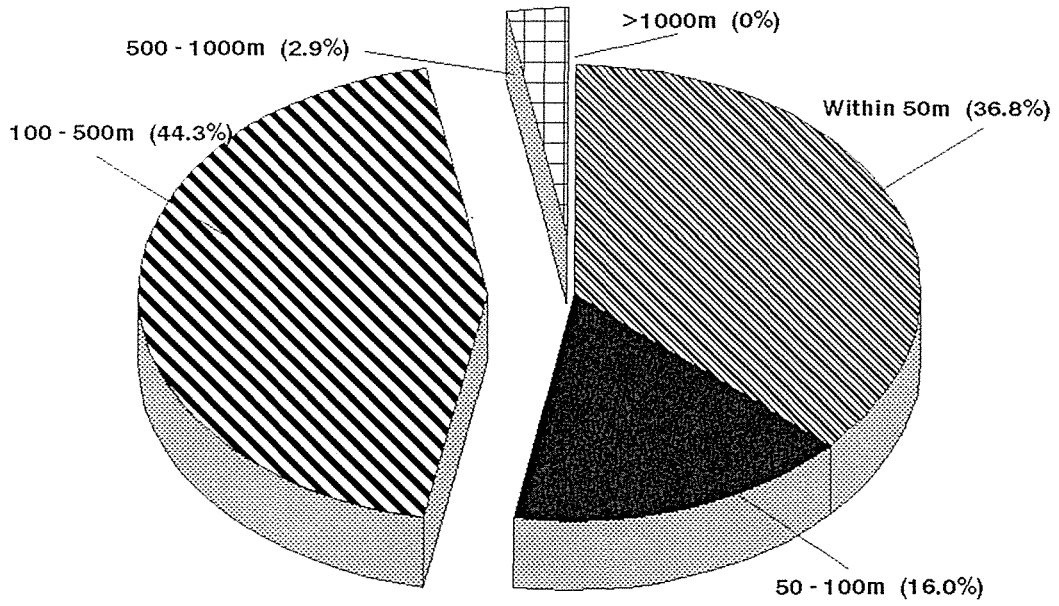


Figure 6.23

Distance From Water Source
Project Area 4

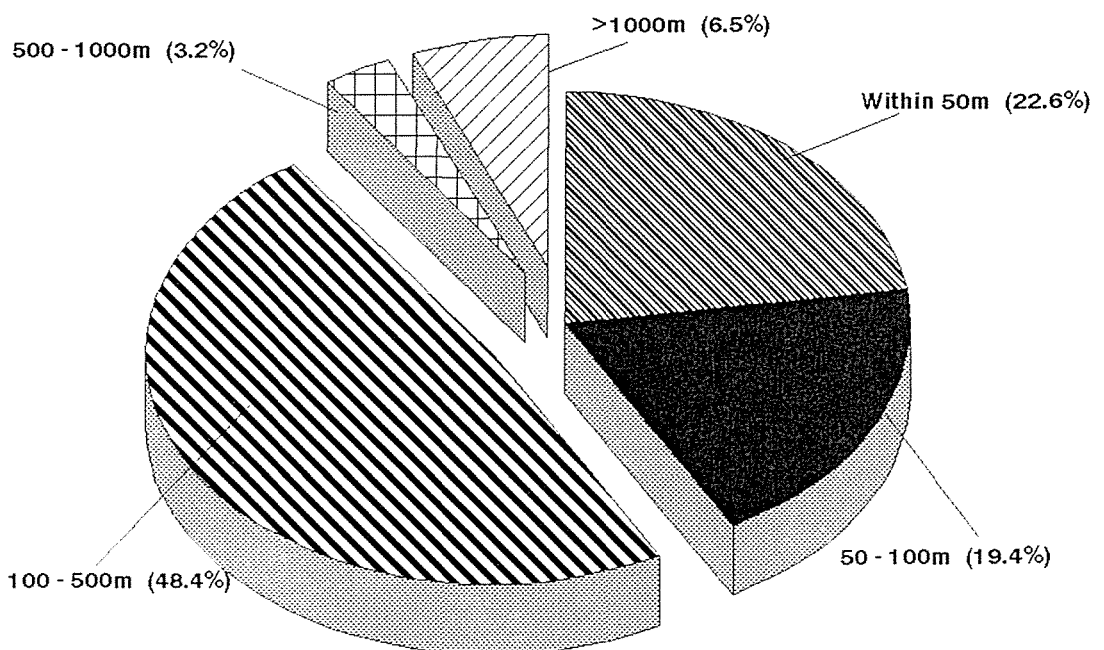


Figure 6.24

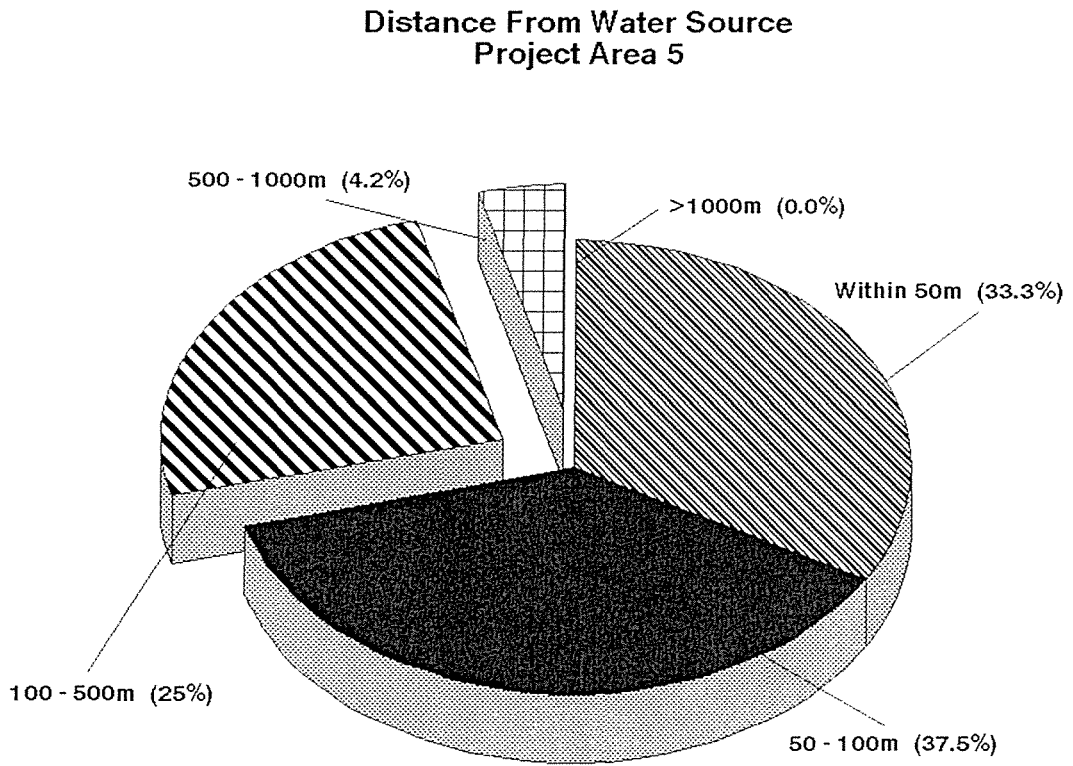
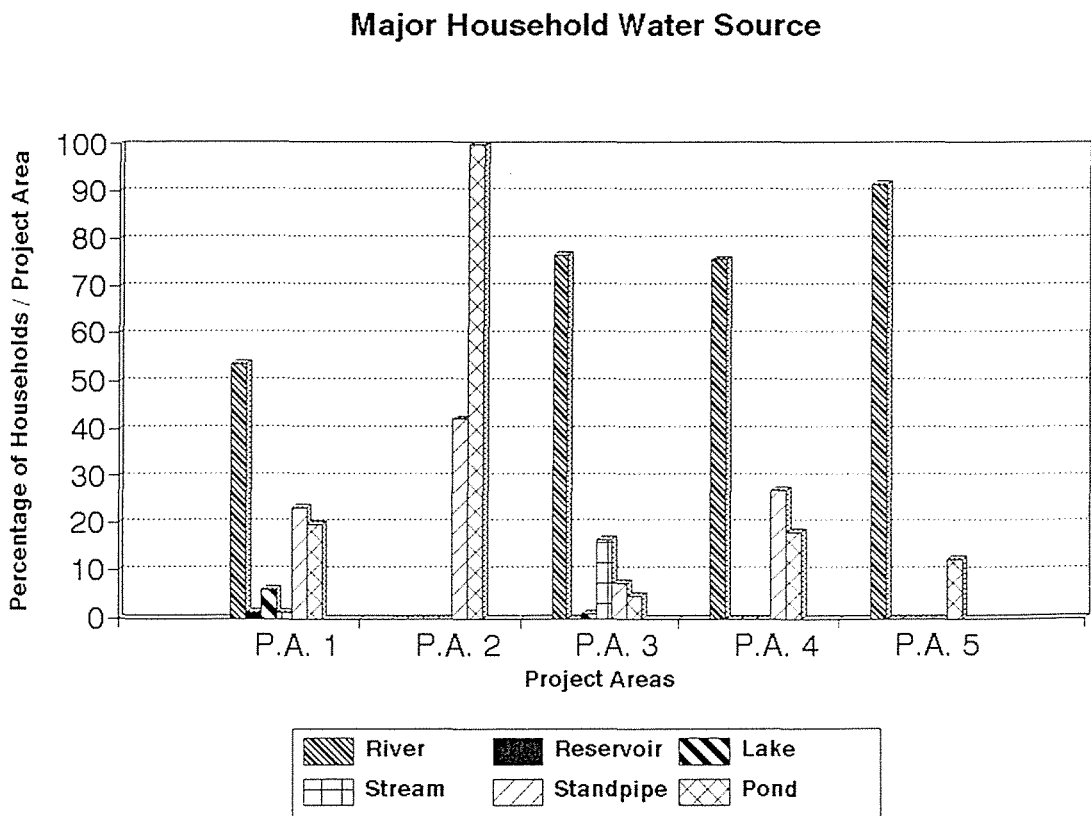


Figure 6.25



This was suggested during the group discussions in project area 3 and was well received by many farmers, especially where vegetable crops were important. The farmers could see the pond serving two purposes. Where soil water retention was poor (i.e. farmers believed that a pond would retain water for less than four months), it was believed that digging a pond deeper would be satisfactory to ensure water was available for longer. In some areas existing ponds were up to five meters deep.

6.4.6 The Prevalence of Existing Ponds

As shown above, the water source study shows that ponds do exist. They are predominantly used for either domestic or irrigation purposes. Very few have been, or are, currently used for fish. Table 6.9 and 6.10 show that in project area 2 the respondents all have access to a pond for domestic requirements. The incidence of ponds here is clearly due to the lack of alternative water sources, except for a few standpipes. The other project areas have few ponds.

Table 6.9 Percentage of Households with Access to Ponds

	% Households with Ponds	Number of Ponds and the Duration (months) for Which they can Retain Water					
		0 - 3	4 - 6	7 - 9	10 - 11	12	No Return
Project Area 1	20	0	1	0	0	12	3
Project Area 2	100	0	9	4	1	4	1
Project Area 3	5	0	2	2	0	1	0
Project Area 4	18	1	2	0	2	0	1
Project Area 5	13	0	0	1	0	2	0

Table 6.10 Pond Use

	Number of Ponds	Fish	Domestic	Domestic/ Irrigation	Irrigation	No Return
Project Area 1	16	1	1	1	0	13
Project Area 2	19	0	19	0	0	0
Project Area 3	5	1	1	0	0	3
Project Area 4	6	0	0	0	3	3
Project Area 5	3	0	0	0	0	3

Although these results show little pattern in the water retention ability of the ponds, the group discussions conducted in project areas 2 and 3 would indicate that with increasing distance

from rivers the water retention ability of the soil increases. Close to the rivers the land is higher and has a lower clay content reducing water retention, a typical characteristic of areas next to old and slow flowing rivers.

Ponds being constructed for aquaculture therefore, will need to be carefully sited. Close attention to the water retention ability of the soil and the likely period for which the pond will be able to retain an appropriate depth of water will be required. Unless a pond can be sited next to an alternative water source it must rely purely on rain for its filling and the water retention capacity of the soil to keep the water for a minimal period. The required duration of this period will be determined by the aquaculture system employed and the fish species stocked. It should be acknowledged that pumping water from an alternative source is unlikely to be feasible for the small resource-poor farmer. Accordingly the aquaculture system employed, pond design and location should therefore be appropriate to the rainfed situation alone.

Little more can be concluded from the pond information as there is uncertainty as to its accuracy. During the group discussions it was discovered that some farmers did not reveal that they had access to, or owned, a pond. Further, those that did were not necessarily consistent in the information they provided. This may have been due to the field staff not investigating closely enough in the course of their discussions with the farmers and so the information was not offered. In some cases it is apparent that households did not want to reveal certain information. Possibly they believed that by not disclosing some of their resources they would be more likely to receive assistance.

Despite this it can be concluded that the number of ponds in all the project areas is generally low. Even in project area 2 where every respondent has access to a pond, the group discussions showed that in most cases this is a village pond. Few farmers have their own ponds. In project area 3 the group discussions revealed that some ponds had been missed by the survey, but they were few and do not affect the conclusion that in general few farm households have their own pond. Observation did reveal however, that the few fish ponds which were found were generally over fertile (with a very high plankton loading) and weed infested. There appeared to be a poor understanding of the requirement to maintain an appropriate level of pond water fertility. In some cases the ponds had been rejected and were no longer used.

6.4.7 The Distance of Household Farm Land from the House

The survey results have revealed that the farm land of many households is some distance from the house. Figure 6.26 shows those households which have crops more than 500 meters away. Although the graph does not show what the average distance is, the results indicate that many farmers must commute up to two to three kilometers to some of their fields. Furthermore, the survey and the group discussions in particular have shown that farms are heavily segmented with some households having their land in up to four different locations, all of which are distant from the house. Figure 6.27 verifies this further by showing that a significant proportion of the households have all their fields more than 500 meters away. Those with some land within 100 meters are surprisingly few.

This fragmentation of farm land holdings is likely to inflict a heavy demand on household labour, with a substantial amount of time being used in commuting between fields. An effort was made in the survey to collect information on work load patterns throughout the year. This was done by plotting on a graph the monthly demand on household labour. Unfortunately, the results returned were not clear and did not permit any firm conclusions to be made. Household members were reported to be very busy most of the time. It would appear that this arose from farmers including off-farm activity with on-farm activity in their response. Thus, it was impossible to clearly identify on-farm work load patterns.

Figure 6.26

Crop Growing Households with their Crops
500m or Further From the House

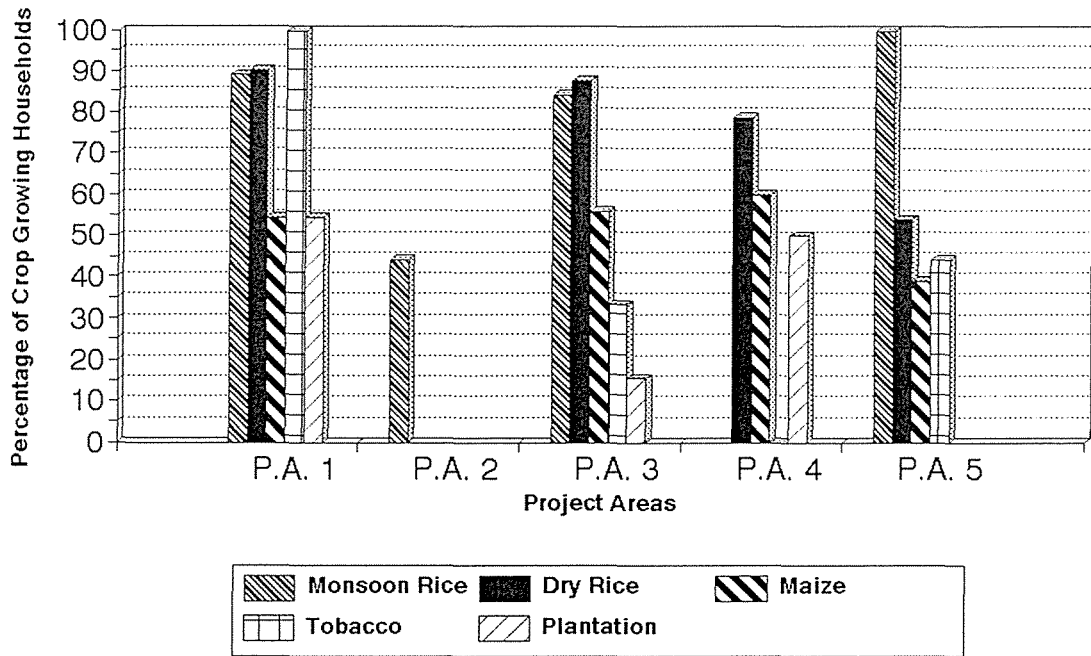
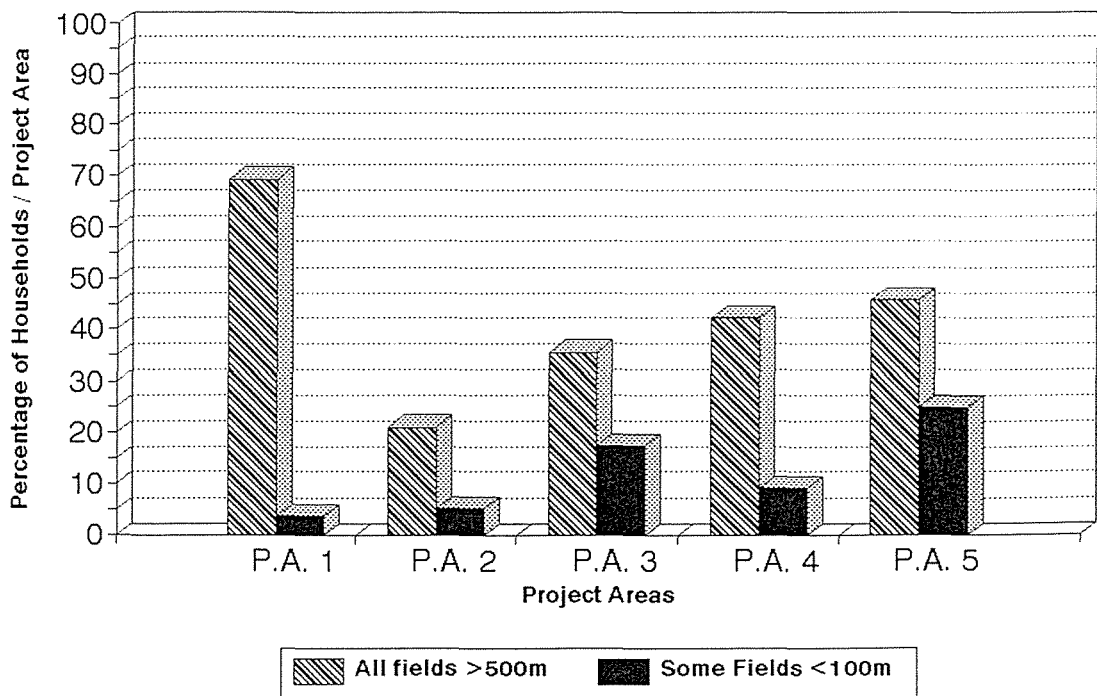


Figure 6.27

Distance of Fields from House



While this increased demand on labour may influence a household's capacity to diversify into integrated aquaculture, fragmented land holdings also has the potential to cause security difficulties. All farmers who have little or no land close to their house expressed concern in the group discussions if they were to have a fish pond which is far from the house. As the fields of most households with rice paddies are more than 500 meters from the house, this problem is particularly relevant for the development of rice/fish culture. For some farmers this was enough for them to reject the development of a pond or rice paddy as too risky. They believed that the possibility of having fish stolen was too great.

