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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
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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 it's 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 it's 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 socioeconommic 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 Cambodian[3] 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.