Socioeconomics of Rice Aquculture and IPM in the Philippines: Synergies, Potentials and Problems. 1999. G. Hostkotte-Wesseler. ICLARM Tech. Rep. 57, 225 p.

TITLES OF RELATED INTEREST

Rice-fish research and development in Asia. 1992. C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao, Editors. ICLARM Conf. Proc. 24, 457 p.

Environmental impact of the golden snail (Pomacea sp.) on rice farming systems in the Philippines. 1991. B.O. Acosta and R.S.V. Pullin, Editors. ICLARM Conf. Proc. 28, 34 p.

Role of fish in enhancing ricefield ecology and in integrated pest management. 1994. C.R. dela Cruz, Editor. ICLARM Conf. Proc. 43, 50 p.

Modeling and analyzing the agroecological performance of farms with ECOPATH. 1998. J.P.T. Dalsgaard and R.T. Oficial. ICLARM Tech. Rep. 53, 54 p.

Integrating aquaculture with rice farming in Bangladesh: feasibility and economic viability, its adoption and impact. 1998. M.V. Gupta, J.D. Sollows, M.A. Mazid, A. Rahman, M.G. Hussain and M.M. Dey. ICLARM Tech. Rep. 55, 90 p.

Research and education for the development of integrated crop-livestock-fish farming systems in the tropics. P. Edwards, R.S.V. Pullin and J.A. Gartner. 1988. ICLARM Stud. Rev. 16, 53 p.

How to order

For book prices and more information, please contact:

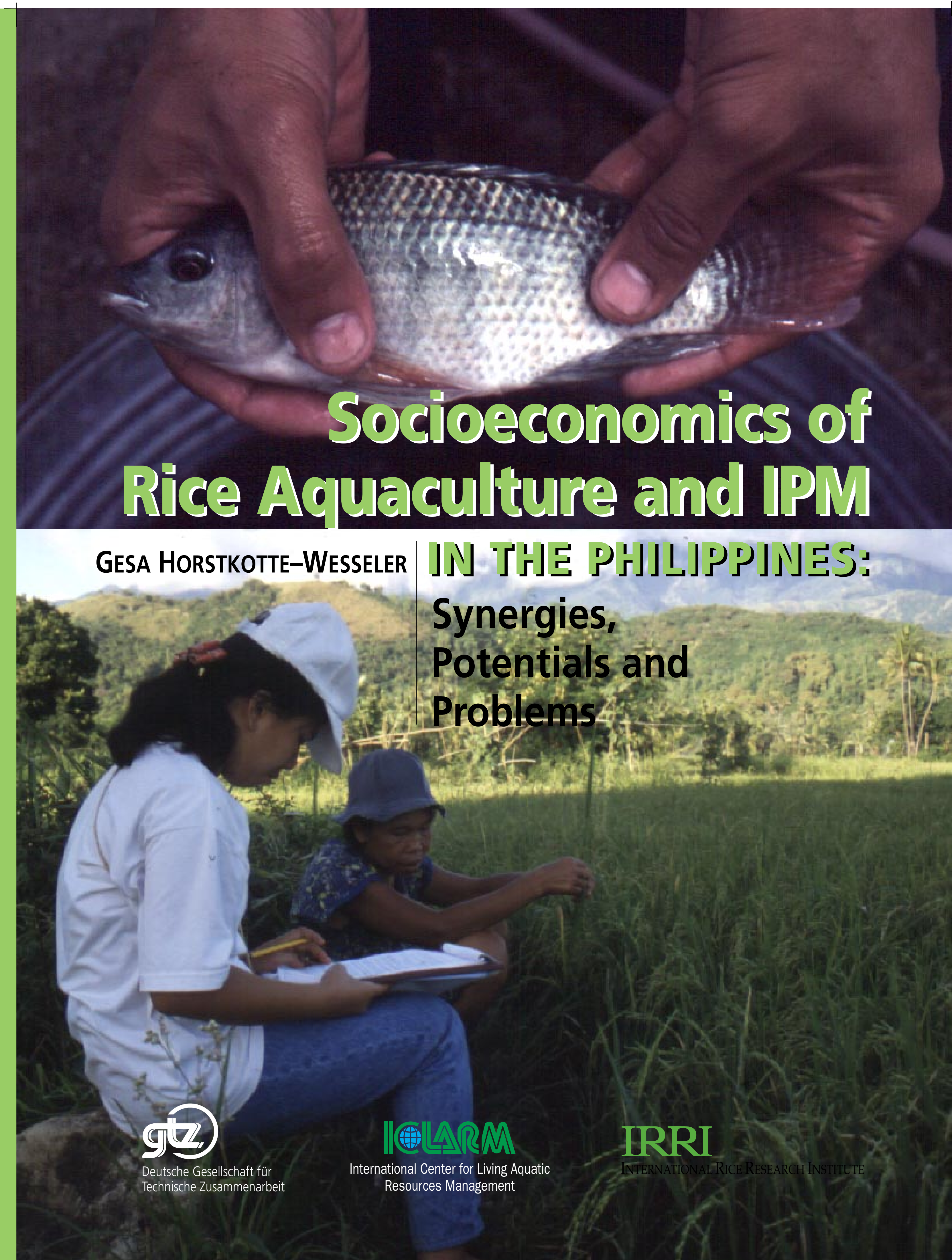
The Publications Unit Manager
ICLARM
MC PO Box 2631
0718 Makati City
Philippines
Tel. No. (63-2) 812-8641, 840-3485 ext. 110
Fax No. (63-2) 816-3183
Email: ICLARM@cgiar.org

Payment should be made in US dollars by bankdraft or check (payable to ICLARM) from a US-based bank (due to high clearance fees of other banks). We also accept payment through the American Express credit card.

Visit our home page: http://www.cgiar.org/iclarm/

Socioeconomics of Rice Aquaculture and IPM in the Philippines

G. Horstkotte–Wesseler



Socioeconomics of Rice Aquaculture and IPM IN THE PHILIPPINES: Synergies, Potentials and Problems

GESA HORSTKOTTE–WESSELER

Deutsche Gesellschaft für Technische Zusammenarbeit

ICLARM International Center for Living Aquatic Resources Management

IRRI International Rice Research Institute

Socioeconomics of Rice-Aquaculture and IPM in the Philippines:

Synergies, Potential and Problems

Gesa Horstkotte-Wesseler

1999

Deutsche Gesellschaft für
Technische Zusammenarbeit

International Center for Living Aquatic
Resources Management

IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

Socioeconomics of Rice-Aquaculture and IPM in the Philippines: Synergies, Potential and Problems

Gesa Horstkotte-Wesseler

1999

Published by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Dag-Hammarskjöld-Weg 1-5, 65760 Eschborn, Germany; International Center for Living Aquatic Resources Management, MCPO Box 2631, 0718 Makati City, Metro Manila, Philippines; and International Rice Research Institute, MCPO Box 3127, Makati City 1271, Philippines.

Printed in Manila, Philippines

Horstkotte-Wesseler, G. 1999. Socioeconomics of rice-aquaculture and IPM in the Philippines: synergies, potential and problems. ICLARM Tech. Rep. 57, 225 p.

Technical editor: Mark Prein
Copyeditor: Jeanette Rive
Coordinators: Lhai Kasala and Sheila Siar
Cover designer and layout artist: Mayanne Wenceslao
Typesetter: Lhai Kasala

Cover: Upper photo – Nile tilapia at consumable size such as grown in rice-fish culture systems (photo by Mark Prein).
Lower photo – farmer and researcher during monitoring interview at rice-fish field in Antique, Panay Island, Philippines (photo by Gesa Horstkotte-Wesseler).

ISBN 971-802-004-7
ISSN 0115-5547

ICLARM Contribution No. 1498

ICLARM is one of the 16 international research centers of the Consultative Group on International Agricultural Research (CGIAR) that has initiated the public awareness campaign, Future Harvest.

Contents

Foreword

Rice farming covers nearly one-third of the arable land of Asia. In the Philippines, rice is planted over about 45% of the total crop area. Rice farms are not only large users of crop land but also large consumers of water and therefore ICLARM has long been interested in how the potential for fish production could be improved within ricefields and their water systems. Coupled with ICLARM's interest in finding new and environmentally sustainable ways to produce the additional fish needed by growing populations, ICLARM was pleased to associate itself with the work reported in this technical report. Typical of work of the many aspects of farm decisionmaking, the study's author drew together many different partners, including the farming families themselves.