Some farmers on the other hand believed it to be less of a problem as they were happy to erect a shelter next to the pond or rice paddy (if a rice/fish system is involved) and have a family member live there during the fish grow-out season.

6.4.8 Income Insufficiency and Household Willingness to Borrow

It is commonly reported that the Cambodian rural population is particularly poor compared to their counterparts in neighbouring Southeast Asian countries. While it was not considered necessary to go into detail on the economic status of households in order to assess the capacity of households to undertake a new initiative, respondents were asked which months of the year their farm income was insufficient to cover their subsistence requirements.³¹ From this information it is possible to ascertain whether there are any patterns within or between project areas and the farming systems characteristic of them. This will be useful in showing the economic capacity of households to undertake a new initiative at any given time in the year.

Figure 6.28 therefore shows the patterns of income insufficiency throughout the year for the households in each project area. It has been prepared by calculating the proportion of households which suffer inadequate income each month.

January to May is the period for which income levels are at their highest for all project areas. The position of project areas 3 and 4 is poorer during this period, however it still remains the period when the least number of households have an income shortage. For the months from May to August the proportion of households with an income shortage steadily rises for all areas with the exception of project area 4 which remains constant. Of most significance however, is the period from August to November when there is clearly a definite income shortage for most households. Again however, the trend in project area 4 is different and does not show a sharp rise until October.

If Figure 6.8 is considered these results may reflect that those areas which have monsoon rice are the norm and project area 4 which does not is the exception. The predominant use of dry season rice here would suggest that its harvest in the early part, or first half, of the year allows household farm income to last longer into the year. Figure 6.12 shows also that dry rice growers in project area 4 market more of their crop than the households in other areas. It might be assumed therefore that their disposable income will be greater.

These results are of significant value in showing the time of year when farmers are likely to be the most economically secure for undertaking the required preparations for an aquaculture development. Fortunately most site preparation will be required prior to and during May, the time when households are shown to be the most financially secure. Unfortunately, the purchase of fingerlings will need to occur at some stage during June to August when the incidence of income shortage begins to increase steadily. Further, if an aquaculture system

³¹ The stratification of the populations in each project area to facilitate the selection of the survey sample, has already given a rudimentary measure of the socioeconomic status of the survey sample (see Section 6.4.1).

is employed which requires the purchase of supplementary feed, this will occur in the period during which the incidence of income shortage is at its greatest. This may be less of an issue in project area 4 where the incidence of income shortage does not increase substantially until October.

This therefore suggests that most households, especially those who are small and resource-poor, will require credit if they are to undertake an aquaculture initiative. To ascertain the current status of the use of credit by households, whether money or in kind the survey asked respondents what their existing attitude to credit was. To this end Figure 6.29 reflects the proportion of households who are currently using credit. The main sources of this credit were found to be either relatives or neighbours. Some households were using private money lenders, but the interest rates were very high. They ranged between 10 and 20 percent per month. When the households were questioned during the group discussions on farmer willingness to borrow to undertake aquaculture the response was highly favourable, with the condition that the interest rate was acceptable. When 10 percent per annum was suggested all group discussion participants were willing.

6.4.9 Current Fish Consumption Trends

Fish consumption has been said to have declined substantially over the last three decades (see chapter 1). It was therefore considered of value to estimate current fish consumption in the SCALE project areas. It was hoped that this would substantiate further the likely interest of and benefit to farmers from producing their own supply of fish for household consumption.

Obtaining this information also allows appropriate IAQS to be matched to the level of production required. By ascertaining a household's current level of consumption it is possible to calculate whether they are above or below the average intake of fish required to ensure adequate protein in the diet.

Unfortunately however, the survey did not return reliable consumption results. While it was impossible to dedicate the time and resources required to measure current consumption levels accurately it was hoped that by asking each household head to estimate their family's consumption per week that a good estimate could be made. Figures 6.30 to 6.32 show very high levels of consumption in the SCALE project areas. Table 6.11 tabulates the average level of consumption as kilogrammes per person per year. All the averages are substantially higher than the suggested 32 kilogrammes per year average calculated by AIT as being that required by people in Cambodia (Edwards, 1993).³²

It was expected that the SCALE survey would return averages for each project area slightly above the national average (see chapter 1). First, the Kandal province is almost entirely a large flood plain. The Mekong, Tonle Sap and Bassac rivers all flow through the province. While the fish catch has clearly declined, the volume of fish taken from Kandal is greater than

32 The required intake of fish calculated by AIT is based on the following assumptions:

- a) average intake required per day, per person equals 1 gram of total protein/kilogramme of body weight;
- b) 33 percent total protein should be animal protein to meet minimal nutritional requirements;
- c) as Cambodians are largely fish eating, 75 percent of the average person's animal protein intake should come from fish (FAO reports that fish provided 70 percent of animal protein in the 1960s - FAO/OSRO, 1991);
- d) therefore the required intake of fish per year per person should be approximately 32 kilogrammes.

Figure 6.28

Income Insufficiency

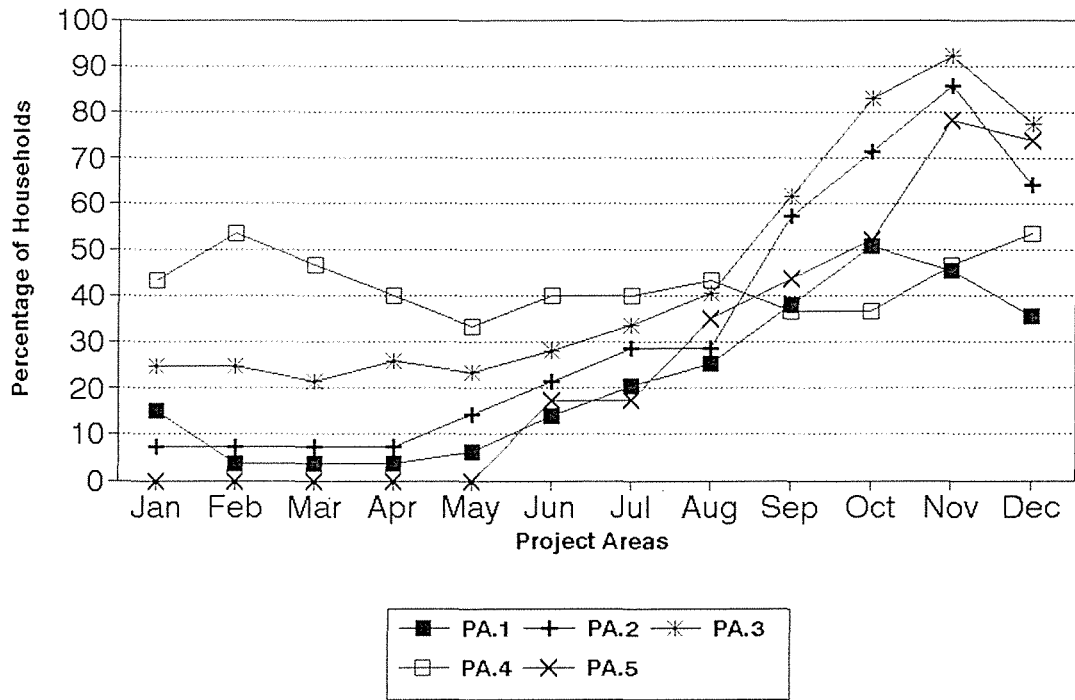
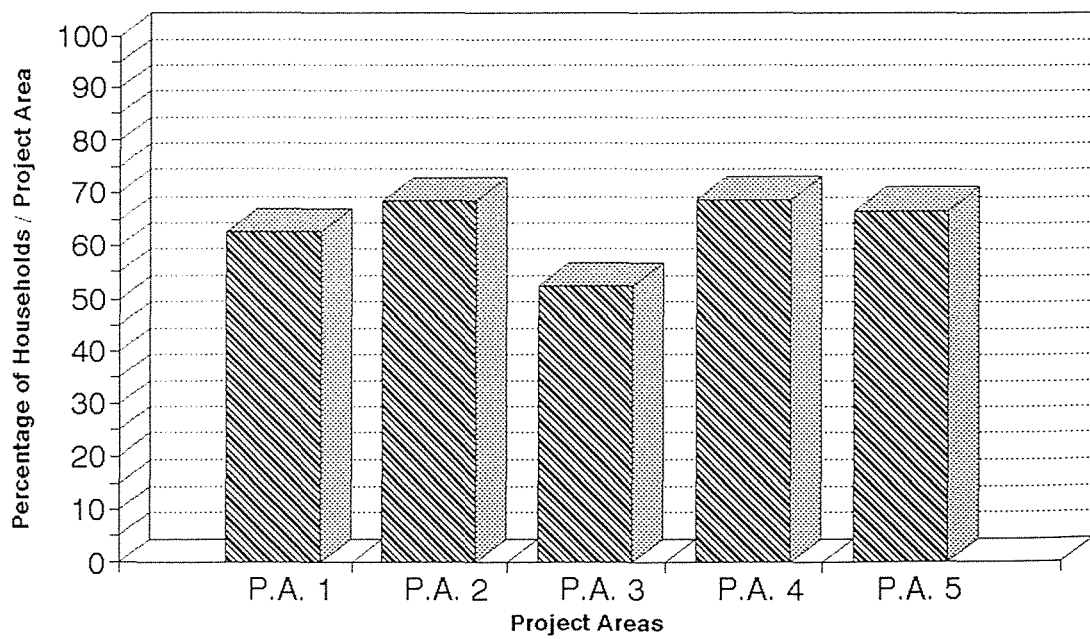


Figure 6.29

Household Willingness to Borrow
(Money or In-Kind)



many other provinces.³³

Second, the survey samples included a higher proportion of households living within a few hundred metres of a permanent water body than those households more distant (see Figures 6.20 to 6.24). As the availability of a

reliable water supply is a major determinant in the socioeconomic status of rural households in Cambodia, those people distant from a permanent water body are less likely to have the capacity to buy fish. Further, catching their own is also less likely due to the high tax which must be paid.³⁴

In project areas 2 and 3 the consumption figures returned were checked a second time during the group discussions. In many cases a sample of one kilogramme of fresh and dried fish was used to assist the participants in making their estimates (kilogrammes are the most common measure used for the purchase of fish). The results were surprising in that every survey respondent participating in the group discussion changed their consumption figures from those given the first time. Further, the field staff noted that if they asked the same question more than once the farmers seldom gave the same reply. However, when the average for the two areas was recalculated, using the group discussion data, the drop from the original calculations was marginal.

The marginal change in the results in project area 2 is particularly inconsistent with what might have been expected. Project area 2 has no permanent water body (see Section 6.4.1) and is shown by Figure 6.2 to have the greatest proportion of households of any of the project areas categorised as poor. The results returned might have been expected to be noticeably lower here than in the other areas. Instead, the average for project area 2 is the highest.

The inconsistency in the farmers returns of their fish consumption estimates is further shown by the results presented in Table 6.12. In nearly every case it is shown that at least half the surveyed households want to increase further the amount of fish they currently consume. The group discussions even suggested that, not half, but nearly all households want to increase their consumption of fish. It might be expected however, that if the high consumption figures were correct the percentage of households wanting to increase the quantity of fish they consume would be much less.

This inconsistency therefore supports the conclusion that the estimates obtained and

Table 6.11 Fish Consumption Averages Per person Per Year (kgs)

Project Area 1	58
Project Area 2	86
Project Area 3	73
Project Area 4	67
Project Area 5	57

³³ Fisheries Department statistics for the freshwater fish catch (pond and cage culture excluded) show that in 1991-1992 Kandal province produced the second highest fish catch of the thirteen provinces with a recognised freshwater fisheries sector (Fisheries Department 1993).

³⁴ All of Kandal's water bodies are divided into fishery lots and tendered out to wealthy entrepreneurs. Anyone wanting to fish in these lots must pay a tax to the lot owner, the size of which depends on the size of the catch. People wanting to fish in the larger rivers (Mekong, Tonle Sap and Bassac rivers) must pay a tax to the provincial fishery office, with the size of this tax depending on the equipment used.

reflected in Figures 6.30 to 6.32 are unreliable and that an accurate measure of household fish consumption is necessary. Accurate measuring techniques will be required, which could possibly involve enumerators directly observing a random selection of households in a representative area as they either purchase or catch their fish over a specified period of time.

Table 6.12 Percentage of Households in Which Preferred is Greater than Actual Fish Consumption

Project Areas	Fresh Fish %	Processed Fish %	Households which buy more than 50% of their current fish consumption
P.A. 1	58	48	83
P.A. 2	58	50	88
P.A. 3	74	52	78
P.A. 4	72	55	58
P.A. 5	78	33	67