The study shows results that are useful for policymakers wishing to promote new diversification opportunities in the crop sector. They show some of the complexities in understanding farming households and farm labor use and how people make decisions on what crops to grow, how to allocate family labor and how best to feed the family. The study also goes beyond just fish farming in ricefields and considers the role of naturally occurring aquatic organisms in ricefields, such as frogs, snails and wild fish. Many of these organisms will return to the ricefields with the use of integrated pest management (IPM) and the consequent reduction in the use of pesticides.

The study showed that seemingly good technical options such as growing fish in ricefields were often not in accord with the capital resources of rice-farming families, nor were the fish grown as affordable as other types of animal protein. Freshwater fish grown in ricefields were often not the preferred species for farming families. The high value of fish, however, enabled the farmers to market their harvests.

Further power is given to the conclusions of the study by the comparative analysis of the two different regions, namely, inland Nueva Ecija that is one of the premier rice growing areas, and Antique, a less favored area for development. The results illustrate how market forces favor rice monoculture and how farmers' own preferences for more controlled fish pond culture works against rice-aquaculture. The comparative analysis also demonstrates the need to disaggregate rice farming systems when considering their potential for diversification.

Presently, training in IPM technology is not useful in helping fish culture, but new courses could be designed to overcome this constraint. Therefore, although rice-aquaculture can be profitable, the constraints to its adoption at household level must be understood if its adoption is to be more widespread.

Meryl J. Williams
Director General
International Center for Living Aquatic Resources Management

References:

International Rice Research Institute, Centro Internacional de Agricultura Tropical and West African Rice Development Association. 1997. Rice almanac. International Rice Research Institute, Los Baños, Laguna, Philippines. 181 p.

Lightfoot, C.L., B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao, editors. 1992. Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Dela Cruz, C.R., editor. 1994. Role of fish in enhancing rice field ecology in integrated pest management. ICLARM. Conf. Proc. 43, 50 p.

Gupta, M.V., J.D. Sollows, M.A. Mazid, A. Rahman, M.G. Hussain and M.M. Dey. 1998. Integrating aquaculture with rice farming in Bangladesh: feasibility and economic viability, its adoption and impact. ICLARM Tech. Rep. 55, 90 p.

Foreword

The more developed regions of the world will enter the new millenium with a stationary population, and may face the problem of declining internal demand for food and disposal of surplus. But the population explosion is still continuing in the less developed regions, particularly in countries where poverty and hunger are widespread. These countries are equipped with only limited financial ability to procure food from the world market. Demographers project that the population of the less developed regions will increase by another 2.2 billion within the next three decades. Two-thirds of this additional number will be located in Africa and South Asia. The national agricultural research systems and the international agricultural research centers will thus continue to face the problem of how to support increasing food supply for the rapidly growing population, while releasing resources for the growing nonfarm sectors of the economy.

In humid Asia, water in the lowland paddy fields is a resource that has not yet been fully exploited in our quest for producing more food. Indeed large-scale water development projects that have supported increasing rice production have reduced the habitat for naturally occurring aquatic animals. While in the past IRRI and ICLARM separately dealt with research on rice and fish, promoting the combination of rice-fish farming systems offers a new way to exploit synergistic effects of two production subsystems and to achieve food security with sustainable farming practices.

This study has brought IRRI and ICLARM together in understanding farmers' current practice of rice-fish systems and in analyzing their potential contribution to household income, food security and balanced nutrition. This study was conducted in two provinces, namely, Nueva Ecija, Central Luzon, a more market-oriented environment, and Antique in Panay Island province, a more subsistence-oriented environment. With the use of the linear programming (LP) model, the author has demonstrated the potential positive impact of rice-aquaculture and/or integrated pest management (IPM) practices on farm household incomes and nutrition. This study also showed that while women tend to overwork in the farm and on expenditure-saving home-based activities to augment household incomes, men could utilize part of their leisure time for labor-intensive technologies such as rice aquaculture and IPM. The author argues that the pressure to generate more income, distance from rivers and coastal area for exploiting opportunities for commercial fishing, rice paddies providing habitat for preferred fish species, proximity of the rice-fish field to the homestead, and use of wild aquatic organisms as predators for rice pests, are key favorable factors for the promotion of large-scale rice aquaculture and IPM. An important finding of this study is that there is no significant association between IPM and aquatic life management (ALM).

While there are niches for rice-aquaculture farming systems, as practiced in the Philippines, it is not yet adopted on a large scale due to various constraints, including access to efficient marketing network and inadequate demonstration of profitable technological options. Research institutions must collaborate with extension agencies including nongovernment organizations (NGOs) to involve both men and women farmers in the design and promotion of the rice-aquaculture farming system, demonstrate integrated pest control for both rice and fish, and conduct training for improved understanding of IPM and ALM. We hope this book will contribute to raising awareness among policymakers and development agencies regarding the potential of utilizing water resources in rice paddies for producing more food in the humid tropics, and the allocation of additional resources for research and extension activities.

Ronald P. Cantrell
Director General
International Rice Research Institute

Foreword

Studies that deal with transdisciplinary issues are sparse because they require scientists to be multi-disciplined and to venture into the sphere of other interest groups. A good example is the study of the socioeconomics of integrated rice fish culture in Asia.

While integrated rice-fish culture, like many integrated farming systems, became marginalized as a result of the dominance by the differentiating forces in the agricultural sector, it was realized that aquatic organisms do play a role in modern rice culture. Although aquatic products from wetland ricefields may not reach a large market share, they are a decisive element in the nutrition of the rural landless poor in particular. The assumption that the benefits of intensive modern rice culture allow to ignore its externalities was proven wrong. Of special interest in this context is the excessive use of pesticides in ricefields with its negative effects on human health and its threat to the ecology of rice production systems. The response of national and international research and development organizations was to introduce the concept of integrated pest management. At the same time, the rediscovery of the importance of aquatic organisms by NGOs and national governments has led to programs in support of rice-fish culture systems for small-scale farmers. The International Center for Living Aquatic Resources Management (ICLARM) became the focal point of this undertaking. Unfortunately, both programs, integrated pest management and integrated rice-fish culture remained below expectations. Most remarkably, despite many commonalities, communication between both groups was almost nonexistent prior to the study of Gesa Horstkotte-Wesseler. Her research tackles this communication gap and investigates the complementarity between the multiproduct system `integrated rice-fish culture' and a rice management technology like IPM. One of the important by-products of her work was to join forces between two international organizations: the International Rice Research Institute and ICLARM. Although this task was an input to the research, the fact that it took place has turned this activity into an output itself.

The findings of this research do not promote specific production systems but they show the niches where there is a role for aquatic resources management in increasing income for small-scale, subsistence farmers, in balancing the supply of animal protein for marginalized people throughout the year and, most importantly, in demonstrating the ecosystem interactions on which intensive production systems still depend. It is probably the last point that underlines the value added of this research: showing that also in modern intensive rice cultivation there are more concerns than short-term production efficiency. Results of the study support ICLARM's priority in the context of its strategic plan. The study may serve as an important reference for the planning of aquatic resources management interventions and their relationships to other production systems.

Hermann Waibel
Hannover, March 1999

Acknowledgements

This study is the result of a collaborative effort between three institutions, namely the Department of Agricultural Economics of the University of Göttingen, Germany, the International Center for Living Aquatic Resources Management (ICLARM), Makati, Philippines, and the International Rice Research Institute, Los Baños, Philippines. These three institutions entered into a collaborative research agreement whereby each provided scientific, administrative and office support. Financial support was provided by the Bundes-ministerium für Wirtschaftliche Zusammenarbeit (BMZ) through the German Agency for Technical Cooperation (GTZ) under its program for Special Studies in International Agricultural Research (Project ID: 91.7860.9-01.185). This collaboration and funding was crucial for the completion of the study and I would like to thank everybody involved in making it happen.

The study would not have been possible without the help and support of many people. First and foremost, I would like to thank the families and individuals in Nueva Ecija and Antique who patiently answered all my questions and who went through the trouble of having their farming activities, time allocation and food consumption monitored over the course of one year, without any obvious benefit to themselves. Many thanks also to the village study assistants and survey enumerators for the great job they did in the field, and to all respondents in the various surveys that became part of this study, who must have wondered why anybody would want to have this kind of information. In particular, I want to thank the families who provided accommodation for the study team during the field activities, making us feel so much at home.