Figure 6.30

Household Fish Consumption Distribution
Project Areas 1 and 2

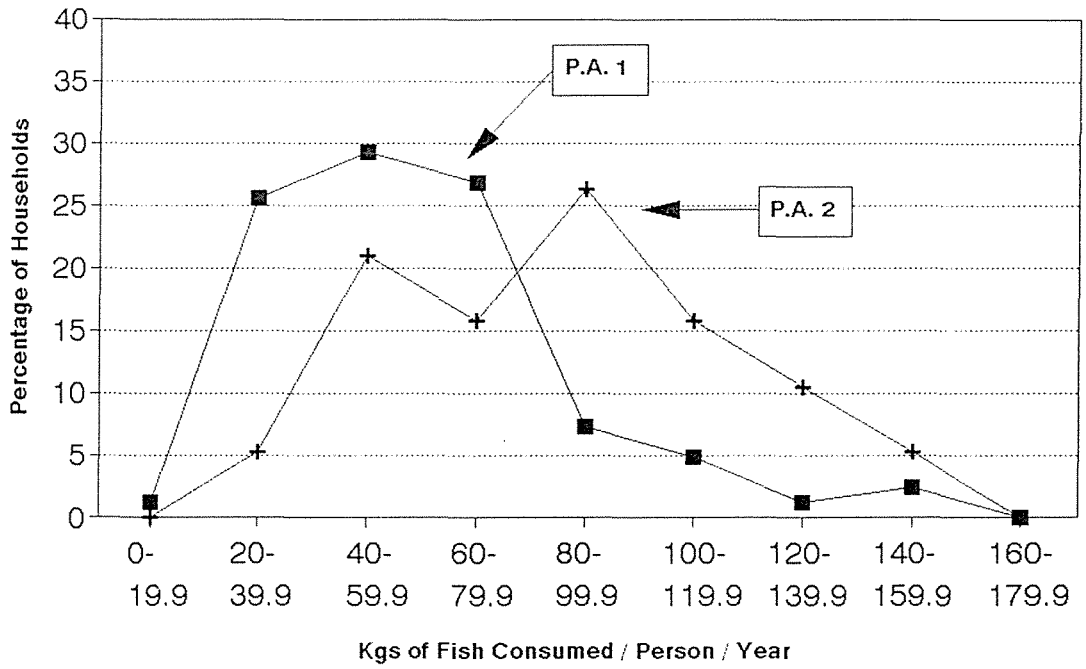


Figure 6.31

Household Fish Consumption Distribution
Project Areas 3 and 4

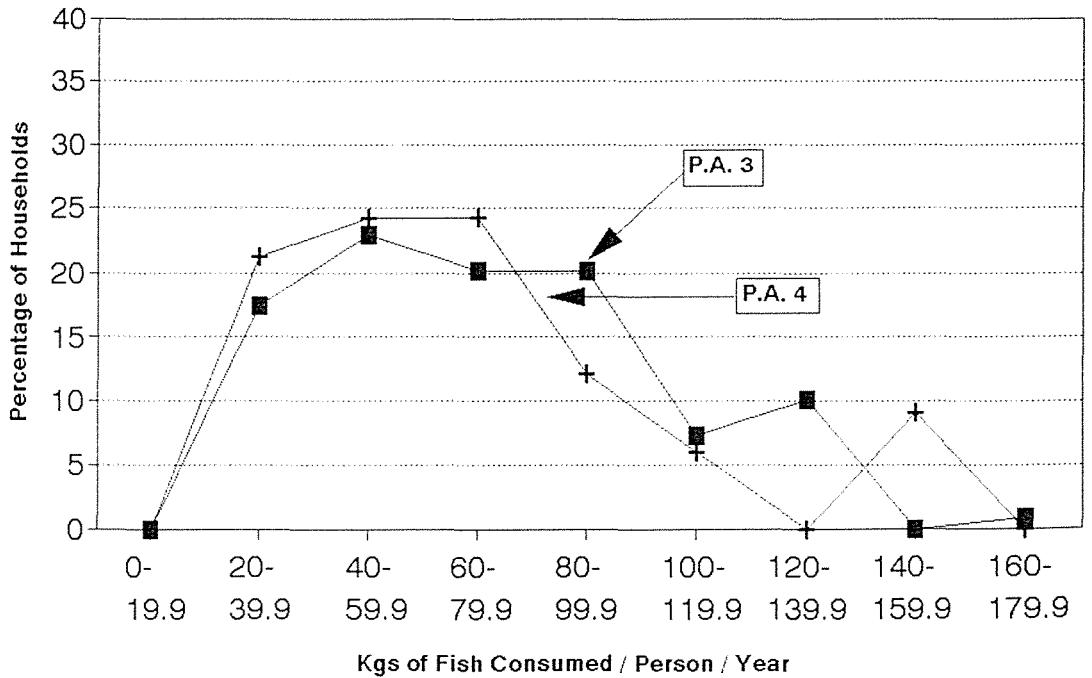
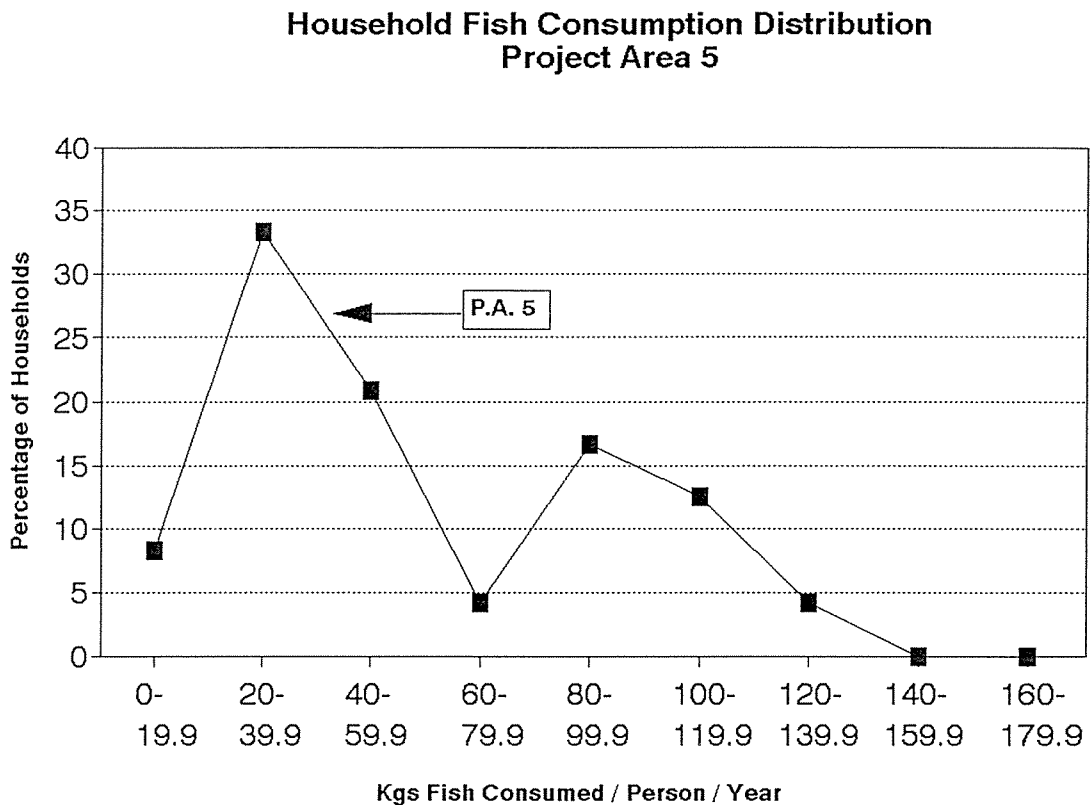


Figure 6.32



6.4.10 Further Results Arising From Group Discussions

While numerous results from the group discussions in project areas 2 and 3 have already been noted there are some further conclusions which can be drawn. Unfortunately at the time of writing, the group discussions had not been completed in the other three project areas. This is due to pressure on time and the requirement to select the FBT farmers in project areas 2 and 3 to ensure they have adequate time to prepare their IAQS sites before the monsoon rains begin. The remaining group discussions are to be held at a later date. Their absence is not expected to adversely affect the conclusions to be made here.

An issue of particular interest arising from the group discussions is the sincere dislike of a substantial majority of the surveyed farmers for the fishery lot system imposed by the Government since 1987 (see also Dennis, 1992). While the degree of dislike varied between some villages, farmers did not hesitate to express their opinions when prompted. They all asserted that previously they could catch fish freely but that with the fishery lot system in place since 1987 their consumption today is less than it was before 1987. The reasons frequently cited for their eating less fish now were:

- a) can no longer fish freely;
- b) cannot afford to pay the required tax to the fishery lot owner;
- c) the fishery lot system has promoted the inflation of the price of fish;
- d) because of the above, farmers have let their fishing equipment fall into disrepair.

It was also acknowledged that the fish stock was generally declining.

Farmers also spoke of the owners of fishery lots often using force in policing peoples' access to them. People were clearly frustrated at having their access to these water bodies restricted and in many cases denied. It was something they spoke of with apprehension and a certain degree of fear.

It can be concluded from the above that the fishery lots are possibly a hidden reason, in addition to those commonly stated (see chapter 1), of the acknowledged decline in fish consumption.

Another point revealed by the group discussions and associated to this problem with the fishery lots is that a high proportion of the fish consumed by people is bought rather than caught. Information provided by the survey suggests the same (see Table 6.12). With the exception of a few fish caught in the rice fields when the monsoon flood peaks and begins to decline, all of the fish consumed by the participants (in both project areas) were bought.

Some explained that this was not only because the fishery lots restricted their access to catching wild fish, but that people did not undertake activities outside of those required by their profession. Farmers kept to farming and fishermen kept to fishing. When asked whether they would market their fish or retain them for subsistence consumption if they were to grow fish themselves, the answer was generally dependent on the socioeconomic status of the person concerned. However, in one village it was asserted that they did not like the taste of pond fish, so they would sell them in order to buy the preferred wild fish species.

Because of the importance of utilising methods of integrated aquaculture appropriate to small scale and resource poor-farmers, household reaction to the use of animal waste as a pond input was sought. The response in project area 2 was strongly in favour. No concern for the consumption of fish from ponds fertilised with animal waste was expressed. While there was some mixed response from the households in project area 3, the concern amounted to little. Only the participants from two villages out of the ten surveyed were against eating fish from manured ponds. Two villages were mixed in their response. Where there was reticence, it was acknowledged that people had no experience of the consumption of fish from manured ponds.

6.5 BACKGROUND INFORMATION

6.5.1 Financial Analyses of Two Potential IAQS

In association with the preparation of an economic analysis on the project, eight financial analyses were done on IQAS with potential for use in the SCALE pilot programme's FBTs. To indicate the financial viability for the integration of aquaculture with small-scale traditional farming systems, the financial analyses of two have been appended as Appendix 6.4. The locations of these IAQS are real and owned by farmers joining the SCALE project's pilot programme. The analyses have been conducted for three years. The first year is based on information provided by the farmers on the enterprise undertaken in 1992. The second year (1993) is the first year with fish and includes all investment costs. The third year (1994) continues with the integration of fish, but shows the likely on-going situation after investment costs have been recovered.

While the financial returns are not high, they reflect a substantial improvement in return on the current farming activity utilised. Further, it should be remembered that the IAQS in question are for subsistence production. Although they are intended to contribute to an improvement in farm production, their primary purpose is to improve the nutritional standards of the farm households diet by increasing their protein intake.

The first analysis conducted on an example of rice/fish culture in a 2000m² rice paddy shows that for an operational cost of 117,861 Riels in the first year (1993), approximately 50kg of tilapia and 52kg of common carp can be produced in a five month culture period.³⁵ If a total of 182kg of rice is collected and the value of both the rice and fish is calculated at the market rate (see Appendix 6.4), this reflects a gross income from the paddy of 444,568 Riels and a net income of 326,706 Riels. When the net income of this rice/fish system is compared to that produced by the paddy in 1992 with rice alone (54,030 Riels) the result is very favourable (net income increases by six times).

To achieve a true reflection of the expected benefits of the rice/fish system however, it is necessary to consider the family labour required. The introduction of this non-cash cost to the analysis has a substantial impact on the results making them more reflective of reality for the farmer. This is predominantly due to the allowance made for the non-cash investment cost incurred through the use of family labour for construction (i.e. digging out the refuge area in the paddy for the fish). The increased net income (per family labour day) in the first year produced by the introduction of fish is reduced to 3.9 times more than with rice alone. In the second year with fish, after the investment cost has been recovered net income per family labour day increases to 4.5 times of that with rice alone.

It should be noted that the achievement of this result is highly dependent on stocking density (which is substantially influenced by the level of organic fertilisation) and the length of the culture period.³⁶ Further, in the area where the SCALE project is developing rice/fish culture the soil has an excellent water retention capacity. This permits a longer culture period and the ability to grow fish out to a larger harvest weight. For further information see the supporting notes and assumptions to the analysis (Appendix 6.4)

The second analysis consists of a vegetable/cattle/fish system using a 171m² pond. Waste vegetables are used as a supplementary feed and the manure from one farm owned breeding cow and purchased off-farm manure is used to fertilise the pond. These two pond inputs allows a three species polyculture to be used which provides an efficient use of the pond environment and maximises fish production.

From this system approximately 42kg of fish is produced over a 120 day culture period. In addition, approximately 2kg of fingerling recruits are produced from the natural reproduction of the tilapia. The collection of these recruits will help prevent the pond from becoming over stocked, thus maximising the daily growth rate of the fish. The potential gross income produced by all three components of the system, the fish, the cow and the vegetables is approximately 438,101 Riels. If only operational expenditure is considered net income with fish is 240,351 Riels (the farmer concerned invested 167,000 Riels in hired labour in the first year with fish to assist with pond preparation, see Appendix 6.4).

When the outcome of this analysis is compared to the situation without fish (1992) the result is an increase in net income of 1.6 times that produced by the vegetables and cow alone. However, when the family labour component is considered as was done in the rice/fish analysis the net income per family labour day is shown to be quite low. The main reason for this is the labour intensiveness of the system's vegetable component (see Appendix 6.4). The multiple increase in net income per family labour day is affected only to a limited extent with the increase in net income still being as high as 1.25 times that without the fish in 1993 and

35 There is no cash capital cost incurred in establishing the rice/fish system as family labour is sufficient for any excavation work required to the paddy. This non-cash cost is included at the end of the analysis where the net income is shown per family labour day invested.

36 A low stocking density has been used in these financial analyses in order to produce maximum harvest weights and to account for the as yet undeveloped management skills of the Cambodian farmer.

1.27 times in 1994.

While there are some constraints to both the above IAQS which became apparent during the group discussions they were selected for the purpose of this analysis as they have potential for integration with the current farming systems of the small-scale farmers in the SCALE project areas. Both analyses are of systems being undertaken by two farm-based trial farmers in the 1993 season. Although there are other IAQS with potential the two provided are adequate to substantiate the financial potential of integrated aquaculture.

With monsoon season rice being the dominant crop in the rainfed lowland environment of Kandal, some form of rice/fish culture may have potential. It requires the use of few resources and is likely to be particularly applicable to those small resource-poor farmers able to undertake little more than an annual crop of rice. However, in areas where the monsoon rice crop is a broadcast or direct seeded crop (see Section 6.4.3), rice/fish culture will not be appropriate as the rice is not contained in dyked paddies capable of holding fish.

The primary concern over rice/fish culture was the unpredictability of the monsoon flood. Farmers asserted that the flood can produce either a lack of water or too much. They were concerned that the flood could potentially top their paddy dykes, erode and breach the dyke wall, introduce predator fish and allow the cultured fish to escape. While the concerns of some were allayed when the idea of raising the height of their paddy dykes was discussed, most remained skeptical.

The security of the fish was another concern for some of the farmers. The ability of farmers to supervise paddies being used for fish culture is limited when their land is fragmented and distant from the house (see Section 6.4.7).

The vegetable/cattle/fish IAQS has been included as it is a simple application of pond culture and uses farm resources which are common in the SCALE project areas. Although the manure from the one cow, if available, is insufficient for the fish and must be supplemented with manure procured off-farm, no new demand is placed on the farmer. The analysis shows that the purchase of off-farm manure to support the vegetable production is a normal practice for the farmer. Further, the survey analysis suggests that the integration of cows with fish is likely to be the most appropriate method of livestock integration. Project areas 2, 3 and 5 show that more than half of the households own cows, of which most own at least two (see Section 6.4.4). Although pigs and poultry have nutrient rich manure (more so than cattle), they are less likely to be appropriate as the proportion of households with either is smaller than cattle and the numbers owned are few. Few of the pig owning households have more than one pig (see Section 6.4.4).

While it is not the case in the above analysis, one constraint to the integration of cattle with fish is the possible competition it poses for the use of the on-farm manure if it is already being used as a crop fertiliser (vegetables and/or rice). While many farmers are currently using their manure (see Section 6.4.4.1), of those survey farmers who participated in the group discussions, some were willing to relocate its use to the fish pond, given that a certain amount of the pond water would be available for irrigating the crops in return.

In the event of one or more cows being purchased specifically to fertilise a fish pond a further constraint is clearly the greater investment cost required. For most of the survey farmers however, this did not feature as a major problem as long as credit was available at a reasonable cost. While some currently utilise credit available from private money lenders all were in agreement that at 10 to 20 percent per month it was very expensive. Accordingly, few borrow from this source. All however, were prepared to borrow if credit was to be available at ten percent per annum. The farmers in one village were all willing to borrow even if the

rate of interest remained as high as five percent per month.³⁷

The third constraint provided by some farmers, as with rice/fish culture, was one of security due to the lack of available land close to their houses (see Section 6.4.7).

6.5.2 Economic Analysis

Although it is accepted that the social benefits of SCALE are of primary importance (contributing to the improvement in the nutrition and health of the rural poor), ascertaining the economic benefit which the project will potentially produce is important also. If it can be shown that the project will produce a positive economic benefit, the likelihood of it contributing to the wider social and economic welfare of the rural community of Kandal in general is greater.

Further, deriving the extent of the economic benefit will aid the justification for the investment required by the project. Moreover, the extensive forecasting of expenditure and income required in the conduct of an economic analysis will ensure that all aspects of the project's implementation and impact are considered.

To calculate the economic desirability of SCALE a comprehensive BCA has been prepared. This is appended as Appendix 6.5. The notes and assumptions associated with it are appended as Appendix 6.6

6.5.2.1 Benefit-Cost Analysis

This analysis covers all components of the project, including the DC fish hatchery and an assumed number of farmer implementations over the BCA period (twenty years). The expenditure and income of the project, relevant to an economic analysis, were extracted from the project budget. The expenditure and income for the FBTs and implementing farmers was estimated according to the hypothetical implementation of nine preliminary IAQS as noted in Appendix 6.6 and the projected schedule of farm implementations as noted in Appendix 6.7.³⁸

In the final analysis of the BCA the Internal Rate of Return ("IRR") was the measure used. Calculating the Net Present Value ("NPV") was considered less appropriate due to the extremely variable current economic situation in Cambodia, the requirement to calculate accurately the cost of capital ("COC") and an appropriate discount rate.³⁹ To accurately show the NPV as being positive or negative is therefore difficult (i.e. the present value of project benefits less project costs). Calculation of the IRR however, does not require knowledge of the COC as it shows the discount rate which will make the NPV equal to zero. Although knowledge of the COC is required to reflect the favourability of the IRR, it is not required for it to be accurately calculated.

37 Given the current trend of rapid inflation and the devaluation of the local currency, five percent per month is not a high rate of interest. A rate less than five percent would make the value of capital impossible to maintain.

38 The characteristics of the IAQS which will be used by SCALE are yet to be finalised. Those used in the BCA are based on information available locally and other examples in Thailand and China. The schedule for their implementation, is based on estimates derived from the information provided by that portion of the SCALE baseline analysis completed at the time of the BCA's compilation. This included all the survey work through to and including the pilot survey of the baseline farmer survey.

39 IRR can be defined by the following:

- a) a discounted measure of project worth;
- b) the discount rate which makes the NPV of the incremental cash flow equal to zero;
- c) the maximum interest the project can pay for the resources used if investment and operating expenses are to be recovered and the Project just break even;

An IRR greater than the COC shows an efficient economic allocation of resources and thus provides adequate economic justification for the investment required. It shows a better allocation of resources with the project than without. A rate of return less than the COC would require establishing whether the social benefit of the project is adequate to compensate.

Because of the difficulty in quantifying secondary and tertiary benefits accruing to the project only immediate benefits (for example, fish and fingerlings produced) were included. They should be noted however, as they will improve the IRR further, which if marginal, is an important consideration. Some of the secondary benefits likely are:

- a) a decrease in medical expenses incurred by the rural family due to improved nutrition and health from the on-farm production of fish;
- b) an increased motivation for development by subsistence farmers resulting from improved nutrition and successful diversification of farm activity;
- c) an improvement in the capacity of subsistence farmers to develop further due to the expansion of the capital assets at their disposal.