Of great value for the research was my supervisor at the University of Göttingen, Prof. Dr. Hermann Waibel. I express my sincere thanks for his unlimited support and confidence, even in difficult times, and for his enthusiasm in visiting even the most remote villages to interact with the people and to understand their perceptions, practices and constraints.

Furthermore, I would like to thank Prof. Dr. Hartwig de Haen of FAO for his valuable comments during the writing of the dissertation and for his willingness to act as the second supervisor to this study. Prof. Dr. Winfried Manig of the University of Göttingen provided very helpful advice during the presentation of the study outline. I would also like to thank all my colleagues in Göttingen who cheerfully tolerated the transformation of the office desk into a diaper changing station and whose support greatly eased my reintegration into colder climates.

At ICLARM, I am very much indebted to Dr. Clive Lightfoot for his many inspirational ideas, guidance and confidence, as well as to Dr. Mark Prein who saw this study through to the final publication. Of my other colleagues at ICLARM who all contributed to a thoroughly enjoyable and stimulating work environment, I would like to mention Dr. Roger Pullin, Dr. "Deng" Palomares, Dr. Peter Dalsgaard, "Maan" Bimbao, "Tet" Lopez, Farlyz Villanueva, "Louie" Orencia, "Dea" Bonilla, "Malu" Tungala and Liza Camañag who helped with big and small problems and generally kept my spirits up.

I gratefully acknowledge the editorial improvement of this text by Jeanette Rive and the layout and cover design by Mayanne Wenceslao. The publication production process was coordinated by Lhai Kasala and Sheila Siar.

At IRRI, I owe special thanks to Drs. Prabhu Pingali, Mahabub Hossain, Kong Luen Heong and James Litsinger who all contributed greatly to the success of the study from their various disciplines and perspectives. Their diverse views on the future of rice farming in the Philippines were highly inspiring and gave me the opportunity to see the complexity of the problems. I would also like to thank

IRRI for providing the vehicle for field work in Nueva Ecija. Dr. Peter Kenmore of the FAO Inter-country IPM Programme offered many stimulating insights on the paradigm shift in Integrated Pest Management and its philosophical underpinnings, and he facilitated the training of enumerators for the IPM/ALM survey in Antique by Ms. Dina Casa. Ms. Dada Morales and Mr. Cesar Galvan of the FAO Inter-country IPM Programme introduced me to the practical implementation of Farmers' Field Schools and shared their enthusiasm and dedication for the process.

The Antique Integrated Area Development (ANIAD) Foundation, Inc., provided office space and logistical support for the field work and I am grateful to Goldelino Chan, Arnold Vandenbroek and all other staff of ANIAD. Most particularly, I would like to thank Willemine Brinkman for not only sharing her house but also for becoming a wonderful friend.

A special word of gratitude is addressed to my parents who have always encouraged and supported me to develop in the direction I wanted. Most of all, I am grateful to Justus who has shared the Philippine experience from a somewhat "higher" perspective and who was much more optimistic about my ability to finish this study than I could ever have been. About two-thirds of the way to completion, we were joined by our son, Paul, who changed our lives more profoundly than anything else, and has made me understand the need for sustainability. He will hopefully read this book and find it interesting when he grows up.

Executive summary

Small-scale farmers in intensive rice-based farming systems in the Philippines are facing a set of three interrelated problems: maintaining an adequate income, securing a balanced diet for their families and preserving their natural resource base for future agricultural production. Farmers have increasingly become dependent on external inputs such as fertilizers and pesticides for a growing cropping intensity. These developments have led to the degradation of the ricefield environment and to increasing ecological and human health costs due to the injudicious and unsafe use of pesticides. On the other hand, declining marine catches emphasize the need to look for alternative sources of animal protein for an ever growing population.

To combat these problems, a number of strategies have been proposed. This study has concentrated or focused on two alternative technologies to intensive rice monoculture, namely rice-aquaculture and IPM.

Rice-aquaculture has long been regarded as an environmentally sound alternative to intensive rice monoculture for small-scale farmers in Southeast Asia. While populations of wild aquatic organisms from ricefields have been drastically reduced with the spread of modern rice varieties, technological progress in aquaculture has helped to overcome many of the problems associated with rice-aquaculture systems. However, adoption of this technology has been minimal in the Philippines.

IPM seeks to minimize pesticide use in rice growing. The emergence of a new paradigm for IPM based on improved farmers' decisionmaking and understanding of ecosystem processes offers a way to integrate rice-aquaculture with IPM, the aquatic organisms being an additional incentive not to use pesticides.

Based on the theoretical background of farm production theory and farm household theory, it was hypothesized that rice-aquaculture and IPM have a positive impact on household income and household nutrition. In Antique, a relatively remote and underdeveloped province, common property resources such as irrigation canals, water courses and roadsides are utilized by many farmers and a wide variety of plants and trees are grown for subsistence purposes in the homestead or in other natural resource types. In contrast, farmers in Nueva Ecija are more market-oriented, with less diversity in their farming systems and less subsistence production than in Antique.

By using secondary data from the Philippines, it could be shown that rice-aquaculture is a more labor-intensive farming practice than rice monoculture. This study showed that while the women's time is already taken up to a large extent by farm and household activities, men have considerable leisure time which could be utilized for labor-intensive technologies such as rice-aquaculture and IPM.

- While wild fish from ricefields are consumed by farmers and landless laborers alike, there are indications that other organisms such as frogs, crabs and edible snails are more appreciated by landless laborers than by farmers.
- The food consumption pattern of farm households showed that a typical Filipino meal consists of rice, vegetables and either fish, meat or eggs. While fresh fish is the main source of animal protein in both provinces, it is consumed twice as often in Antique as in Nueva Ecija.

- The share of aquatic organisms which can be produced or caught in ricefields amounts to only between 4% and 6% of all animal protein foods.
- Rice-fish farmers in Nueva Ecija consume more fresh fish than non-rice-fish farmers in the same province. In addition, there are indications that rice-fish farmers have a higher income than non-rice-fish farmers which allows them to consume greater amounts of meat and poultry.
- In terms of recommended dietary allowances, the diet of rice-fish farmers in Nueva Ecija seems to be more or less adequate. In contrast, non-rice-fish farmers in Nueva Ecija have a deficient intake of animal protein foods whereas farmers in Antique have a balanced but insufficient diet.
- However, a preference ranking of different fish species among women in Antique revealed that marine fish is highly preferred over freshwater fish and that wild fishes occurring in ricefields are valued higher than fishes suited for rice-aquaculture.

The hypothesized complementary relationship between IPM and aquatic life management (ALM) was analyzed with the help of scales which measure farmers' proficiencies and skills in both technologies. These results imply that trained farmers have increased their knowledge and skills with regard to IPM but have remained at the same level of ALM as before the training. It can thus be concluded that IPM training has no impact on proficiencies and skills with regard to ALM.

Partial analyses of the income effect of rice-aquaculture suggest that this farming practice is a profitable alternative to rice monoculture. In order to analyze this effect in a farm-household context, a linear programming model was developed which simulates the allocation of land, labor and capital for the integrated production of rice and tilapia in a typical Philippine farm-household system, both under conventional pest management and IPM. In addition, the model accounts for the nutritional requirements of the household and allows for time spent in off-farm activities.

While returns to land and labor are considerably greater in the case of rice-aquaculture, returns to cash are slightly higher for rice monoculture under IPM. These results suggest that the availability of own funds or access to credit can be a serious constraint to rice-aquaculture, which is further stressed by the observation that cash requirements are particularly high in the beginning of the first cropping season when most own funds have been exhausted. Labor requirements also increase considerably under rice-aquaculture.

While it was expected that food expenses would decrease with the practice of rice-aquaculture, all fish produced in the farm of marketable size are sold and none is consumed in the household. This shows that there are cheaper sources of animal protein available to the farmer than own fish.

A price sensitivity analysis for tilapia revealed that price reductions of up to 45% have no impact on the optimal solution of the base model. Further price decreases lead to the gradual replacement of rice-fish culture by rice monoculture. Only at 70% price reduction is rice-fish culture no longer part of the optimal solution. This high stability of the solution indicates that rice-fish culture can even be competitive in areas where the price for these fish is low. At the same time, however, the amount of own fish consumed in the household increases with decreasing prices.