Medical expenses have been estimated to account for five to ten percent of the rural households income (Davies, 1993). The potential benefits of reducing this cost by improving the nutrition and health of the rural family are undoubtedly substantial. While gold is the most common commodity used for safeguarding capital, the subsistence household has little or none. In its absence, rice (when stored appropriately) and preserved fish (dried, paste, pickled, smoked, sauce) become important capital assets. Accordingly, the subsistence production of fish will contribute substantially to increasing the disposable capital of the subsistence household.

Tertiary benefits will increase as transport and communications improve. Currently, secondary and tertiary roads are either in poor repair or non-existent. This severely restricts access to the district market for most subsistence farmers, making the transportation of produce to the market a time consuming operation. As these roads are improved however, the marketing of excess fish production and farm produce in general will be simpler and less costly.

The income distributional effect of an IRR greater than the COC is impossible to estimate without conducting an impact analysis. However, this is not likely to be of major importance as the targeted beneficiaries of SCALE are subsistence farmers, whose production is predominantly for on-farm consumption, not the creation of income.

The above therefore suggests that the IRR of 3.44 percent produced by the BCA requires the COC to be less than 3.4 percent if SCALE's investment is to reflect an efficient allocation of resources (see Appendix 6.5).⁴⁰ As outlined in the table below, this IRR improves further under some of the sensitivity analyses conducted. In each sensitivity analysis, only the variables noted are changed from those used to derive the above IRR.⁴¹ They are summarised in Table 6.13.

Considering the uncertainty of some of the data and the assumptions which had to be used in the BCA, the five sensitivity analyses cited below offer further economic endorsement for the project. In addition to the design of the IAQS used, one of the largest variables in the

40 This IRR was produced using the farmer implementation schedule as noted in Appendix 6.7.

41 Exchange rate = 2000 Riel/1 USD; 55 new farms implemented in each of the first two wider implementation years (1995 and 1996) and 30 in each year thereafter; the current market price of fish as noted in Appendix 6.4.

Table 6.13 BCA Sensitivity Analysis

Current IRR (percent)		3.44
Alternative Scenario		New IRR
1)	Decrease in the number of farmer implementations in the first 2 years of the wider implementation from 55 each year to 30.	1.8
2)	As for (1) above and thereafter a decrease of 5 new farms implementing per annum (i.e. from 30 to 25).	-0.19
3)	Increase of 8 new farms implementing in the years 1999 to 2010 (i.e. from 30 to 38).	5.15
4)	A increase in the real price of harvested fish by 25 percent.	6.74
5)	A 25 percent change in the exchange rate (i.e. from 2000 riel per 1 USD to 2500 riel) over and above that resulting from inflation .	0.22

analysis is the projected farmer implementation schedule. While the schedule provided in Appendix 6.7 has been calculated as much as possible on realistic expectations, the margin for error is still likely to be sizeable.

Scenario (1) of the sensitivity analysis shows that a significant drop in the number of farms joining SCALE in the first two years of the wider implementation (1995 and 1996) has some effect on the IRR achieved. It remains positive however, at 1.8 percent. The impact of reducing the number of farms over the entire twenty year period, as in scenario (2), is greater. This reduces the IRR to -0.19 percent (3.63 percent less). However, while the IRR becomes slightly negative it's overall movement, compared to the large drop in the number of farmer implementations over the twenty year period, is not great. This therefore indicates that substantial changes are required in the farmer implementation schedule before the corresponding detrimental impact on the outcome of the economic analysis becomes sizeable.

Scenario (3) shows the extent by which the IRR can be increased if the number of farms joining SCALE later in the analysis period is increased.

Scenario (5) indicates that the effect of a devaluation in the Riel is sizable. However, this change (as for the price of fish) is *real* and is in addition to that attributable to inflation. Riel/US dollar exchange rate fluctuations are included in local surveys of commodity prices.

Of the five scenario's shown however, of most interest is number (4). Here, the influence of the *real* price of fish on the IRR is shown. A 25 percent increase registers a 3.3 percent increase in the result to 6.74 percent.

The current fisheries and demographic situation in Cambodia justifies the inclusion in the analysis of an increase in the real price of harvested fish (i.e. an increase over and above inflation). The following reasons can be cited:

- a) the demand for fish exceeds supply and is likely to remain so in the medium term;
- b) the annual increase in the fisheries catch is minimal (see Table 1.2);
- c) population growth is high (at least 2.8 percent per annum (World Bank, 1992));
- d) with the exception of rice, fish remains the most important component of the Cambodian diet.

While the magnitude of the increase can only be estimated, a 25 percent increase in the real price of fish over the analysis period of the BCA is not unrealistic. In fact, it could be much higher if recent statistics continue to prevail. The price of fish rose at a rate of 547 percent over the first ten months of 1992, while the average increase in commodity prices was 300 percent (CDRI, Oct 1992).

The IRR shown in scenario (4) therefore, is likely to be realistic and if accepted as that most accurate, the results for each of the other scenario's are improved substantially. If scenario (2) was to eventuate, it's IRR would become strongly positive.

Recommended IRR for SCALE	6.74 Percent
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Now, having calculated the IRR, the economic favourability of the project can be assessed by estimating the COC. The simplest procedure for making such an estimate is to consider what the opportunity cost of the capital invested is (what else the invested funds could have been used for). In other words, assuming that the money invested in the project is labled for Cambodia, what could it return if placed in an interest earning bank deposit in Phnom Penh. Currently the rate earned (by US dollars) for the investment of capital with the newly re-established Thai lending institutions is 3.5 percent per annum. Another method of calculating the opportunity cost of the capital is to analyse alternative project uses. Assuming that the funds have been committed for the purpose of rural development then the following questions provide examples of alternatives which might be considered:

- a) could the invested funds have been more efficiently used within the design of the current project to produce the same level of development activity and farm production improvement?;
- b) could the invested funds have had a greater impact on fisheries production and therefore the availability of fish generally, had they been committed to improving the fish stock of capture fisheries?;
- c) would fisheries production be more efficiently improved with a larger scale and more intensive application of aquaculture?;
- d) could the long term improvement of rural nutrition and health have been more efficiently attained by:
 - i) the improvement or development of a different component (other than aquaculture) in the farming system (for example, potable water supply, animal and/or rice production);
 - ii) the development of the total farming system (including aquaculture if appropriate);
 - iii) a more general community development approach;

Undertaking an analysis of the potential impact of (and level of investment required by) these

alternative examples is beyond the scope of this analysis.⁴² They are noted here however, as an indication of what an investigation into the opportunity cost of SCALE's capital might involve.

If the 3.5 percent deposit rate is used as the opportunity cost of capital then an IRR of 6.74 percent is a positive outcome and shows a very favourable economic allocation of resources for a project of this nature, especially given that social objectives are prioritised. The result is further endorsed in the financial analyses provided in Section 6.5.1 above. The return to the farmer is comparatively higher.

42 The SCALE project was formulated accepting that the previous studies of FAO and the Cambodian Fisheries Department (see Chapter 1) show the development of aquaculture to be important if fisheries production and rural fish consumption is to be improved. As opposed to comparing the economic efficiency of aquaculture development with other methods of rural development, this analysis endeavours to substantiate that integrated aquaculture can be sustainably used as a socioeconomically appropriate and financially feasible means to rural development by small scale farmers.

CHAPTER SEVEN

CONCLUSION

7.1 A SUMMARY AND CONCLUSION OF THE RESEARCH

The research in this study is to show that integrated aquaculture is a viable means to sustainable rural development in Cambodia. The research was undertaken over a period of one and a half years and involved an extensive literature review and three surveys. The research began with the design of the SCALE project. Almost simultaneously with the beginning of the project's implementation in November 1991, the development of the surveys started. They were implemented over the next year and became known as the baseline analysis programme. This programme provided the essential information needed to establish the potential for integrated aquaculture in Cambodia and was completed in February 1993.

The following objectives were the focus of the study:

- a) to establish whether integrated aquaculture can contribute to facilitating sustainable rural development in Cambodia;
- b) substantiate the rationale for integrating aquaculture with traditional agricultural farming systems in Cambodia;
- c) to ascertain important considerations affecting the potential for aquaculture development;
- d) to decide whether the methods and practices of integrated aquaculture developed in other countries of Southeast Asia can potentially contribute to Cambodia's requirement to arrest the decline of its fisheries catch and consequent deterioration in rural nutrition;
- e) to establish the potential for the use of low input integrated pond systems by small-scale subsistence farmers;
- f) to conduct a case study of the Southeast Asian Outreach SCALE project, utilising its baseline analysis programme as a means of providing definitive conclusions on the above objectives.

7.1.1 Literature Research

The review of literature (since 1960) has provided an understanding of how integrated aquaculture has developed in other countries in the region, why its development has become an integral part of agricultural (rural) development, and how it might be appropriately applied to Cambodia and the requirements of the small-scale farmer.

While introducing aquaculture and the concept of sustainability, Chapter one substantiated the rationale for integrating aquaculture with agricultural systems (objective, b) by making four basic conclusions.

First, aquaculture applications can easily utilise on-farm resources, and thus remain low cost. Secondly, aquaculture provides benefits which accrue to other farm activities (for example, fertiliser for garden and field crops). Thirdly, the simple methods of integration available, facilitate ease of adoption by small-scale farmers who may or may not be educated or familiar with farming systems other than those traditional to them. Finally, the key to successful integration lies in the methods used being tailored to the local social and physical environment.

Chapter two considered the concept and history of aquaculture and its integration. This provided the background from which the potential for aquaculture (objective, c) could be

considered. The following conclusions were made with regard to aquaculture potential:

- a) its potential is linked to the use of small homestead ponds or rice paddies requiring minimal input and simple methods of integration;
- b) its simplicity of integration and the degree to which it complements existing farming practices aids its acceptability to rural communities;
- c) its ability to increase farm and fisheries production can greatly contribute to the overall development of the rural sector and in particular to combating the problem of poor rural nutrition (protein deficiency and thus, general health);

There are some further considerations in realising aquaculture's potential. The development of aquaculture should focus on increasing the total production and productivity of farmer activity and not purely the aquaculture application itself. This requires the development initiative to be based on the social, economic and behavioral patterns predominant in the local community and on local participation in planning, design, research and extension. The likely constraints should be identified and assessed as to the potential impact they may have on the aquaculture development's implementation. Once quantified, a procedure can be designed to ensure their impact is minimised. Those relevant to the small-scale farmer will generally relate to the prevailing socioeconomic conditions and physical environment.

While the required conditions for the implementation of small-scale aquaculture are shown to be significant, of primary importance is people's willingness to amend their current farming practices. The farmers concerned must see the potential benefit of diversifying. This requires that aquaculture development is seen to complement traditional farming practices in a way which is sensitive to, and respectful for, farmer knowledge of traditional farming systems.

The methods and practices of integrated aquaculture which are likely to be appropriate to the Cambodian social and physical environment were considered in Chapter three. The experience of other countries in the region was reviewed and showed that small integrated systems are technically simple, relatively high yielding, and low cost. Although they may not produce the high yields of larger, more intensive aquaculture systems, they can contribute substantially to the overall production of a farming system. This fits well with the hypothesis that small-scale aquaculture should be designed to enhance farm productivity generally as opposed to seeking maximum yield in itself.

7.1.2 The Surveys

While the SCALE project provided a case study (see Chapter four) of how integrated aquaculture can be utilised in rural development, its baseline programme (see Chapter five and six) and the research it involved verified its potential.

The results suggest that three main methods of integration are likely to be feasible.

- a) Ponds integrated with cattle. The prevalence of households owning one cow or more was found to be high and greater than in the case of other animals. Further, where cows are not owned the practice of procuring off-farm manure for fertiliser is common and inexpensive;
- b) Ponds integrated with vegetable crops (and/or livestock). In some parts of the research area vegetables are an important secondary crop and are able to provide the required waste for the growth of herbivorous fish;
- c) Integration with (transplanted early) monsoon season rice for a concurrent rice/fish crop. This method of integration poses no competition for the use of on-farm resources in that the water required by the rice is simultaneously used by the fish, the paddy provides the necessary fish food, and the fish

fertilise the rice.

As suggested by the literature these systems are most appropriate if small-scale, low cost and complementary to existing farm activity. This is verified by the results on the grounds that:

- a) most households have few occupants with an education sufficient to read and write competently, which may accordingly restrict their capacity to relate to new concepts and farming techniques;
- b) most small-scale farmers have fragmented and scattered land holdings, thus restricting the time and management that they can devote to any one piece of land;
- c) the average household's landholding is small, making the inclusion of small-scale aquaculture in the farming system feasible only if it is easily integrated with the other traditional farming activities currently in use;
- d) water is generally a restricted resource which for many households is some distance from the house, thus requiring much time to be given to its collection. Small rainfed aquaculture applications will incur the least demand on household and farm water requirements;
- e) while most families have some animals, they are few in number and likely to be suitable only to small, simple integration methods;
- f) the financial resources of the average farmer (and especially the poor farmer) are already restricted. At certain times of the year there is an income deficiency, thus restricting the household's capacity to undertake a new development and the extra risk it involves.

The survey analysis of the SCALE baseline programme suggests that socioeconomic factors are likely to have an important influence on the establishment of aquaculture and its integration within the prevailing traditional farming systems.

First, the literature's assertion (see Chapter 1) that fish is of major importance to the Cambodian diet was verified. A very high percentage of the survey population in the group discussions were found to prefer fish as their primary source of animal protein, with most of the fish consumed having to be bought. The rapid inflation in the price of fish (at a rate faster than any other food item) therefore suggests that it will become increasingly unavailable to the small and poor farm household. Accordingly, facilitating its subsistence production will combat this trend and promote self-reliance at the same time.

Secondly however, if aquaculture is successfully to contribute to subsistence production and sustainable farming system development generally, the needs and desires of the farmers should be met and the applications used must match the capacity of farmers to comprehend new concepts and ideas. The SCALE survey suggests that in some areas successful farmer uptake will only be possible with the use of carefully designed extension methods based on seeing and doing (graphic and practical presentations) (see Chapter six, Section 6.4.2). Only in this way will the managerial capacity of the poorer, uneducated farmers be extended adequately to include a new, although complementary, farm activity.

Thirdly, the extent to which farmers agree that integrated aquaculture is viable and are willing to accommodate it within their existing farming system is important. Although the group discussions of the SCALE survey highlighted numerous constraints, a large number of farmers remained interested and were willing to try the scheme. This interest endorses the potential for aquaculture in the survey area. An effort should be made, however, to ascertain to what extent these farmers are willing because they genuinely appreciate its potential, or because they perceive special benefits from working with an NGO. It is acknowledged that some of the willing farmers were reserved and cited numerous constraints until they became

confident that the SCALE Management were committed to them. Confidence quickly grew as the number of visits increased. Possibly the importance of the constraints diminished as the candidates increasingly believed that the SCALE Management would assist therewith.

In addition to the above socioeconomic considerations, the outcome of the financial analyses is helpful in substantiating the potential of integrated aquaculture. Although in some cases the profits in the first year are not high due to the effect of the investment cost, the relatively low investment and operational costs allow the profit to improve significantly in the second year. Of most importance, is that the systems considered are able to yield a harvest of fish which will contribute to the rural household's subsistence requirements (nutrition) while the investment cost remains within their reach. Accordingly, these low cost systems keep the risk which the farmer is required to carry low. In the event of a poor, or failed, yield of fish therefore, other farm activities and production are unlikely to be affected.

At the project level economic desirability is endorsed beyond the outcome of the economic analysis if the effect of the project's emphasis on socioeconomic objectives is considered. The economic analysis showed that such an emphasis was not at the expense of achieving a positive economic outcome. This is substantiated by two findings:

- a) the SCALE survey work endorsed that socioeconomic factors have a major influence in determining the rate of farmer uptake and that an emphasis on them in the development of appropriate IAQS can improve the rate of farmer uptake;
- b) the economic analysis confirmed that an increase in the rate of farmer uptake improved the economic outcome of the project.

This compatibility of social and economic objectives further verifies the potential of the farmer implementations.

The SCALE survey results suggest that the impacts of integrated aquaculture development are potentially numerous. The following (points) are some conclusions which can be made concerning the nature of these impacts.

- a) Most of the fish produced by the rural household are likely to be used for subsistence consumption (either fresh or preserved), with the surplus generally being sold. Only in some cases will most of the fish be sold. Where this is so, possible reasons may be:
 - i) to use the proceeds to purchase a preferred species of fish;
 - ii) the household concerned is more financially secure and so has a greater interest in the pursuit of income than food.
- b) The aggregate impact over time on the availability of low cost fish by households undertaking integrated aquaculture will increase. If the aggregate increase in fisheries production is faster than that of population growth, the following benefits will result:
 - i) a gradual increase in the consumption of fish;
 - ii) an improvement in the nutrition and well-being of the rural population (i.e. increased protein intake);
 - iii) increased consistency in consumption trends as the ability of households to preserve their own fish increases;
- c) a valuable contribution will be made to arresting the decline in the productive capacity of the inland fisheries sector;

- d) disposable income of the implementing households will increase as the requirement to buy fish is eliminated or at least reduced;
- e) self-reliance will become more attainable and the requirement to pursue off-farm business or labour decrease.
- f) Where ponds are used the availability of water for irrigation will improve.
- g) As the number of households undertaking integrated aquaculture increases, so will the aggregate impact on the local fish market (even if the portion of production which is marketed per farmer remains small). This could potentially stress existing market facilities. A further study of local marketing arrangements and facilities may be necessary.