If additional benefits of IPM such as reduced health costs due to reduced pesticide use and increased populations of wild aquatic organisms are included in the model formulation, the main effect on the farmers is a reduction in food expenses because of the consumption of snails, frogs, crabs and fish.

The competitiveness of rice-aquaculture increases with a growing ratio of family labor over land. An interactive process revealed that while farmers expressed an interest in rice-aquaculture, they had other priorities such as livestock raising and vegetable culture. Furthermore, farmers preferred to have backyard fishponds rather than converting their ricefields for a rice-aquaculture enterprise. They can be constructed near the house and tenants do not have to negotiate with their landlords the conditions of a rice-aquaculture operation. In addition, backyard ponds can be used for the culture of higher-valued fish such as catfish.

It is concluded that while there is a niche for rice-aquaculture in Philippine rice farming systems, it is not likely to be adopted on a large scale. Figures defining the potential area for rice-aquaculture in a country should be adjusted to account for the differential types of riceland as well as for the distance of fields from the farmer's house. Food consumption habits need to be considered in the promotion of new agricultural or aquaculture products and farmers should be given the opportunity to select among different options for diversification rather than facing only one alternative. IPM improves the environmental sustainability of rice production and can lead to a return of wild aquatic organisms to the ricefields. The revival of capture systems of rice-aquaculture through IPM is the least costly, least risky option which benefits landless laborers as well as farmers and steps should be taken to integrate the management of aquatic organisms in ricefields with IPM training programs.

List of acronyms and abbreviations used

ADB	Asian Development Bank
ALM	Aquatic life management
ANIAD	Antique Integrated Area Development Foundation, Inc.
BAS	Bureau of Agricultural Statistics
BFAR	Bureau of Fisheries and Aquatic Resources
CLSU	Central Luzon State University
CPI	Consumer price index
DAS	Days after seeding
DAT	Days after transplanting
DS	Dry season
EM	Ecosystem management
ET	Economic threshold
FAC	Freshwater Aquaculture Center, CLSU
FAO	Food and Agriculture Organization of the United Nations
FFS	Farmer Field School
FL	Family labor
FNRI	Food and Nutrition Research Institute of the Philippines
FPA	Fertilizer and Pesticide Authority of the Philippines
FSR/E	Farming Systems Research and Extension
GTZ	German Agency for Technical Cooperation
HYV	High yielding varieties
ICLARM	International Center for Living Aquatic Resources Management
IPM	Integrated pest management
IPP-Curve	Intertemporal production possibility curve
IRRI	International Rice Research Institute
KAP	Knowledge, attitudes and practices
MEY	Maximum economic yield
MBCR	Marginal benefit cost ratio
MRPS	Marginal rate of product substitution
MSY	Maximum sustainable yield
MV	Modern variety
NRT	Natural resource type
NSCB	National Statistical Coordination Board
NSO	National Statistics Office
pd	Person day
PEM	Protein-energy malnutrition
PhP	Philippine peso
PhilRice	Philippine Rice Research Institute
Pn	Current price
Po	Base year price
RDA	Recommended dietary allowance
RESTORE	Research Tool for Natural Resource Management, Monitoring and Devaluation
RP	Republic of the Philippines
RPI	Retail price index
TVP	Total value product
VMP	Value of the marginal product
WHO	World Health Organization
WS	Wet season
Wo	Base year weight

Chapter 1

Introduction

The heading of an article in the January/February 1991 issue of AgriScope, a Philippine agricultural journal stated that '*Ricefield fish culture is good farming idea*' (Martinez 1991). At around the same time, two other subjects were discussed repeatedly in newspapers and journals all over the world, exemplified by these headlines:

'*Severe fish shortage predicted in 3 years*' was the headline of the Philippine Times Journal of November 12, 1992 (Anon. 1992). And indeed, '*RP suffers worst fish shortage, says BFAR*'[1] could be read in the Sunday Times of November 21, 1993 (Anon. 1993). In April 1995, Newsweek devoted its cover story to the same subject: '*Empty nets – too many fishermen, too few fish*' (Emerson 1994).

A little earlier The U.S. News & World Report had published an article in its September 14, 1992 issue entitled '*The joy ride is over – farmers are discovering that pesticides increasingly don't kill pests*' (Holmes 1992). In Indonesia, 57 trade formulations of insecticides for use on rice were banned in 1986 and price subsidies for pesticides were subsequently eliminated (Kenmore 1991). Consequently, the use of pesticides on rice crops dropped by almost two-thirds from 14 200 metric tons in 1986 to 5 800 tons in 1987 (Todd 1988).

Brought together under a common context, these headings define the scope of this study. It deals with the potential of integrated rice-aquaculture at a time when intensive rice monoculture systems show signs of degradation and marine resources are becoming exploited. In particular, the contribution of rice-aquaculture to income and nutrition of small-scale rice farmers[2] is analyzed. The study also investigates complementarities between rice-aquaculture and integrated pest management (IPM), proposing that in combination, these technologies can overcome constraints to adoption and offer rice farmers viable and environmentally sound alternatives.

The practice of raising aquatic organisms in ricefields has a long tradition in many parts of Asia. Its decline began with the diffusion of the Green Revolution technology which made the growing environment less favorable to aquatic organisms. However, over the past 20 years it has attracted renewed attention, mainly for two reasons (Waibel et al. 1993):

- Wild fish populations in inland water resources throughout Asia are decreasing as a result of water pollution and overfishing.
- Technological progress in aquaculture such as the development of more reliable hatchery, nursery and grow-out methods for small-scale farmers, improved feeding techniques by use of on-farm resources, as well as the genetic improvement of fish species suited for culture in ricefields, gives further scope for the potential of integrated agriculture-aquaculture systems.

---

[1] RP = Republic of the Philippines; BFAR = Bureau of Fisheries and Aquatic Resources.
[2] The term 'farmer' comprises both women and men.

IPM seeks to minimize pesticide usage in rice. The initiatives to look for sustainable pest management technologies were triggered by environmental damage, the development of pesticide resistance and the increasing health risks to users in developed as well as in developing countries (Rola and Pingali 1993).

However, adoption of both rice-aquaculture and IPM has been slow when they have been promoted separately. A number of drawbacks in design and promotion prompted many farmers to return to their old practices as soon as the external influence (such as a government program or project) terminated. In this study, the possibility of combining the two technologies in order to exploit synergies and to overcome constraints to adoption is being explored. On the one hand, aquatic organisms can act as a vehicle for the introduction of sustainable farming practices, such as IPM. The potential loss of aquatic organisms through the use of pesticides can be so big that it pays for farmers to stop using pesticides, even without the application of knowledge-intensive methods. On the other hand, knowledge and skills in IPM-techniques can make farmers more confident to culture aquatic organisms in their fields, which will give them a new source of income and easy access to protein-rich food. Thus, the combination of rice-aquaculture and IPM offers a new way to exploit synergistic effects of two production subsystems and to generate sustainable farming practices.

This study was initiated as a collaborative project between the International Center for Living Aquatic Resources Management (ICLARM), the International Rice Research Institute (IRRI) and the Institute of Agricultural Economics, University of Göttingen, with funding from the German Agency for Technical Cooperation (BMZ/GTZ).

Empirical work for this study was undertaken in the Philippines. Therefore, secondary data from this country are used as much as possible, even if the developments discussed pertain to the larger region.

The chapters are organized as follows:

Chapter 2 presents background information on rice and fish production in Southeast Asia and discusses the nutritional situation of rice farmers. It closes by stating the objectives of the study.

Chapter 3 provides an overview of small-scale aquaculture on rice-based farming systems in Asia. An introduction to ricefield ecology is followed by a classification of aquaculture systems in rice and a brief review of the historical development of aquaculture in Asia. The preconditions and requirements of rice-aquaculture systems are stated and tilapia production in the Philippines is reviewed.

Chapter 4 deals with aspects of pest control in irrigated rice in Southeast Asia. After presenting technical aspects of rice pests and pesticides, the development of pesticide markets in Southeast Asia is reviewed. In addition to a discussion of pest management practices of rice farmers in the Philippines, research findings on the farm-level economics of pesticide use in rice are summarized. The concept of IPM is introduced and bio-physical interactions between rice-aquaculture and IPM are presented.