The potential impact on the status of employment was discussed in Chapter one. The SCALE surveys suggest however, that the impact will be minimal. Firstly, at the time the SCALE baseline analysis was conducted the indication was that rural unemployment in the project area (Kandal province) was not widespread due to all household respondents having land.⁴³ Secondly, the contribution to the alleviation of rural under-employment will not be significant. Two reasons are apparent:

- a) With the exception of pond or paddy preparation, which can happen at any time in the dry season when farm activity is low, rainfed aquaculture production begins with the arrival of the rains. Where monsoon season rice (particularly early rice) and or vegetables feature, household labour resources are likely to be already in demand at this time. For SCALE this has implications for a large proportion of rural households in at least three of its project areas.
- b) contrary to that asserted in Chapter three (Section 3.1) aquaculture activity may often be required to be located some distance from the house. This may cause an extra demand on labour. Someone may be required to supervise the fish to ensure none are lost through theft.

There are some negative impacts which may also occur. The careful planning of ways and means to minimise these impacts will be required. Two of these negative impacts, as highlighted by the SCALE baseline analysis, are listed below:

- a) There is potential for competition for water (highlighted by small-scale aquaculture being restricted to rainfed systems) between aquaculture and irrigation requirements. This may be partially alleviated by pond water being available for irrigation requirements also. Where the water retention capacity of the soil is poor, this may require the fish grow-out period to be compromised to ensure the availability of some water for irrigation. It may be assumed that with decreasing soil water retention capacity the competition for water with other farming activities will increase.
- b) Observation of the ponds already in use in the SCALE project areas suggest that a problem with over fertility may arise. As a technical problem this will

43 Two variables could cause the employment situation to deteriorate.

- a) large numbers of returning refugees from Thailand (parts of Kandal province are receiving areas);
- b) as the children of the post 1979 baby boom reach maturity and increase the demand for land and employment.

require consistent extension advice and trial and error on the part of the farmer to rectify.

7.2 REPLICATION OF THE SCALE EXPERIENCE - SOME RECOMMENDATIONS

The conclusions hitherto presented have been based on the SCALE baseline analysis in Cambodia's Kandal province. It can be asked however, to what extent are they applicable to other parts of Cambodia. Can integrated aquaculture be used in the development of the rural sector in other provinces? Further, what are the likely preconditions for success if a project similar to SCALE were to be implemented elsewhere?

7.2.1 The Socioeconomic Environment

In attempting to answer these questions, care must be taken not to make hasty assumptions on the characteristics of the socioeconomic environment in other parts of the country.

As indicated in Chapter one it is necessary to acknowledge that farmer requirements for undertaking integrated aquaculture are likely to vary. The objectives, strategies and techniques used are therefore required to be flexible if farmers are to participate in and make successful investments in the development process.

Further, some of the general preconditions for small-scale aquaculture development formulated by Ben-Yami (1986) and cited in Chapter two, are of particular relevance. These are:

- a) that people's needs and attitudes in the impact area favour change and are amenable to trying something new;
- b) that adequate resources, in particular water and land, are available;
- c) that credit facilities with terms favourable to the small-scale farmer (who is unable to offer security) are available;
- d) that the farmers in the impact area can be convinced of the personal, financial and social benefits of integrated aquaculture;
- e) that financial viability is clearly apparent.

7.2.2 Water Availability

Water availability, is of major importance and will require careful consideration in the assessment of integrated aquaculture's feasibility elsewhere. Although small-scale aquaculture relies on rain-fed systems, if farmers do not have enough to fulfill their domestic requirements, the use of water for fish will be of low priority. Further, rain-fed aquaculture is heavily reliant on the water retention capacity of the local soil type. Therefore, as water retention capacity decreases so do the options for small-scale, rain-fed aquaculture. The importance of water availability is also endorsed by the SCALE analysis which found that it (distance to and reliability of a permanent water body) is related to socioeconomic status. This promotes the conclusion that if an aquaculture development is to be focused on the poorest segments of a rural community, it is likely that their problems with water availability will be greater. This conclusion is likely to be applicable to most parts of Cambodia as those areas with poor access to a permanent water source tend to be traditionally impoverished. Where this is the case, particular care will be required to ensure the farming systems designed are feasible in low rainfall years. If not, sustainability will be jeopardised.

7.2.3 The Demand For Fish

Demand is also an important factor and should be quantified if an aquaculture application is

to be tailored to household requirements. If the optimal level of household fish consumption is known then measuring current household consumption will establish the consumption deficit. Knowledge of this deficit quantifies the requirement for undertaking an aquaculture application and facilitates the design of an application appropriate to consumption requirements. This further helps to substantiate the potential for improving household nutrition and well-being.

7.2.4 Farmer Participation

The importance of farmer participation in the design of the integrated aquaculture systems to be used cannot be underestimated. In the SCALE analysis farmers were found to have an excellent knowledge of their farming systems and intimately knew the constraints of their environment. This invaluable knowledge will be integral to shaping the design of aquaculture applications, whatever the location. On a project level, this local participation is also important. Design will not only benefit from local knowledge of the physical and social environment, but an essential process of dialogue, training and building of local managerial capacity, will contribute to the development process becoming locally controlled and sustainable.

Chapter two, again in citing Ben-Yami (1986), and further, Pillay (1990), endorsed this view by concluding that without respect for the prevailing traditional systems and views of the local people and the contributions which they can make, success in introducing a new concept to their farming systems will be jeopardised.

A possible example of how farmer participation might be extended is in the role farmers can, or should, play in the rearing of fingerlings. While SCALE has established a fish hatchery designed to rear fingerlings, the potential for the farmer rearing of fry warrants examination. Simple methods using hapa nets are available which allow farmers on receiving fry to grow them out in the protected environment of the hapa. While a higher degree of knowledge is required to grow out larger fingerlings (for example, to monitor feeding and maximise survival), the methods used remain simple and are likely to become within the reach of the small-scale farmer in Cambodia as the concept of aquaculture becomes increasingly established. In the meantime however, the hatchery will be strategic in ensuring fry are reared which are able to survive the rigours of the environment and farmers unfamiliar with rearing fish.

7.2.5 Education and Training

The education and training of local project staff will also be integral to replication. An important component of achieving the sustainability of an integrated aquaculture development process is for local project staff to be well trained, to become committed to their role in the development and eventually to attain the required skills and capacity not only to manage, but also assume total control for the ongoing evolution of the development process.

7.2.6 Extension

Concerning the farmer, extension methodology will be important to the development and dissemination of appropriate integrated aquaculture systems. The extension process is then more likely to become indigenised, self-perpetuating and sustainable, if farmer-based (where the farmers are actively involved in extending the new concepts themselves). The willing and active participation of most farmers in the SCALE group discussions suggests that they can be encouraged to communicate well together. They know best their requirements and socioeconomic constraints and have a well-developed understanding of the socio-cultural peculiarities and physical constraints of their environment. Further, the likely enthusiasm of farmers who have discovered the benefits of aquaculture will be a very

effective means of testifying to others the potential of integrated aquaculture.⁴⁴

This farmer-based approach however, does not discount the necessity for traditional extension workers for they will be required to facilitate and support the evolution of the farmer-based extension process. It will, however, keep their number to a minimum.

In theory, the farmer clubs being considered by SCALE are an important aspect of the farmer-based extension methodology. Their applicability in other areas however, would require research. As their effectiveness is dependent on farmers' willingness to discuss and have confidence in each other, the poorer security status in some parts of Cambodia compared to the SCALE project area (Kandal) may influence their willingness to cooperate together.

In implementing this farmer-based extension process there may have been value in the SCALE project areas being smaller than those defined by the landuse appraisal. Although the surveys were largely responsible for determining their size, the implication now is that the development process (the SCALE pilot programme) will be initiated in numerous villages across each project area. If the establishment of the development process in the pilot programme is to be focused on IAQS refinement and not farmer implementation, then it should be contained to project areas small enough to facilitate simple management and an appropriate application of resources, yet large enough to ensure they remain representative. The concentration of FBTs in a small number of villages (three per village is optimal) would possibly allow the impact in their immediate surroundings to be greater.

Although the temptation to reach a large number of villages is attractive, it will require the FBTs to be spread thinly. This may eventually facilitate a wide network of farmers who have implemented IAQS, but the spread of farmer implementations will tend to remain thin and less manageable for a prolonged period. Concentrating the FBTs in a maximum of two villages per project area (which are considered the most representative of the area's farming systems and socioeconomic situation), would have the effect of keeping the immediate impact area smaller. The farmers participating in the early stages of the development process would be in closer proximity of each other, better able to participate in farmer clubs and therefore more effective in extending their successes to others. The management of the development process in its infancy will be less demanding and in the long term possibly facilitate a more rapid process of development throughout a wider area as the number of farmers becoming involved escalates.

7.2.7 The Scope For Multi-faceted Development

Finally, in the name of maximising farmer productivity and the potential for sustainability there is one further consideration. While it has been shown that the SCALE development strategy seeks to develop integrated aquaculture as a subsystem of current farming systems to facilitate the enhancement of productivity and sustainability, still greater potential exists if all components of the farming system are developed. The active development of other components in the farming system in the light of aquaculture's integration with them, has the potential, at low cost, to effect an even higher degree of integration, productivity and sustainability.

The drawback with this strategy however, is its complexity. Its multi-faceted approach requires considerable aptitude, willingness and understanding on the part of the farmer. In the early stages of rural development such an approach will be beyond the affordability and capacity of small-scale and poor rural farmers to implement.

⁴⁴ The pilot programme of the SCALE project is an example of how a farmer-based extension methodology can be established.

The current development strategy utilised by SCALE is therefore more appropriate in the initial stages of development (as is found in Cambodia). The total farming system is carefully studied to ensure all aspects of the farming system environment (physical and socioeconomic) are accounted for, the potential for integration is maximised, the accrued benefits positively impact all aspects of farm activity, and finally, that farm productivity is improved with a minimum of cost. Further, traditional farming practices are utilised and complemented by the development activity in as far as they participate in and benefit from their integration with aquaculture. Simplicity is maintained by restricting the development activity to one subsystem, aquaculture, and those with which it is directly integrated.

Only as the managerial and economic capacity of farmers improve will the multi-faceted approach become increasingly feasible and therefore attainable and sustainable for small-scale farmers.

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APPENDIX 4.1**THE SCALE TRAINING PROGRAMME****1) Intensive Annual courses**

1992: Socioeconomic Analysis

- a) Introduction:
 - i) An introduction to SCALE;
 - ii) Commitment and team work;
 - iii) Communication skills;

- b) Socioeconomic analysis:
 - i) Introduction to development theory;
 - ii) Communicating with farmers;
 - iii) Methods of socioeconomic analysis;
 - iv) Survey preparation;
 - v) Respondent selection;
 - vi) Interview techniques;
 - vii) Hard and soft data analysis;

- c) Introduction to Integrated Aquaculture:
 - i) The concept of integrated farming;
 - ii) Principles of integrated aquaculture;
 - iii) Simple methods of integrated aquaculture;

1993: Integrated Aquaculture and Farm-Based Trial Methodology

- a) Principles and practice of farming systems analysis;
- b) Theory of farm-based experimentation;
- c) Integrated aquaculture methodologies;
- d) Farm-based trial methodology;
- e) Farmer selection;
- f) Facilitating and supporting FBTs;
- g) Monitoring and evaluation;

1994: Extension Training

- a) Programme to be set.

1994: Extension Refresher Training

- a) Programme to be set according to extension programme progress.

2) Ongoing Training

Weekly training days are held (beginning from the inception of the pilot programme). These training days provide the field staff with the opportunity to review their week's work on the FBTs and to benefit from each other's experiences. There are three main objectives to each

training session. They are as follows:

- a) each person gives a report of their FBT to the group and any difficulties or decisions to be made are discussed;
- b) discussion on the progress being made in the active participation of the FBT farmers in planning and decision making;
- c) each session has a theme for discussion to prompt the field staff to consider a particular aspect of their work. Alternatively it is used by the trainers as an opportunity to introduce the field staff to new ideas, concepts, or techniques in their work. An example is the reinforcement of the field staff understanding of the procedure/strategy used for FBT implementation.

APPENDIX 4.2

STAFFING REQUIREMENTS FOR THE FBTs AND THREE YEARS OF THE EXTENSION PROGRAMME

Year	Farm-Based Trials		Wider Farmer Implementation		
	1993	1994	1995	1996	1997
Total No. of farmers involved	14	11 (1yr) 18 (new)	11 (2yrs) 14 (1yr) 55 (new)	----- 14 (2yrs) 44 (1yr) 55 (new)	----- ----- 44 (2yr) 44 (1yr) 30 (new)
Visits per week	28	47	120	136	93
Extension worker teams required	3	4	10	12	11
Weekly visits per extension team	9.33	11.75	12	11.33	8.5

*Note:*1) **Anticipated Visit Requirements of Farmers:**

- a) Year 1 2 visits per week.
- b) Year 2 1 visit per 2 weeks (1 visit per week for FBTs).
- c) Year 3 1 visit per 4 weeks.
- d) It is assumed that the first two years of the wider farmer implementation phase (1995-96 and 1996-97) allows for 55 new farmers joining SCALE annually. In subsequent years 30 new farmers join annually (see Appendix 6.7).

2) **Extension Team Case Load**

- a) Minimum of two extension workers per team.
- b) A maximum of 3 farm visits per day.
- c) A maximum of 4 days field work per week.

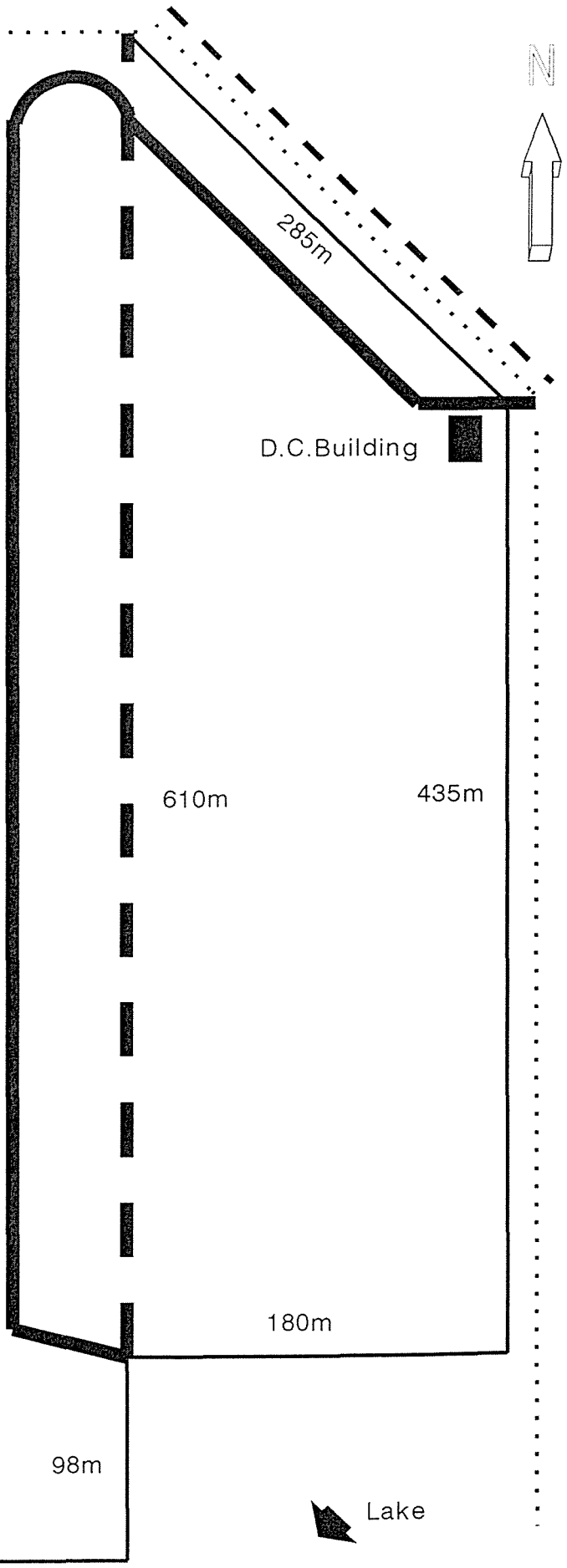
3) These figures are purely estimates, likely to change as the extension programme is implemented. They are, however, adequate for forward planning.