The theoretical background for this study is provided in Chapter 5 which begins by reviewing the theoretical context of the green revolution. Next, the shift in focus from the production system to the farm household system is discussed. Farm production theory and the theory of the farm household provide the theoretical framework for the selection of enterprises in the farm household system. This theoretical background leads to the formulation of hypotheses for the subsequent empirical part of the study.

An introduction to the study area is the topic for Chapter 6. Rice cultivation practices and rice-based farming systems are described, followed by an analysis of labor requirements for rice production and additional labor needed for rice-aquaculture and IPM. The time allocation of rice farm households is analyzed with respect to the intra-household division of labor and the availability of labor for additional farming activities.

Chapter 7 deals with the role of aquatic ricefield organisms in farm-household nutrition in the Philippines. Current utilization patterns of aquatic organisms are examined and the diet of rice farmers is analyzed with particular reference to the supply and sources of animal protein. An attempt is made to elicit farmers' preferences for different types of fish.

Chapter 8 presents an analysis of the association between IPM and aquatic life management (ALM) and the implications of this relationship for sustainable farming practices.

In Chapter 9, an economic assessment of rice-aquaculture with and without IPM is conducted with the help of partial and whole- farm analyses. A linear programming model is employed to simulate different scenarios of IPM and rice-aquaculture practices and their combinations, in order to determine the most profitable option and to identify constraints. The model is augmented by a nutritional component to study the impact of different technology options on household nutrition. In addition to a base model, various sensitivity analyses are conducted.

The findings and conclusions of this study are discussed in Chapter 10 and summarized in Chapter 11.

Chapter 2

Problem analysis and objectives

Sustainability of intensive rice production systems

Irrigated rice production in most rice-growing regions of the world has undergone tremendous changes since the 1950s. A continuously growing population and the rapid closing of the land frontier in Southeast Asia after World War II called for higher land productivity and cropping intensity to meet the growing demand. The introduction of modern varieties (MVs) in the 1960s has contributed to a significant increase in irrigated rice production (Herdt and Capule 1983; Barker and Herdt 1985), leading to the development of farming systems in the irrigated lowlands where rice is predominantly grown in monoculture with up to three harvests per year (Barker and Herdt 1985; Lipton and Longhurst 1989). The effect of these developments could be felt from the field level up to the national level. While the so-called 'Green Revolution' has been heavily criticized mostly for issues relating to economic and social equity (e.g. Griffin 1974), the environmental consequences of an intensification of rice production have received little attention so far. However, shorter growth duration, increasing land-use intensity, monoculture and higher use of chemical inputs have all had an impact on the ricefield ecosystem which raises questions about the sustainability of intensive rice production.

The spread of MVs throughout Asia was extremely rapid by any standard (Dalrymple 1985). In 1965, there was almost no use of MVs. By 1970, they were covering 9 million hectares or 12 percent of the rice growing area, 23 million hectares or 28 percent in 1975, and 33 million hectares or 40 percent in 1980 (excluding Cambodia, Laos, and Vietnam) (Barker and Herdt 1985). During that time, rice production grew faster than the population in many developing countries of Asia (following the FAO classification).

For example, between 1960 and 1980, the production increased by an annual average of 3.02% in Cambodia, 3.82% in China, 3.47% in Indonesia, 3.14% in Laos, 3.13% in Myanmar, 3.20% in Pakistan, 3.41% in the Philippines, and 2.04% in Sri Lanka.

The corresponding increases in population are 0.86% in Cambodia, 2.13% in China, 2.29% in Indonesia, 1.94% in Laos, 2.24% in Myanmar, 2.27% in Pakistan, 2.84% in Philippines, and 2.02% in Sri Lanka.

However, what had first been regarded as an overwhelming success for the food security and income of small-scale rice farmers, soon began to show problems. Declining rice prices, a growing dependence on external inputs (chemical fertilizers and pesticides), an increased production risk through the loss of diversity in the farming systems as well as growing resistance of pests to the common pesticides leading to epidemic pest outbreaks, all exemplify the limits of modern production technology (e.g. Pingali et al. 1990; Pingali 1992; Lipton and Longhurst 1989). Since the middle of the 1980s, this situation has been further exacerbated by the realization that the highest yields at experiment stations in the Philippines have been exhibiting a long-term decline (Flinn et al. 1982; Flinn and De Datta 1984; Pingali et al. 1990; see also Box 2.1), giving cause for the concern that the growth in aggregate rice output has peaked and is starting to decline (Byerlee 1987; Barker and Chapman 1988).

Box 2.1

LONG-TERM RICE YIELDS AT RESEARCH STATIONS IN THE PHILIPPINES

IN THE PHILIPPINES, rice yields on farmers' fields have continued to increase since the first MV (IR8) was distributed on a large scale. They rose from a national average of 1.32 t/ha in 1966 to 2.85 t/ha in 1992 (IRRI 1995). In contrast, yield levels of IR8 and the highest-yielding entries in nitrogen-response trials at four Philippine research stations have exhibited a long-term decline. At the time of its release in 1966, IR8 yielded as much as 10 t/ha in the dry season and 6 t/ha in the wet season under experimental conditions, while farmers in the neighborhood of the research station were getting yields of 2.0-2.5 t/ha. Since then, yields of IR8 have declined by 0.15 t/ha/year in the wet season and 0.3 t/ha/year in the dry season (Flinn and De Datta 1984). None of the later varieties with better insect and disease resistance have been able to match the initial yield potential of IR8. Likewise, the highest- yielding entries in nitrogen response trials have declined at an annual rate of 0.1 t/ha in both the wet and the dry season (Flinn and De Datta 1984). This phenomenon can be linked to the intensification of rice production systems described below. Both the increase in cropping intensity under a single crop and the greater use of chemical fertilizer and pesticides lead to a degradation of natural resources such as soil microorganisms and nutrients as well as of beneficial organisms capable of keeping insects pests and diseases under control. While no definite relationship has been established yet, it is suggested that the chemical properties of organic matter fractions change over time in continuously submerged soils, and that these changes reduce the rate of N mineralization and thus reduce the soil N supply that is available to the rice crop (Cassman and Pingali 1993). Pesticides have negative external effects on the environment on- and off-farm and on human health (Rola and Pingali 1993). Indiscriminate pesticide use, by disrupting the pest-predator balance, leads to higher pest-related crop losses than no application of pesticides at all (Rola and Pingali 1993). It thus becomes increasingly obvious that intensive, lowland irrigated rice production systems which depend heavily on external inputs raise serious doubts about their sustainability.

As the new varieties of rice were disseminated throughout tropical Asia in the 1960s, it became increasingly evident that they were best suited to irrigated and favorable rainfed lowland conditions (Herdt and Capule 1983; Barker and Herdt 1985; David 1990). Indeed, a positive association between irrigation ratio and share of MVs in total rice area can be found. Adoption studies indicate that environmental characteristics, especially degree of water control or irrigation, are the most important factors explaining differential technology adoption (Barker and Herdt 1985; Lipton and Longhurst 1989; David 1990). The environmental effects of MVs can therefore best be observed under irrigated conditions. Since a sufficient and reliable water supply as well as a high level of water control are also preconditions for the culture of aquatic organisms in the ricefield, it can be assumed that those areas where integrated aquaculture has a potential are predominantly planted with MVs.

The changes in rice agronomy associated with the spread of MVs and with consequences for the aquatic life in the field mainly pertain to cropping intensity[3], crop rotation[4] and the use of chemical inputs. Short-duration MVs of rice increased the area of land that can grow two or even three crops per year, provided that there was adequate water control (Barker and Herdt 1985). Higher yields and higher profitability of MVs compared to traditional varieties induced farmers to grow the same crop

3 For the purpose of this study, cropping intensity is defined as the number of crops per year on a given piece of land.

4 Crop rotation refers to the sequence of crops grown on a given piece of land. The extreme case is monoculture where the same crop is grown in succession season after season.

or even the same variety for several years in succession, often with two or three seasons a year and to displace other crops that used to be part of the rotation (Lipton and Longhurst 1989).

The loss of crop and varietal diversity in the field increases the risk of pests and diseases, because they reduce, respectively, seasons and places when the pest lacks its preferred food (Lipton and Longhurst 1989). This, in turn, increases the period over which exponential build-up of a crop pest is possible. Hoppers and borers for example, could have year-round homes (Lipton and Longhurst 1989).

MVs are shorter and stiffer-stemmed than the traditional varieties, which makes them resistant to lodging and achieves high fertilizer response (predominantly to nitrogen) (Barker and Herdt 1985). Consequently, chemical fertilizer consumption in Southeast Asia increased tremendously from the 1960s to the early 1990s. Only few national data series indicate how much fertilizer is used on rice and how much is used on other crops. However, estimates giving an indication of the trends in fertilizer use on rice during the post-World War II decades have been derived from surveys. Following these estimates, fertilizer use on rice increased from less than 5 kg/ha in the late 1950s to 30-50 kg/ha in the late 1970s in many developing countries in South and Southeast Asia (Barker and Herdt 1985). It can be assumed that use must have increased even more in the 1980s.

There are two aspects to the increase in fertilizer use. On the one hand, the culture of MVs requires appropriate fertilization to avoid a decline in soil fertility due to a rapid depletion of soil nutrients. On the other hand, the increased use of fertilizer on MVs, which provide less of a crop canopy, compounded the problems of weed control (De Datta 1981). The interaction of fertilizer application and insect control is another common example resulting in undesired effects of fertilizer use. If the variety is susceptible to a particular insect or a group of insects, heavy application of nitrogen fertilizer may aggravate the problem. Without insect control, it may be desirable to apply little or no fertilizer (De Datta 1981). Therefore, the effect of increased fertilizer use on the ricefield environment has to be seen in connection with an increased use of chemical pesticides on rice.

With traditional varieties, the use of chemical pesticides on rice was almost nonexistent. Adaptation to pests was achieved by the selection of varieties that are resistant to diseases and insects, genetic diversity in the field and cultural practices such as crop rotations, fallow periods and transplanting in order to combat weeds (Norton and Way 1990). The introduction of MVs, which initially were attacked for their 'notoriously low threshold', for being 'susceptible to disease and insects' (Lipton and Longhurst 1989) changed this situation.

Pesticide use in selected developing countries in Asia increased at an annual compounded rate of growth of 7.6% between the early 1960s and the late 1970s (Barker and Herdt 1985). This rate increased to roughly 12% in the Philippines, Thailand and Vietnam, and to more than 20% in Indonesia between 1980 and 1992 (own computations based on IRRI 1995)[5].

Because of the still comparatively low level of pesticide use in the developing countries of Southeast Asia, concern about pesticide use in rice is more about injudicious and unsafe use rather than overly intensive use (Rola and Pingali 1993)[6].

The Green Revolution in rice has raised productivity in the irrigated lowlands of South and Southeast Asia. However, there is reason to believe that the positive trend in production cannot be projected into the future. Environmental sustainability of rice production is the key issue that needs to be resolved in order to protect the natural resource base.

---

5 For a more detailed discussion of pesticide market development see Chapter 4.
6 Issues relating to pesticide use and pest management in rice will be discussed in detail in Chapter 4.

Developments in marine fisheries and aquaculture

Questions of sustainability also arise when discussing fishery resources. While from the late 1940s to 1971 annual marine fish production increased by 6% per year on average, the growth rate fell to only 2.3% in the 1970s and 1980s:

> "Much of these smaller production increases over the last two decades reflects an increased number of countries reporting catches to the FAO, a greater number of different species landed, and an increase in the extent of waters fished. Catches of many of the species groups with the longest histories of harvesting, such as demersal fish, lobsters, and sharks, have increased little over the last 20 years (Williams 1996, p. 5)."

In 1992, an FAO-report revealed that more than a quarter of the 200 fished stocks in all parts of the world are overexploited, depleted or recovering. These stocks can only produce greater catches if they are returned to a healthier state. Thirty-eight percent are fully exploited and cannot produce more catch without depleting the base stock (Williams 1996).

Returns to fishing efforts are also declining, which is evident from FAO-estimates that the world fishing fleet increased at twice the rate at which fish catches increased over the last 20 years (Williams 1996). The reasons for this development and the relationship between biological and economic overfishing are presented in Figure 2.1. Annual fishing effort (measured in number of fishing gear or boats, operating hours, or number of fishers[7]) and the resulting yield can be linked by a parabola

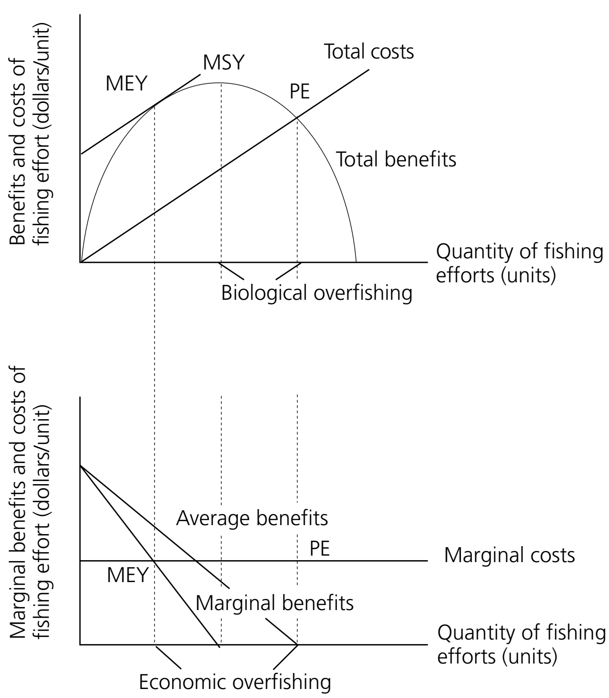


Figure 2.1. Economic and biological overfishing. Source: modified after Tietenberg 1988.

[7] The term "fisher" refers to both men and women.

which reaches its maximum in the 'maximum sustainable yield' (MSY), beyond which biological overfishing occurs. Every additional effort leads to a decrease in total yields because stocks are exploited and do not have time to recover. However, because of the open access nature of marine fisheries, the individual fisher will increase his or her efforts as long as the average returns are higher than the fishing costs. Thus, from the individual's point of view, an equilibrium is reached in point personal equilibrium (PE). This point is far beyond the 'maximum economic yield' (MEY) where the difference between total effort and total yield is maximized (marginal benefits = marginal costs), and also beyond the point of maximum sustainable yield (Pauly and Saeger 1992). Therefore, further increases in fishing effort will cause further declines in catch per unit effort.

Only the better management of marine resources will be able to reverse this trend of declining catches and degradation. In the meantime, the growing demand for fish by an ever increasing population has to be satisfied by other means. Aquaculture production is expected to bridge the supply-demand gap:

> "World aquaculture production (marine and inland) more than doubled between 1984 (the first year with recorded global statistics) and 1993, reaching 16.3 million tons (FAO 1995). It is difficult to estimate potential global production because new technologies and new enterprises will certainly push the potential up, within the limits of the natural resource base and access to it. In contrast to natural fisheries production, production from aquaculture could greatly increase if care is taken in the expansion (Williams 1996, p. 5)."

The Philippine example is a case in point. Fish is the most important source of animal protein in the Filipino diet (FNRI 1984, 1987). Fish provides 30% of total protein intake and accounts for about 70% of food supply from animal origin (ADB 1993a). Annual per-capita consumption of fish in the Philippines is estimated between 35 and 40 kg, one of the highest in the world (ADB 1993a; FAO 1993).

Aggregate fish/marine production rose by 3.18% from 2.21 million mt in 1987 to 2.36 million mt in 1989 (NSCB 1990), mainly due to the upgrading of fishing vessels and promotion of deep sea fishing, i.e. further exploitation of stocks without replenishment (NSCB 1990). Pauly and Saeger (1992) have described the decline in fish stocks in the Philippines and the corresponding increase in fishing efforts since the 1940s: fishing efforts are far beyond the economic or ecological optimum, based on the need of the individual fisher to earn his or her living. Consequently, it can be expected that total fish catches will decline, leading to increased competition over scarce resources and further deterioration of the livelihood of small-scale fishers. In addition, the resulting price increases for marine fish without any readily available substitute will further squeeze the incomes of small-scale farmers for whom fish is the most important source of animal protein.

On the other hand, there has been an increase in the competitiveness of aquaculture in the fisheries sector of the Philippines[8]. Figure 2.2 demonstrates the growing importance of aquaculture compared to commercial and municipal fisheries. In addition, the figure indicates that there is a growing conflict

---

[8] For administrative purposes, fishing activities in the Philippines have been categorized as commercial (farther than 15 km offshore, involving vessels in excess of three gross tons), municipal (inland, tidal, and marine waters within 15 km of the municipal coastline, involving vessels of three gross tons or less) and aquaculture (the controlled rearing of aquatic plants and animals in fresh, brackish and marine waters) (ADB 1993a).