**SCALE Development
Centre**

**Original and Actual
Dyke Placement**

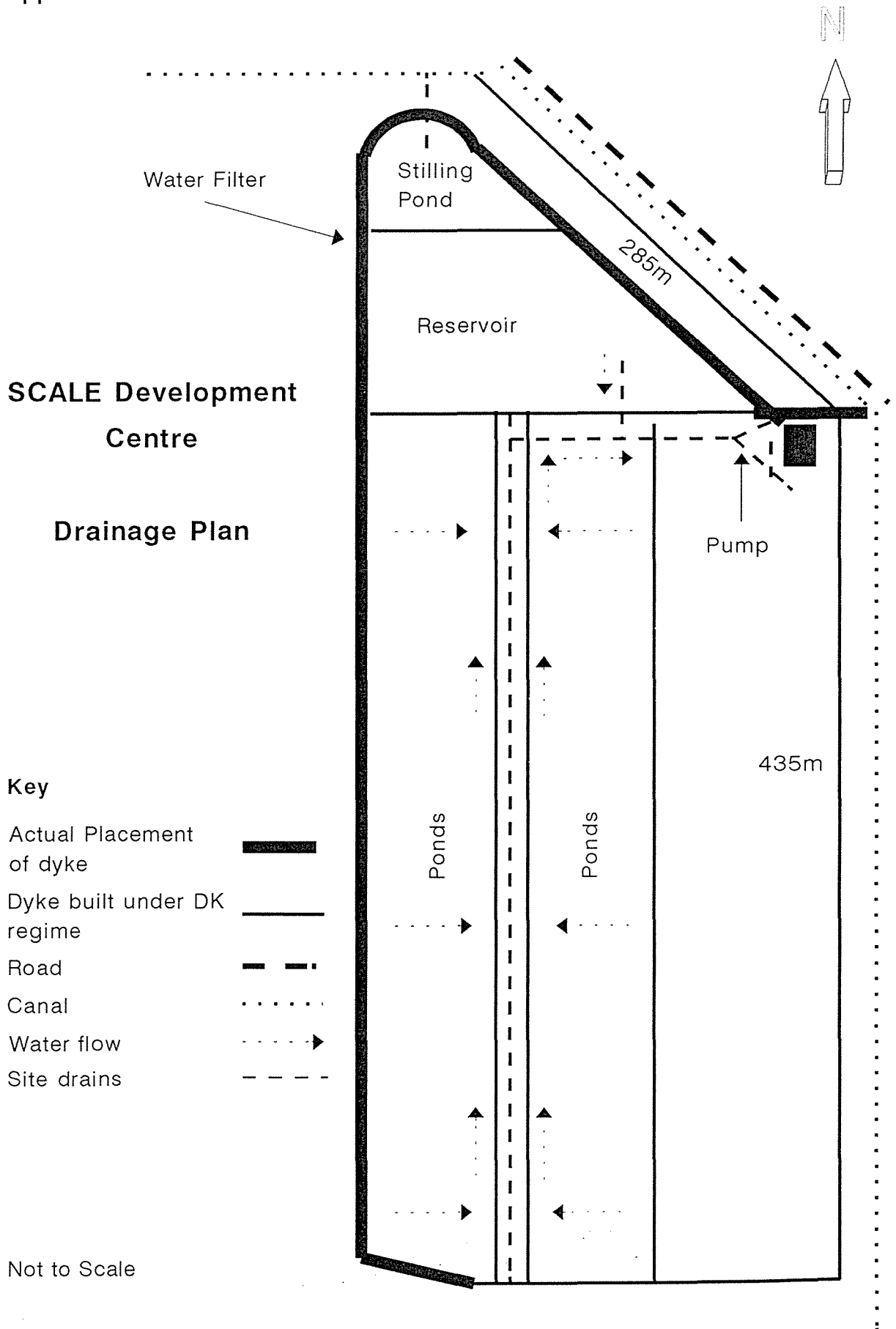
Key

- Actual placement of dyke
- Plan for original placement of dyke
- Dyke built under DK regime
- Road
- Canal



Not to Scale

Appendix 4.4

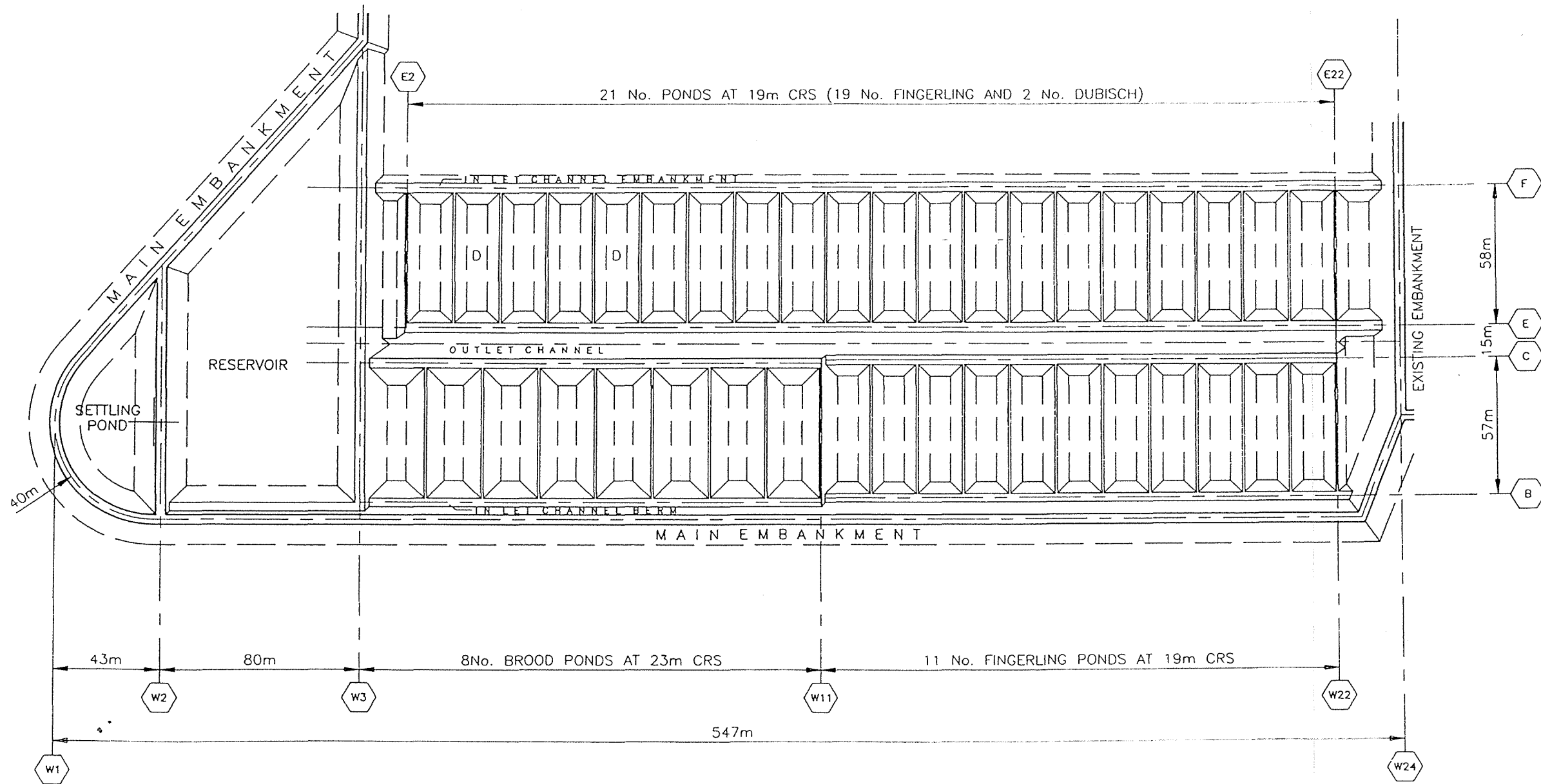


APPENDIX 4.5



NOTES

- 1. D = DUBISCH
- 2. DIMENSIONS IN METRES (ROUNDED TO NEAREST METRE)



Development Centre Fish Hatchery Plan

SCALE Project, Tourl Krosang Site

Kandal Province, Cambodia

APPENDIX 5.1

VILLAGE LEVEL DATA

Enumerators Name..... Date:.....
 Srok Name:..... Srok code.....
 Khum Name:..... Khum code.....
 Phum Name:..... Phum code.....

Table No: 1

Khum/Phum Leadership				
	Chief	V.Chief	Dir.Agr	V.Dir.Agr
Khum				
Phum				

Table No: 2

Khum Demographic Data							
Khum Population Total.....							
Phum Population Total.....							
Male				Female			
Age	Age	Age	Age	Age	Age	Age	Age
Number of Families:		Khum:		Phum:			
Total Labour Force:		Khum:		Phum:			
Male 16-60yrs:		Khum:		Phum:			
Female 16-55yrs:		Khum:		Phum:			
Life Expectancy: ⁴⁵		Male:		Female:			
Ethnic Groups							
1 Major (%)		2 Major (%)		1 Minor (%)		2 Minor (%)	
Phum Growth Rate (immigration & Births)							

45 Average age which people live to (Death by natural causes including illness).

Table No: 9

DETAILS	Name	Hectare's	% Sold	% Kept ⁴⁶
Major crop (land area) ⁴⁷	1.			
	2.			
Growing season (months)	1.			
	2.			
Crop residue	1.			
	2.			
Major crop (economic) ⁴⁸	1.			
	2.			
Growing season (months)	1.			
	2.			
Crop residue	1.			
	2.			
Medicinal crops	1.			
	2.			
Growing season (months)	1.			
	2.			
Crop residue	1.			
	2.			
Drought resistant crops				
Crops used in flood years				
Crops lacking (reason)				

Market constraints⁴⁹

VI CROPS

46 For domestic use (ie. percent of crop used by the farmer).

47 Which crop covers the most hectares.

48 Which crop provides the most income (money).

49 For example, poor roads to the market, or prices often changing.

Table No: 19

Rainfall			
Season	Date		Months of water shortage
	Begin	End	
Monsoon season			
Dry season			

Table No: 20

Water Resource Management					
Water source	Location of water source	Distance from Phum centre	Major use	Period available	Importance of water source 1..2..3
River					
Stream					
Lake					
Wetland					
Flooded forest					
Reservoir					
Well					
Bore					

XI NATURAL RESOURCES

Table No: 21

Irrigation			
Water source able to provide irrigation water	Ha's able to be irrigated	Months irrigated	Ha's potentially able to be irrigated ⁵⁰
River			
Stream			
Lake			
Wetland			
Flooded forest			
Reservoir			
Well ⁵¹			
Bore ⁵²			

Table No: 22

Other Natural Resources						
Name	Importance maj,med, min,no	Avail-ability high,med,low	Source	Use (where)		Use (how)
				Home	Market	
Firewood						
Forest						
Fish						
Sand						
Stone						
Clay ⁵³						

XI NATURAL RESOURCES

50 The area that could be irrigated in addition to that already irrigated.

51 A well is of wide diameter and is dug by hand.

52 A bore is of narrow diameter and is mechanically drilled.

53 For roofing tiles, pots and bricks.

Table No: 23

Phum Religions		
Name	The proportion of population observing	Holidays/celebrations which influence Phum activities
Buddhism		
Islam		
Christianity		
Others		

Major customs/traditions influencing Phum lifestyle and work patterns:

- 1.....
- 2.....
- 3.....
- 4.....
- 5.....

Table No: 24

Animal	Attitude to the Consumption of Animals					Phum slaughter men (no:) ⁵⁴
	Quantity of Phum population willing to consume/eat their own animals					
	Most (60% +)	Many (30-59%)	Some (10-29%)	Few (1-9%)	None (0%)	
Fish						
Water Buffalo						
Cows						
Pigs						
Chicken						
Ducks						

XII SOCIO-CULTURAL

54 A man who is paid to kill animals.

APPENDIX 5.2.

SOCIOECONOMIC INDICATORS FOR BASELINE SURVEY

PRIMARY INDICATORS

1) House

Details	Poor	Average	Good
Size of the house	Small	Average	Large
Roofing material	Palm leaf/ old iron	New tidy leaf/old tiles/iron	Tiles/ New iron/ cement board
Walls	Leaf/bamboo/ old iron	Light timber/ New tidy leaf	Heavy timber or cement
Raised off the ground	On the ground	On/off the ground	Off the ground

2) Material Goods

Details	Poor	Average	Good
Material goods visible	Very little other than basic necessities	A few household effects obvious and some animals	T.V aerial, numerous animals and household effects

SECONDARY INDICATORS

3) Geographical Location

Detail	Poor	Average	Good
Distance from a main road (Srok road)	More than 2 km	1 - 2 km	Close to a main road
Distance from the Srok market	More than 5 km	2 - 5 km	Close to the market (less than 1 km)

4) Water

Details	Poor	Average	Good
Distance to a River, Lake, Stream or Reservoir	More than 5 km	1 - 5 km	Close (less than 1 km)
Well or Bore	0.5 km or more	100 - 500 m	Close/Own
Household Pond	No pond	1 Pond close to house (if owned, donated/unre-liable in dry season)	Own pond (dug privately)

5) Fruit Available

Details	Poor	Average	Good
Fruits	Few around the house	Some	Many

APPENDIX 5.3

HOUSEHOLD SUMMARY SHEET

Name: _____

Location of house: _____

Socioeconomic categorization:

Primary Indicators				Secondary Indicators			
No.	Score	No.	Score	No.	Score	No.	Score
1.a		1.d		3.a		4.b	
1.b		2.a		3.b		4.c	
1.c				4.a		5.a	
Total				Total			
Grand Total A				Grand Total B /2 =			

Final Score (A+B) = + = _____

Household Status: Poor Average Good

APPENDIX 6.1

MAJOR RICE ECOSYSTEMS

Rice cannot be simply placed into a single category. In fact, a complex classification is involved. While analysing this classification detail is not required here, a summary outline of what it entails is provided.

Traditionally, Cambodia is a RLR area. According to Lando and Solieng (1990) 1,348,480 hectares or 83.5 percent of the total area of The State of Cambodia planted in rice in 1989 was RLR. In recent years however, the use of Dry Season Rice has increased. This is of particular importance to Kandal as it is a major dry season rice area for The State of Cambodia. While dry season rice generally only amounts to about 5 - 8 percent of the total hectares cultivated in rice nationally, in Kandal it amounted to approximately 40 percent throughout the years from 1982 to 1989.⁵⁵

Deepwater or floating rice (i.e. rice grown in water deeper than 50cm and up to four metres deep and seeded in April-May so that they will germinate with the first rains) can also be classified as a rice ecosystem. In Kandal it can be found in some depressions beside the rivers, especially along the Mekong, however it is of minor significance compared to RLR and dry season rice. According to the Cambodia-IRRI Rice Project 4752 hectares were grown in Kandal in the 1990 wet season, 13 percent of the total wet season rice area (Rice, 1991). As Khmer does not define a separate classification for deepwater rice it has been categorised under the RLR classification for the SCALE projects requirements.

Therefore in Kandal, two major rice ecosystems can be said to exist, both of which are classified as wet culture rice. Within these two ecosystems there is a detailed and specific local classification. The following is a generalized breakdown of some of the Khmer terms and classifications of the different culture types as provided by Tichit (1981). Dry culture rice has also been noted, although it is of little significance to the Kandal province.

Dry Culture Rice (Mountain Rice):	<i>Chamkar Leu</i>
Wet Culture Rice:	
Monsoon Season Rice:	<i>Sre Vossa</i>
Ordinary Rice (transplanted):	<i>Sre Vossa Stung</i>
Ordinary Rice (direct seeded):	<i>Sre Vossa Prous</i>
Floating Rice:	<i>Sre Vea</i>
Dry Season Rice:	<i>Sre Prang</i>

The diversity of the RLR ecosystem must not be understated. As is pointed out by Khush (1984), its growing conditions can vary considerably according to the:

"...amount and duration of rainfall, depth of standing water, duration of standing water, flooding frequency, time of flooding, soil type and topography." (Khush, 1984)

Effectively, an individual RLR farmer in Kandal could be managing fields which fall into numerous categories. As noted by Lando and Solieng (1990) some of these are:

- a) rainfed shallow, favourable;

⁵⁵ Source: Department of Agronomy, Ministry of Agriculture (unpublished data).

- b) rainfed shallow, drought prone;
- c) rainfed shallow, drought- and submergence-prone;
- d) rainfed shallow, submergence-prone;
- e) rainfed medium deep, waterlogged;
- f) rainfed deepwater.

Like RLR, dry season rice can be difficult to define. It cannot be neatly compartmentalised, for example, as irrigated rice culture, and it can consist of numerous different rice crops i.e.

- | | | |
|----|----------------------------------|---------------------|
| a) | Late rainy season crop | (August to January) |
| b) | Early dry season crop | (October to March) |
| c) | Late dry season crop | (November to April) |
| d) | Small-scale flood recession crop | (January to May) |
| e) | Reservoir flood recession crop | (March to August) |

All aspects of the rice environment (its location, topography, soil type, time and method of cultivation) can vary. Generally it is planted in three locations:

- a) In receding water, around lakes, rivers etc;
- b) In deep flooded areas as supplementary irrigated rice (i.e. where floating rice would otherwise be grown);
- c) At the end of the wet season as a fully irrigated second crop.

Hellei (1970) gives a good description of the nature of dry season rice in Cambodia.

"In most cases, the dry season varieties are planted in land area which is not utilizable for rice culture in the rainy season. In this way it is possible to consider that dry season rice is unique in the agricultural year, where it is cultivated. During the rainy season the land area is inundated, or for diverse reasons is not cultivatable." (Hellei, 1970)

APPENDIX 6.2

A DESCRIPTION OF LANDUSE BY PROJECT AREA

The project areas and the major landuses they represent are as follows:

- | | | |
|----|----------------|-------------------------------------|
| a) | Project Area 1 | Dry Season Rice, Maize and Tobacco; |
| b) | Project Area 2 | Monsoon Season Rice; |
| c) | Project Area 3 | Fruit and Maize; |
| d) | Project Area 4 | Maize and Tobacco; |
| e) | Project Area 5 | Monsoon and Dry Season Rice. |
-
- a) **Project Area 1 (Khsach Kandal and Mok Kum Pul):** This area includes the communes on either side of the Upper Mekong river, north of Phnom Penh, which forms the border between the two districts. A variety of crops including fruits and vegetables are grown close to the river, but maize, tobacco and dry season rice prevail. The incidence of cage culture is significant along both sides of the river.
- b) **Project Area 2 (Phnom Penh):** This area includes a selection of communes from east to west in the centre of the Phnom Penh district. Monsoon season rice is particularly prevalent. Sugar palm is a major secondary crop, which in many areas is the sole activity for farmers through the peak of the dry season. Villages are significantly more concentrated in this district.
- c) **Project Area 3 (Saang):** The Bassac river flowing through the centre of Saang encourages the prevalence of fruit and maize in this area, which constitutes the communes on either side of the river from north to south.
- d) **Project Area 4 (Kien Svay and Leuk Dek):** This project area extends over the two eastern-most communes of Kien Svay district and the two northern-most communes of Leuk Dek district. Maize and tobacco feature as the major crops. A significant feature of Kien Svay is the large Srey Ampal irrigation system which was built under the Khmer Rouge regime. It is particularly noteworthy among such irrigation works as it actually functions properly. However, this irrigation system only services nine of the thirteen communes in the district. The two communes included in project area 4 (Koki Thom and Som ROUNG THOM) are not serviced by the system and are therefore more restricted in their agricultural activity.
- e) **Project Area 5 (Koh Thom):** Koh Thom is situated in the southern-most region of Kandal and is particularly isolated due to inadequate road access. Access by boat on the Bassac river is possible however. Monsoon and dry season rice are the major crops. The cultivation of dry season rice is largely possible due to cultivation of flood recession rice.