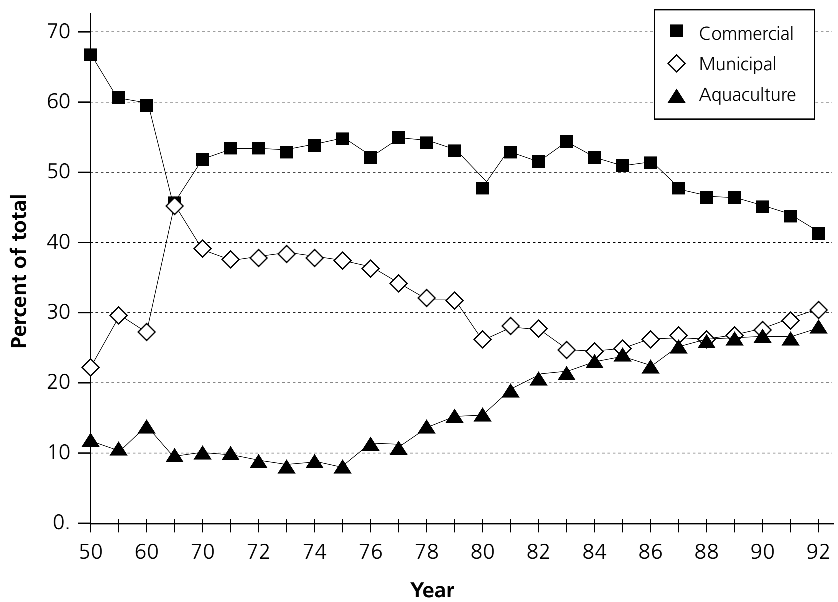


Figure 2.2. Quantity of fish production by type of production (in percent of total), Philippines, 1950-1992. Source: NSCB 1993.

between commercial and municipal fisheries, the main burden of which is carried by municipal (i.e., small-scale) fisherfolk.

The fact that the share of municipal fish production in total fish production is declining while population densities in coastal areas are still growing, suggests that real incomes of municipal fisherfolk are decreasing. The Philippine Fisheries Management and Development Plan, which was pursued by the Government during the four-year period 1992-1995 states the explicit objectives to limit further exploitation of coastal and nearshore fisheries resources and to intensify and improve aquaculture production (ADB 1993a). The culture of aquatic organisms in ricefields is one option for improved aquaculture in the Philippines.

The widening gap between rice and fish prices

In this section, the development of rice and fish prices is analyzed with the help of available statistical material. Based on the previous two sections, the following processes can be expected:

- rice prices are declining due to the increase in production after the introduction of MVs
- fish prices show an increasing trend which reflects the exploitation of marine resources and the resulting decline in catches.

If these trends can be verified, fish production will have increased its competitiveness compared to rice production. Fish culture in ricefields should therefore have become more attractive to farmers.

Global development of rice and fish prices

It is difficult to compare the prices of rice and fish at the global level. Rice is a rather uniform commodity even though price premiums are paid for Basmati rice and other high-quality varieties. On the other hand, many different fish species are caught in waterbodies all over the world and are cultured in a broad range of agroclimatic zones, making it an extremely heterogeneous commodity for which a single price statistic is meaningless. Therefore, the price development for distinct groups of fish species has to be analyzed among a fairly homogeneous group of countries to come up with an assessment of the growing scarcity of marine fish. The developing countries in Asia[9] were selected for the comparison because they represent the potential area for rice-fish culture. Since there are no published statistics that provide world market prices for fish, unit values of exports were computed from international trade statistics.[10]

The FAO statistical database on fisheries can be accessed through the Internet.[11]

Typically, most rice is consumed by the producers so that only a small fraction of total production reaches the market. In fact, most of the rice crop is consumed within the country in which it is produced and less than 5% of world rice production is traded (David 1990). Therefore, the world market price (which is derived from export statistics) can only be used to reflect the overall abundance or scarcity of rice at the global level. Even though large fluctuations can be observed, the real price of rice in the world market has exhibited a gradual long-term decline (Mitchell 1987; David and Huang 1992). This is an indication of the fact that rice production has grown faster than demand, an achievement of the Green Revolution. Even among the traditionally rice importing countries of South and Southeast Asia, the real price of rice has declined by as much as 40 to 50% (Philippines and India) over the last three decades as the widespread adoption of modern rice technology led to achievement of self-sufficiency (David and Huang 1992).

In contrast, average export unit values for different groups of marine fish (demersal, pelagic, and total marine fish) for 30 developing countries in Asia, deflated with the FAO index for export unit values of total agricultural products, show an ascending trend (see Appendix 2, Figure A2.1). This observation corresponds to the notion of biological and economic overfishing presented above.

Figure 2.3 brings the price development of rice and fish into a common context. In this graph, the price per kg of fish is divided by the price per kg of rice in order to show how much fish can be bought with 1 kg of rice. The declining trend of the line reveals that relative to fish, rice has experienced a loss in value.

Development of rice and fish prices in the Philippines

Price indices can be used to describe the price development of a group of goods over time[12]. Either they can be employed as deflators of nominal price data to obtain the real prices of goods or time series data of indices for different goods can be compared directly to analyze the growth rates of prices in relation to a base year. A steeper slope of the index curve indicates that the price for this group of commodities has increased more strongly in relative terms (i.e., in percent of the price in the base year) than that of other groups of commodities. Thus, differences in the development of price indices among commodity groups have to be attributed to factors other than the general inflationary trend.

---

9 This group consists of 30 developing countries in Asia, following the FAO classification.

10 Only export quantities and export values are provided in the FAO Yearbook of Fisheries Statistics and in the FAO Statistical Database. These data can be used to compute unit values of exports which can then be interpreted as world market prices.

11 Address: http://www.fao.org

12 Of the different types of price indices, this discussion will concentrate on the Laspeyres formula with fixed base and weights. In its aggregative form, the formula is: $I = S\ (Pn * W_0)/S\ (P_0 * W_0)$ where: Pn = current price, P_0 = base year price, and W_0 = base year weight.

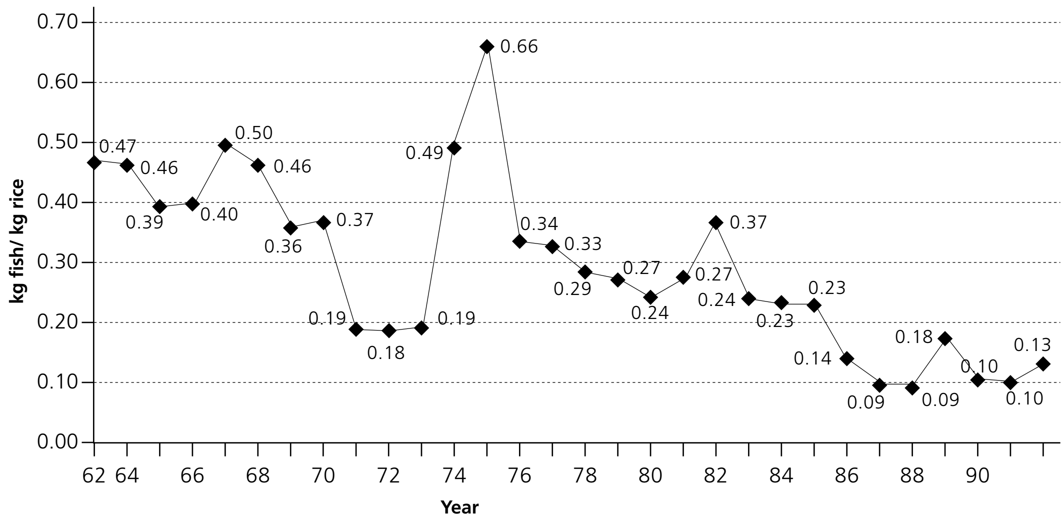


Figure 2.3. Price relatives of rice and fish, Asian developing countries, 1962-1993.
Source: Own computations from FAO Trade Yearbooks (various years) and FAO Statistical Database.