It was found necessary to add a further two strategic areas (Areas A and B) to the main five selected. These areas are significant because of the aquaculture activity they contain and the political interest they hold. Po Neah Leu has an extensive growing pond culture industry and Takhmau is adjacent to the SCALE Development Centre. These two areas can be seen in Figure 6.1.

APPENDIX 6.3

VILLAGE REPORT - SAO SCALE PROJECT

Identity Village	Commune	District	Project Area
V183 Anlong Tasek Krom	Prek Ambil	Sanng	3
Chief Oum Cheng		Vice-Chief Ndaou Senri	

General Information

Village is 5km from the Bassac river but beside a stream.

Low socioeconomic status based on villagers life style.

Many sick in 0 - 14 age group with typhoid, flu, chicken pox and dysentery. Some malaria amongst adult male popn. Typhoid and flu also a problem amongst adult age groups. Public hospital 5 - 6 km from village.

Purchase of rice seed and pesticides require selling of rice and off-farm employment. The phum leadership has met difficulties over the last year in complying with military and monastery contributions.

Village Status

Phum Khum
LL

H = High
A = Average
L = Low
P = Poor
V = Very poor

Population

Total 2014	Families 355
Male 869	Female 1145
0 - 16	
Male	Female

Economic

Rice and plantation land 100 - 150kg rice/ha. Money borrowed for short periods at no interest from neighbours.

Communications

Roads	River
Yes	No

Landuse

Monsoon	Dry	Economic Crop	Hectares		
300	0	Tobacco,chilli	Economic	Irrigation	Total
			65	325	0

Consumption of Own Livestock			
Cows	Pigs	Chickens	Ducks
M	F	M	F

M = many, S = some,

F = few

Ponds

Pond Use	Number of Ponds
	0

Appendix 6.4

Financial Analysis of a Rice/Fish Farm-Based Trial
(PP-PK 1 Mrs Sot Pum - Strategy No.6)

INCOME	Quantity	1992	1993	1994
Kilogrammes of fish harvested				
Tilapia (326 @ 201g)	50		151424	151424
C.carp (266 @ 253g)	52		156265	156265
Fingerling recruits (kg)				
Tilapia (1000/kg, 300/kg Riel)	10		3028	3028
Rice yield without fish				
Paddy area = 1467sq m				
165kg @ 400 Riels/kg		66000		
Rice yield with fish				
165kg x 1.1 = 182kg @ 400 Riels			72600	72600
Livestock				
1 calf (6 months)			61250	61250
pigs				
TOTAL INCOME		66000	444568	444568
EXPENDITURE				
Purchase of fingerlings				
Tilapia	1085		54274	54274
C.carp	888		44406	44406
Rice Seed (kgs)				
Paddy area without fish	17.7	7070		
Paddy area with fish	13.2		5281	5281
Fertiliser				
Inorganic				
Organic				
6 cart loads of cow manure	6		9000	9000
Animal health		4900	4900	4900
TOTAL EXPENDITURE		11970	117861	117861
NET INCOME		54030	326706	326706
Family labour requirement (days)				
Paddy preparation	20			
Paddy maintenance	5			
Fish production	24.5			

Rice production	45
Livestock Production	22.3

TOTAL FAMILY LABOUR DAYS 73 112 97

NET CASH INCOME PER FAMILY LABOUR DAY 742 2910 3359

Notes

FISH RELATED

Paddy area (square metres)	1467
Refuge area (square metres)	497
Total rice/fish area at maximum water level (square metres)	1964
Total area at minimum water level (harvest)	398
Culture period (days)	150

	Stocking		Harvest		Growth rate (g/day)
	No.	wt (g)	No.	wt	
Tilapia	1085	5	326	155	1
C.carp	888	8	266	195.5	1.25

	Stocking density of fingerlings		Stocking density at harvest refuge area
	paddy	refuge area	
Tilapia	0.33	1.21	0.82
C.carp	0.27	0.99	0.67
Total	0.60	2.20	1.49

Mortality rate of fingerlings after arrival at the farm gate (70%) 0.7
Tilapia recruits (1000/kg) 10

tilapia at harvest x 0.5 = number of female fish
female fish x fish weight = total kgs of female fish
kgs of female fish x offspring per kg of fish
= total fingerlings produced

nb: offspring per female fish
= 200 per breeding cycle for three cycles

Average per kg price of harvested fish (Riels) 3000
Average price of fingerlings (Riels) 50
Cost per 150kg (wet weight) cart load of manure (Riels) 1500

Labour Requirements

Labour required for fish production (days) is as follows:

fingerling stocking	0.5
manure collection & application (total per week for 22 weeks)	22
first harvest	0.5
tilapia recruit harvests (2 times)	1
final harvest	0.5
TOTAL	24.5

RICE RELATED

Rice yield without fish (kg)	165
Rice yield with fish (kg - plus 10%)	181.5
Price of harvested rice (riels)	400
Seeding rate of rice (kg/ha)	90

Labour Requirements

Days of labour required for rice production per are (100sq m) is as follows:

Seed bed preparation & sowing	0.3
Land preparation	2
Weeding	0.3
Harvesting	0.4
Treshing	0.1
TOTAL	3.1

LIVESTOCK RELATED

Cows owned (breeding)	4
Income in Riels from a 6 month old calf	250000
Animal health charges (annual)	20000
Proportion of cattle production given to the analysis	0.245
Pigs owned (breeding)	
Income in riels from pigs sold (avg wt = 80kg)	
Number of pigs sold per annum (average)	

Labour Requirements

Days of labour required for rearing livestock:

Grazing and Feeding (2hrs/day for 356 days)	89
Reproduction and calving	2
TOTAL	91

Assumptions

- 1) The rice is transplanted in late July, and fingerling stocking is in late August.
- 2) Water dries up in March.
- 3) The total yield for the farmers 8000sq m of rice in 1992 was 900kg. This is used as an average for estimating future years' yields (increases 10% with fish).
- 4) Three cart loads of manure are applied to the paddy for seedling production each year.
- 5) On-farm pig manure is applied as it is available.
- 6) Six cart loads (150kg/cart, wet weight) of manure are required for the fish in order to apply 4-6kgs (wet weight) of manure daily.
- 7) The livestock are assigned to the FBT according to the proportion of the rice growing area which the FBT represents. In this financial analysis therefore the FBT rice growing area is about 24.5% of the total. 24.5% of the total cash and non cash expenditure and income directly associated with livestock is included in the analysis.
- 8) The livestock are fed using on-farm vegetation and their waste is utilised as a fertiliser for the rice crop. Where it is utilised for the fish its opportunity cost in lost rice production is included as a cost in the analysis (see Note below).
- 9) The seeding rate used for rice is as provided by the farmer (90kg/ha). This is higher than what is advised. The seed used is taken out of last year's crop and is therefore charged to

the analysis using the price for harvested seed (this is less than buying rice seed).

Note: If on-farm manure is used its opportunity cost should be calculated as follows:

Six cart loads of manure are withdrawn from rice production annually to improve the fish growth rate.

- a) It is assumed that each cart load contains 150kg of manure (wet weight).
- b) 6kg of manure (wet weight) is to be applied daily.
- c) Opportunity cost of cow manure calculated according to the rice production lost due to the manure being withdrawn.
- d) If 900kg of rice is produced off 8000sq m with 12 cart loads then it is assumed that 800kg will be produced with only 6 cart loads.
- e) Opportunity cost of 6 cart loads of manure is therefore is 100 Kilogrammes.

Financial Analysis of a Vegetable/Cattle/Fish Farm-Based Trial
(S-PT1 Mr and Mrs Meu Chea - Strategy No. 11)

INCOME	Quantity	1992	1993	1994
Kilogrammes of fish harvested				
Tilapia (139 @ 149g)	21		61914	61914
C.carp (62 @ 170g)	10		31396	31396
Puntius (108 @ 98g)	11		31673	31673
Fingerling recruits (kg)				
Tilapia (1000/kg, 300/kg Riel)	2		619	619
Livestock production				
1 calf (sold at 6 months)	1		12500	12500
1 calf (new born)	1	3500		
Pigs	2	19000		
Vegetables (kgs)				
cabbages (2 plantings)	2000	300000	300000	300000
TOTAL INCOME		322500	438101	438101

EXPENDITURE (Operating)

Purchase of fingerlings				
Tilapia	231		11543	11543
C.carp	103		5130	5130
Puntius	180		8978	8978
Pig feed		10000		
Cabbage seed (g)				
Seed for 2 plantings	25	10000	10000	10000
Tilling				
Hire of draft cattle		700	700	700
Fertiliser				
Urea (2 plantings) (kgs)	25	20000	20000	20000
Cow manure (cart loads)				
vegetables (2 plantings)	20	60000	60000	60000
fish	3.8		11400	11400
Insecticides				
1.5 litres per planting		70000	70000	70000

EXPENDITURE (Capital)

Pond preparation				
Hired labour			167000	

TOTAL EXPENDITURE 170700 364750 197750

NET INCOME 151800 73351 240351

Family labour requirement (days)

Pond preparation 5
 Vegetable production 113
 Livestock production 4.55
 Fish production 26.5
 Pond maintenance 2

TOTAL FAMILY LABOUR DAYS 118 149 146

NET CASH INCOME PER FAMILY LABOUR DAY 1291 492 1646

Notes

FISH RELATED

Total pond area at maximum water level (square metres) 171
 Total pond area at minimum water level (harvest) 145
 Culture period (days) 120

	Stocking		Harvest		Growth rate (g/day)
	No.	wt (g)	No.	wt	
Tilapia	231	5	139	149	1.2
C.carp	103	8	62	170	1.35
Puntius	180	8	108	98	0.75

	Stocking density of fingerlings	Stocking density at harvest
	Max WL	Min WL
Tilapia	1.35	0.95
C.carp	0.60	0.42
Puntius	1.05	0.74
Total	3.00	2.12

Mortality rate of fingerlings after arrival at the farm gate (40%) 0.4
 Tilapia recruits (1000/kg) 2.1

tilapia at harvest x 0.5 = number of female fish
 female fish x fish weight = total kgs of female fish
 kgs of female fish x offspring per kg of fish
 = total fingerlings produced

nb: offspring per female fish
 = 200 per breeding cycle for three cycles

Average per kg price of harvested fish (Riels) 3000
 Average price of fingerlings (Riels) 50
 Cow manure required

Total kgs/day (wet wt)	6
Total kgs required	720
Total cart loads (150kg wet wt/cart load)	4.8

Labour Requirements

Labour required for fish production (days) is as follows:

fingerling stocking	0.5
manure and waste vegetable collection & application (total for 22 weeks)	22
first harvest	1
tilapia recruit harvests (2 times)	2
final harvest	1
TOTAL	26.5

LIVESTOCK RELATED

Income in Riels from calves sold	
6 months old	250000
new born	70000
Cow manure produced (carts)	1
Income from pigs sold (riels per pig)	190000
Proportion of livestock production given to this analysis	0.05

Labour Requirements

Days of labour required for rearing livestock:

Grazing and Feeding (2 hours per day)	89
Reproduction and calving	2
TOTAL	91

VEGETABLE PRODUCTION (Cabbages)

Seed (g)	
weight/planting (g)	12.5
price per g	400
Kilogrammes produced per planting	1000
Income received per kg of Cabbage (Riels)	150
Fertiliser used per planting	
Urea (kgs)	12.5
Price of urea per kg (Riels)	800
Cow manure (No. of carts)	10
Price of cow manure per cart load (Riels)	3000
Insecticide	
1.5 litres per planting (Riels)	35000
Waste vegetables per planting	
approx 30% (kgs)	286
Tilling	
Draft cattle hire per planting (Riels)	7000
Labour Requirements for Vegetable Production (days per planting)	
Family labour units per day	1.13

Length of production period per planting (days)	50
Total family labour days per planting	56.5

POND PREPARATION

Hired labour (15 days)	167000
------------------------	--------

Assumptions

- 1) The pond is filled with water by the beginning of September ready for fingerling stocking.
- 2) Water recedes to the minimum water level at the end of December.
- 3) As the pond was in use for irrigation purposes prior to the introduction of fish production the only income produced from this farm subsystem prior to the introduction of fish was that from the vegetables and one cow.
- 4) The pond has been dug deeper in preparation for the fish, so it is assumed that it can still be used for irrigation purposes without adversely affecting the minimum water level and culture period.
- 5) The one cart of manure collected from the farmers existing cow is to be used as a fertiliser for the fish pond. As the amount is insignificant its opportunity cost has been discounted.
- 6) The cow produces one calf yearly. After the introduction of fish the calf is sold at 6 months.
- 7) The livestock are assigned to the FBT according to the proportion of the crop growing area which the FBT represents. In this financial analysis therefore the FBT crop growing area is about 5.0% of the total. 5.0% of the total cash and non cash expenditure and income directly associated with livestock is included in the analysis.
- 8) The livestock are fed using on-farm vegetation and their waste is utilised as a fertiliser for the rice crop. Where it is utilised for the fish its opportunity cost in lost production is included as a cost in the analysis (see No. 5 above).

Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11

3060	1530	10560	8130	3060	1530	10560	8130	3060	1530
1817	0	158	1143	1508	0	467	316	1508	309
75000	75000	75000	75000	75000	75000	75000	75000	75000	75000
657	657	657	657	657	657	657	657	657	657
1220	1220	1220	1220	1220	1220	1220	1220	1220	1220
81754	78407	87595	86150	81445	78407	87904	85323	81445	78716
229760	249562	279565	298348	322741	354274	371526	404079	420312	444705
311514	327969	367160	384498	404186	432681	459430	489402	501757	523421

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
32700	29900	57400	52000	32900	25000	58000	49100	34600	25600
46700	49000	49400	51700	52500	54300	54800	57000	57500	60100
1038	1038	1038	1038	1038	1038	1038	1038	1038	1038
15400	15400	14600	15500	16100	16000	15200	16100	16800	16700
7700	8100	10900	11300	10100	9900	14000	14000	13100	13000
103538	103438	133338	131538	112638	106238	143038	137238	123038	116438
156269	173141	188641	205217	221874	238406	253906	270482	287138	303671
259807	276579	321979	336755	334511	344643	396944	407720	410176	420108
0	0	0	0	0	0	0	0	0	0
259807	276579	321979	336755	334511	344643	396944	407720	410176	420108
51707	51391	45181	47743	69674	88037	62487	81682	91581	103313
51707	51391	45181	47743	69674	88037	62487	81682	91581	931269

APPENDIX 6.6

BACKGROUND INFORMATION ON DATA

PROJECT BUDGET NOTES AND ASSUMPTIONS

Notes

1) Actual Figures

The figures for the years 1991-92 and 1992 (April - October) are actual according to expenditure already incurred.

2) Water Supply Channel

The cost of water supply channel without lining for the fish ponds constructed in the DC embankment has been budgeted, including concrete bases where the water enters from the reservoir and at the outlet to each pond.

It may be necessary to line this channel at some time in the future, however this cost has not been budgeted for. Lining could be in either tiles or concrete.

3) Hatchery

a) At this stage the nursery facilities for just-feeding fry are provided by the 800m² earthen ponds. There may be benefit, if artificial spawning is practiced in the future, in using concrete nursery tanks (5 x 20m²), to ensure the maximum survival of fry. The cost of constructing such tanks has not been allowed for in this budget.

b) The hatchery facility costs have been based on the use of local materials wherever possible. In some cases, where it has been considered that supplies may need to be imported, prices are taken from quotes previously obtained from the United Kingdom. Suppliers in Thailand are likely to be competitive and more accessible, so will be approached when and if the required supplies and materials are unavailable locally.

c) Hatchery equipment maintenance has been budgeted for at 10 percent of the investment cost for the first 10 years and 20 percent thereafter.

4) Farmer Credit

Credit for farmers for the FBTs has only been budgeted in token measure, because of the currently extensive efforts being done presently on establishing a rural credit system, by other NGOs. It is anticipated that it may be more desirable to encourage FBT farmers to utilise this alternative facility.

5) Funding Support in Kind

Significant financial support both already received, and pending, from World Food Programme ("WFP") from their Food for Work programme, has been used for the payment of workers constructing the embankment in 1992. It will also be available for the 1993 construction of the first 14 brood and fingerling ponds. As this is non-monetary funding support the labour cost of these workers has not been included.

As it is not known whether WFP will be in a position to support the construction of the remaining ponds in the two following years, their construction has been calculated in dollars on current labour costs.

6) Brood Stock Prices (1 kg stock average):

- a) 2000 tilapia at 1400 Riel each;
- b) 50 common carp at 3000 Riel each;
- c) 50 grass carp at 3000 Riel each;
- d) 50 silver carp at 3000 Riel each.

7) Drainage Pump Operation in 1993 - 1994:

Eight months work is budgeted for on every other day. After 1994 - 1995, 30 litres of diesel per day is budgeted to allow for the use of a second and larger pump.

8) Cambodian Staff Trainee Policy

After the 1992 -1993 year all trainees taken on will enter a three month trainee programme, where they will be paired up with a senior field staff member. Their salary will be at the trainee rate for the duration of this period.

9) Overseas Training for Field Staff:

Scholarships (USD 200 per term):

- | | |
|-------------------------------|----------------------|
| a) April 1992 - October 1992 | 1 person (USD 600); |
| b) November 1992 - March 1993 | 2 people (USD 600); |
| c) 1993 - 1994 | 2 people (USD 1000); |
| d) 1994 - 1995 | 1 person (USD 200). |

Special annual scholarship for one or two year graduate studies is payable at the rate of USD 833 per term to a maximum of USD 5000 for two, three-term years of study.

The budget makes provision for up to two field staff each year undertaking a short course (approximately three months) in other Asian countries.

The provision for the annual training programme includes the cost of one training consultant for three weeks.

10) Embankment Maintenance

- a) 1000m³ is budgeted in every second year.
- b) 500m³ is budgeted every other year.

11) Vehicles

Two 4x4 vehicals are owned and each is replaced after four years' use. The number of Motorbikes purchased increases to a total of 15 as field staff numbers increase (see schedule in number (10) above. Each motorbike is replaced after two years' use.

12) Telephone and Fax Charges

Calculated as follows at USD 5.65 per minute:

- a) one IDD telephone call every two weeks of an average 5 minute duration equals USD 734.50;
- b) three IDD facsimile calls per week at an average two minute duration USD 1762.80.

13) External Evaluation

- a) One evaluator for three weeks on site (USD 160 per day).
- b) Ten days allowed for writing up the report.
- c) Subsistence allowance: 21 days at USD 50 per day.
- d) Return air travel to Cambodia is paid.

14) Translation services

An average of 120 pages of work per year at 5000 Riel per page.

15) Insurance

An annual 'self insurance' figure is budgeted to establish a small contingency fund for minor injuries incurred by project staff in the course of their work. For example:

- a) road accidents (public liability);
- b) losses due to theft.

Assumptions

- 1) It is assumed that artificial spawning will begin in 1994 (the second year of the hatchery's operation).
- 2) All artificial spawning equipment budgeted is selected for hypothetical systems. The chosen facilities represent, for budgetary purposes, one possible system (the Chinese circular spawning system) which could be utilized. Final planning and selection of the best artificial spawning system cannot occur until the full requirements of such facilities are known, which will not be until the first year of hatchery production is completed.
- 3) Project Income

- a) Fish and Livestock

The DC income figures from fish and livestock are purely hypothetical. For the purposes of the budget the following two systems have been costed:

- i) tilapia monoculture with ducks;
- ii) tilapia, common carp and snakehead polyculture with pigs;

It should be noted that these are only examples of two possible systems. They are

	96-97		97-98		98-99		99-00	00-01	01-02
Trainee	5	0	0	0	0	0	0	0	1
G.1	12	15	13	11	9	9	7	5	3
G.2	6	7	7	8	8	8	8	8	8
G.3	3	4	4	5	5	5	5	5	5
Total	26	26	24	24	22	22	20	18	17

- 5) Compassionate leave is not included from year nine as *in situ* expatriate advisors will leave by the end of the eighth year.
- 6) The price of all fuel has been taken as being the October 1992 market price.

BCA NOTES AND ASSUMPTIONS

Notes

The following notes provide the parameters to the BCA. For an explanation on the compilation of project expenditure and FBT composition please refer to the Project Budget Notes above and the Farmer Implementation Notes below.

- 1) Period for the economic analysis:
20 Years
- 2) Project start date:
1 November 1991. This is the date when the first SAO Project Director was *in situ* and officially began project implementation. The project's financial year is from 1 April to 31 March. Year one therefore is a short year, beginning on 1 November 1991 and ending on 31 March 1992.
- 3) Discounting begins from year zero.
- 4) All figures are included as real and do not account for inflation.
- 5) While both the Cambodian currency (riel) and US dollars are used in the project and FBT budgets as required these are standardised into US dollars in the budget summary and BCA.
- 6) The market exchange rate current in October 1992 (2000 riel = 1 US dollar) was used in all calculations. The absence and uncertainty of Government policy prior to the UNTAC sponsored elections in May 1993 made it impossible to calculate a shadow exchange rate or ascertain whether its use was required.
- 7) All figures are rounded to the nearest US Dollar or Cambodian Riel. Figures for the SCALE summary budget are rounded to the nearest USD 50.
- 8) The salvage values of equipment replaced during the 20 year period are included as

income in the budget at the following rates:

- a) vehicles and motor bikes - 30 percent of the purchase price;
 - b) other plant - 40 percent of the purchase price;
- 9) No by-gones are included. For example, where farmers already own livestock or have a pond, the cost of their establishment or purchase are not included.

For example it is assumed that:

- a) for those farmers using cattle in their IAQS, one cow is already owned;
- b) Farmers in the two strategic project areas have a pond already, and therefore pond preparation does not feature as a cost. Four such farmers are included in the analysis in each of the two pilot programme years.

Assumptions

- 1) Although a high proportion of the fish produced is intended for subsistence consumption and therefore will not produce an income to the farmer, their value has been taken as being the current market price in October 1992. The consumed fish would otherwise be purchased at the market price or substituted for with other meats.
- 2) The opportunity cost of land has been included as a cost to the farmer implementations and DC to account for the income which would have otherwise been earned had the IAQS not been implemented or the DC established. This cost has been calculated by using the per hectare income which would have been generated from an average crop of RLR (monsoon rice). While this is not the likely alternative use of land in every case it is the most common major land use in Kandal. It is therefore considered relevant for the purpose of standardizing the opportunity cost of land in this analysis.

RLR Gross Margin (expenditure and income per Hectare);

<i>Income</i>	Riels
Rice harvested (1.3 ton @ 400 R/kg)	520,000
 <i>Expenditure</i>	
labour (land prep, planting, harvest etc) 78 days @ 2000 R/day	156,000
Seed (86 kg @ 280 R/kg)	24,000
Ammophos (42.3 kg @ 550 R/kg)	23,265
Manure (NPK value)	
Ammophos (24kg)	13,200
Urea (160kg @ 600 R/kg)	<u>96,000</u>
 Total Exp	 312,465
 <i>Balance</i>	 207,535

a) To support 1 ha of RLR a nursery bed of approximately 0.2 ha is required;

b) Farmyard manure applied;

nursary bed	=	3.5 tonnes
paddy	=	<u>1.8 tonnes</u>
total	=	5.3 tonnes

NPK value of 5.3 tonnes of farmyard manure

Nitrogen	=	76.32 kg
Phosphorus	=	10.07 kg
Potassium	=	50.35 kg

Fertilizers commonly used are Urea and Ammophos. Amounts therefore required to replace the NPK value of the Farmyard manure used are,

Urea (46-0-0)	=	160 kg/ha
Ammophos (11-42-0)	=	24 kg/ha

Note: these fertilizers do not replace the Potassium value of the farmyard manure;

c) All equipment requirements are owned by the farmer.

d) Average RLR rice yield is 1.3 tonne per hectare.

e) For the purposes of the economic analysis the value of the farmyard manure has been taken as being the NPK value as provided by Urea and Ammophos. If the manure was not available, the use of inorganic fertilizer would need to be increased to maintain rice yield.

(compiled from information provided by the *Cambodia - IRRI Rice Project*, Phnom Penh. See: Lando and Mak (1990).

3) All headquarters costs (for example, expatriate personnel allowances and support, administrative support) are phased out by year nine (1999-2000) due to the expectation that local control will be complete by that time. In years seven and eight these costs are reduced to 50 percent of year six to account for the phased hand-over which is anticipated.

4) Expatriate advisors will leave by the end of the eighth year and hence reduce the headquarters costs.

FARMER IMPLEMENTATION NOTES AND ASSUMPTIONS

Notes

1) All prices used are current for October 1992.

2) The cost of labour is set at 2000 riels per day per labour unit ("LU").

3) Nine IAQS have been selected for the analysis as follows:

- a) *ricefish* Nile tilapia and common carp polyculture;
- b) *ricefish* common carp monoculture;

- c) *pig/fish* Nile tilapia monoculture including two six month production cycles per annum;
 - d) *pig/fish* Nile tilapia, common carp, snakehead polyculture including two six month production cycles per annum;
 - e) *duck/fish* Nile tilapia, common carp, silver carp, grass carp polyculture including two four month production cycles per annum;
 - f) *duck/fish* Nile tilapia monoculture including two four month production cycles per annum;
 - g) *pangasius*, Nile tilapia, puntius, common carp polyculture using supplementary feed (the development of this system is to be done with established fish farmers already using it in SCALE's two strategic project areas);
 - h) *cattle/fish* Nile tilapia, common carp, silver carp, grass carp polyculture using one 120 day culture period. One cow only is owned by the farmer prior to implementation. A second cow must be purchased.
 - i) *cattle/fish* as in (h) above but where farmers own two cows prior to implementation, thus eliminating the requirement to purchase a second cow.
- 4) The nine IAQS used for the purpose of this analysis are theoretical and not necessarily those which will be finally suggested to the FBT farmers for implementation. The finalising of the IAQS for the FBT's implementation will be done on the completion of the Farmer survey's analysis and during the pilot programme's preparation in the first half of 1993.

Assumptions

- 1) It is assumed that 14 FBTs are implemented in the first year of the pilot programme, plus a further 15 in the second year, giving a total of 29 by the beginning of Phase 4 of the project. For the first two years (i.e. 1995-1996) following the pilot programme it is assumed that 55 new farmers will join the project in each year. Thereafter a total of 30 new farmers will join annually (see Appendix 6.7).

It is assumed that farmers dropping out are all in their first year of the trial and that the farmers no longer require any form of support after three years.

While this implementation schedule is arbitrary, it is considered both feasible and realistic. The drop-off from 55 to 30 annual implementations after 1996 is to account for the initial interest in the project having been satisfied.

- 2) Paddy maintenance in rice/fish systems has been set at 20 percent of the establishment cost in the first year.
- 4) Cattle:
- a) All farmers implementing a cattle/fish system own at least one cow prior to undertaking fish culture;
 - b) This cow is replaced in the fourth year (with a calf reared on-farm) and all others every fifth year;
 - c) Culled cows are sold for 80 percent of the purchase price;
 - d) The servicing fee for cows is fixed at 5000 riel per head;
 - e) One calf per cow is expected annually and sold at six months;
 - f) All cattle are also used for work.
- 5) All pigs and ducks used are bought in for IAQS implementation.

- 6) All ponds are excavated manually at the rate of 2m³ per LU per day.
- 7) With the exception of IAQS 7 which is a fish only system, the only supplementary feed provided for fish is natural vegetation or waste crops and/or vegetables where herbivorous fish are grown. The natural environment of the pond in all other cases (enhanced by animal/plant waste, and in the case of cattle/fish, urea), provides the necessary requirements for fish growth.
- 8) Rice/fish systems are based on closed dyke, simultaneous culture.

APPENDIX 6.7

FARMER IMPLEMENTATION SCHEDULE AND BUDGET

Farms Implemented	1993	1994	1995	1996	1997	1998	1999	2000	2001
Number (new)	14	18	55	55	30	30	30	30	30
Number (continuing)	0	11	25	69	113	137	161	185	209
Number (dropout 20%)		3	4	11	11	6	6	6	6
Total	14	29	80	124	143	167	191	215	239
IAQS Composition									
1 (total)	2	5	12	19	22	25	28	31	34
old		1	4	11	18	22	24	27	30
new	2	4	8	8	4	3	4	4	4
2 (total)	2	5	12	19	22	25	28	31	34
old		1	4	11	18	22	24	27	30
new	2	4	8	8	4	3	4	4	4
3 (total)	1	2	8	13	15	18	21	24	27
old		1	1	6	11	14	18	20	23
new	1	1	7	7	4	4	3	4	4
4 (total)	0	2	9	15	18	21	24	27	30
old			1	7	13	17	21	24	26
new		2	8	8	5	4	3	3	4
5 (total)	0	1	7	12	14	17	20	23	26
old			1	6	10	13	16	19	23
new		1	6	6	4	4	4	4	3
6 (total)	3	5	11	16	19	22	25	28	31
old		2	5	10	15	18	21	24	28
new	3	3	6	6	4	4	4	4	3
7 (total)	4	4	10	14	14	17	20	23	26
old		4	4	9	13	13	16	19	22
new	4		6	5	1	4	4	4	4
8 (total)	1	3	6	9	11	12	14	16	18
old		1	3	5	9	10	12	14	16
new	1	2	3	4	2	2	2	2	2
9 (total)	1	2	5	7	8	10	11	12	13
old		1	2	4	6	8	9	11	11
new	1	1	3	3	2	2	2	1	2

2002	2003	2004	2005	2006	2007	2008	2009	2010
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30	30	30	30	30	30	30	30	30
233	257	281	305	329	353	377	401	425
6	6	6	6	6	6	6	6	6
263	287	311	335	359	383	407	431	455

37	40	43	46	49	52	55	58	61
34	36	39	42	46	48	51	54	58
3	4	4	4	3	4	4	4	3
37	40	43	46	49	52	55	58	61
34	36	39	42	46	48	51	54	58
3	4	4	4	3	4	4	4	3
30	33	36	39	42	45	48	51	54
26	30	32	35	38	42	44	47	50
4	3	4	4	4	3	4	4	4
33	36	39	42	45	48	51	54	57
29	33	35	38	41	45	47	50	53
4	3	4	4	4	3	4	4	4
29	32	35	38	41	44	47	50	53
25	28	32	34	37	40	44	46	49
4	4	3	4	4	4	3	4	4
34	37	40	43	46	49	52	55	58
30	33	37	39	42	45	49	51	54
4	4	3	4	4	4	3	4	4
29	32	35	38	41	44	47	50	53
25	28	31	35	37	40	43	47	49
4	4	4	3	4	4	4	3	4
19	21	22	24	26	28	29	31	33
17	19	20	22	24	26	27	29	31
2	2	2	2	2	2	2	2	2
15	16	18	19	20	21	23	24	25
13	14	16	18	18	19	21	23	23
2	2	2	1	2	2	2	1	2

FARM INCOME AND EXPENDITURE SUMMARY FOR BCA

	1993	1994	1995	1996	1997	1998	1999	2000	2001
IAQS Expenditure									
1	152240	356600	817440	1182280	1242640	1375000	1555360	1711720	1868080
2	124240	286600	649440	916280	934640	1025000	1163360	1277720	1392080
3	2695996	4551991	20727965	30007943	31199934	36767921	41495907	47903894	53471881
4	0	5421991	23558960	34784934	37877921	42650907	47423894	53036881	59489868
5	0	2998796	20151569	30945547	33583138	40059525	46535912	53012299	58648685
6	3543452	5265754	11392658	15698411	17641863	20225315	22808768	25392220	27655672
7	15005907	15005907	37514768	52520675	52520675	63775105	75029535	86283965	97538396
8	1568807	3426420	5572840	7719260	5736874	6025680	6603294	7180907	7758521
9	768807	1057613	2884034	3461647	3270454	3848067	4136874	3945680	4714487
TOTAL EXPENDITURE (A) Riels	23859448	38371672	123269673	177236976	184008138	215752520	246752903	279745286	312537669
TOTAL EXPENDITURE (A) US dollars	11930	19186	61635	88618	92004	107876	123376	139873	156269
IAQS Income									
1	163220	408051	979322	1550594	1795424	2040255	2285086	2529916	2774747
2	178100	445251	1068602	1691954	1959104	2226255	2493406	2760556	3027707
3	2755200	5510400	22041600	35817600	41328000	49593600	57859200	66124800	74390400
4	0	6307200	28382400	47304000	56764800	66225600	75686400	85147200	94608000
5	0	2739600	19177200	32875200	38354400	46573200	54792000	63010800	71229600
6	3073200	5122000	11268400	16390400	19463600	22536800	25610000	28683200	31756400
7	21134400	21134400	52836000	73970400	73970400	89821200	105672000	121522800	137373600
8	1134800	3404400	6808800	11913200	12482800	17017600	15887200	18156800	25866400
9	1134800	2269600	5674000	9303600	9078400	14068000	12482800	13617600	18492400
TOTAL INCOME (B) Riels	29573721	47340902	148236325	230816948	255196929	310102510	352768091	401553672	459519254
TOTAL INCOME (B) US Dollars	14787	23670	74118	115408	127598	155051	176384	200777	229760
NCF (B - A = C) Riels	5714273	8969230	24966652	53579971	71188791	94349990	106015188	121808386	146981585
NCF (B - A = C) US dollars	2857	4485	12483	26790	35594	47175	53008	60904	73491

2002	2003	2004	2005	2006	2007	2008	2009	2010
2000440	2180800	2337160	2493520	2625880	2806240	2962600	3118960	3251320
1482440	1620800	1735160	1849520	1939880	2078240	2192600	2306960	2397320
59039868	63767854	70175841	75743828	81311815	86039801	92447788	98015775	103583762
65102854	69875841	76328828	81941815	87554801	92327788	98780775	104393762	110006748
65965072	72441459	78077846	85394232	91870619	98347006	103983393	111299779	117776166
30559124	33142576	35406028	38309480	40892932	43476384	45739836	48643289	51226741
108792826	120047256	131301686	142556116	153810547	165064977	176319407	187573838	198828268
8047327	8624941	8913747	9491361	10068974	10646588	10935394	11513008	12090621
5292101	5580907	6158521	5967327	6736134	7024941	7602554	7411361	8180168
346282051	377282434	410434817	443747200	476811582	507811965	540964348	574276731	607341113
173141	188641	205217	221874	238406	253906	270482	287138	303671
3019577	3264408	3509239	3754069	3998900	4243730	4488561	4733392	4978222
3294857	3562008	3829159	4096309	4363460	4630610	4897761	5164912	5432062
82656000	90921600	99187200	107452800	115718400	123984000	132249600	140515200	148780800
104068800	113529600	122990400	132451200	141912000	151372800	160833600	170294400	179755200
79448400	87667200	95886000	104104800	112323600	120542400	128761200	136980000	145198800
34829600	37902800	40976000	44049200	47122400	50195600	53268800	56342000	59415200
153224400	169075200	184926000	200776800	216627600	232478400	248329200	264180000	280030800
21561200	30290800	24965600	27235200	37664800	31774400	42089200	35178800	37448400
17022000	22916800	20426400	21561200	28816000	23830800	33240400	27235200	28370000
499124835	559130416	596695997	645481578	708547160	743052741	808158322	840623903	889409484
249562	279565	298348	322741	354274	371526	404079	420312	444705
152842783	181847982	186261180	201734379	231735577	235240776	267193974	266347173	282068371
76421	90924	93131	100867	115868	117620	133597	133174	141034