The price development for rice and fish in the Philippines was examined through the Retail Price Index (RPI) of the Agricultural Food Basket (BAS 1990). This index is compiled from sub-indices for five commodity groups, namely cereals (rice and corn), eggs, meat, fish, and fruit and vegetables. Each commodity group consists of a set of specific commodities which also constitute the agricultural market basket in the computation of the Consumer Price Index (CPI). Retail prices of these commo dities are monitored three times a week in 63 provincial public markets throughout the Philippines and in 15 public markets in Metro Manila.

Based on the observation that overfishing of marine resources leads to declining fish catches, the effect of this process on fish prices was examined by comparing the RPI of fish to the RPIs of other commodity groups in the agricultural food basket. As shown in Figure 2.4, fish prices in the Philippines have risen in roughly the same way as prices for other commodities between 1980 and 1989 (the most recent data available). Only the price index for fruit and vegetables increased more strongly than the rest since 1987. Thus, the growing scarcity of fish which lead to rising prices at the global level had not yet affected the Philippines by the end of the 1980s.

Nominal prices for six species of fish were deflated with the CPI for food, beverages and tobacco. The resulting real prices for fish have remained surprisingly constant between 1980 and 1989 (Figure 2.5). One possible explanation for this could be that due to increasing competition among small-scale fishers and their fragmented position in the market, they have increased their effort per unit catch, thus maintaining or even increasing the total catch while receiving lower returns per unit of catch. However, a more likely explanation is that the decline in catches would only be felt in the period after 1989 (world fish production reached its peak in 1989 and dropped only in the following years). For the period 1990-1993, price data are available from a different source, thus there is a break in the series. But even if it is assumed that the shift in price level between the two sources is due to methodological differences, only prices for striped mackerel exhibit an increasing trend. Due to the lack of more recent data, no final conclusion with regard to the development of fish prices in the Philippines can be reached.

At a first glance, the RPI for cereals (of which rice constitutes more than 80%) shows no significant deviations from the RPIs of other agricultural commodity groups (see Figure 2.4). It does, however,

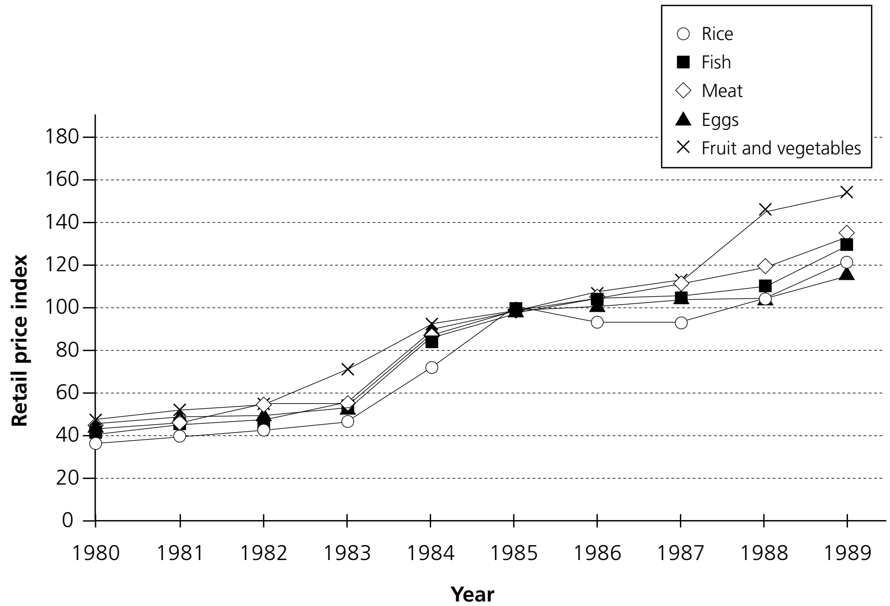


Figure 2.4. RPI of the Agricultural Food Basket by commodity group, Philippines, 1980-1989 (1985=100). Source: BAS 1990

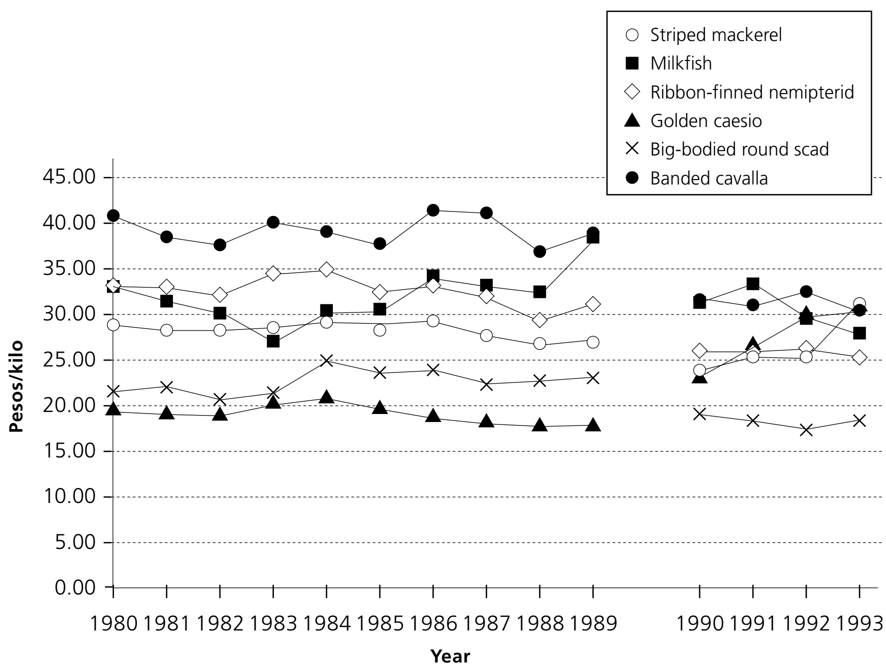


Figure 2.5. Real fish prices (Pesos/kg), Philippines, 1980-1993 (1988 = 100). Note: Break in data between 1989/1990; different sources. Source: RPI of the Agricultural Food Basket and unpublished data collected by ICLARM 1990-1993.

demonstrate that the price of rice has increased less than the prices of all other commodity groups, except for eggs. Time series data for government support prices and farm harvest prices were deflated with the CPI for food, beverages and tobacco. Both prices exhibit a declining trend between 1975 and 1982 (Figure 2.6), with some disturbances in the following years. During the period of declining

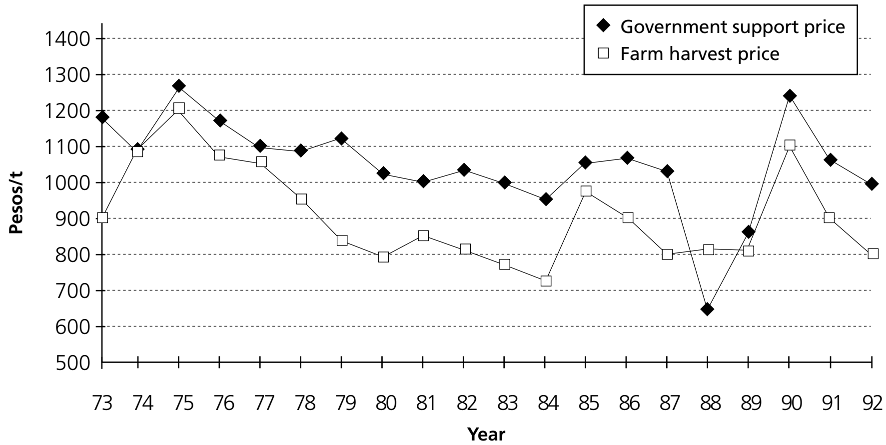


Figure 2.6. Real government support prices and farm harvest prices (Pesos/t) of rough rice, Philippines, 1973-1992 (deflated with the CPI for food, beverages and tobacco, 1978=100). Source: Own computations based on IRRI (1991, 1995) and NSCB (1991, 1993).

prices, the gap between the prices received by farmers and the official government support price widened, indicating that the amount of rice purchased by the National Food Authority at the support price was not sufficient to stabilize the domestic price level. In the years following 1984 (which were years of political instability in the Philippines), farm and support prices showed some erratic movements, with the support price even falling below the farm harvest price in 1988.

In concluding this section, it can be stated that the overall development of rice and fish prices in Southeast Asia up to the beginning of the 1990s has increased the relative competitiveness of fish culture in ricefields compared to rice monoculture. However, the situation in the Philippines is less clear. A rise in fish prices cannot be detected, maybe due to the lack of more recent data. The RPI for fish has increased to a greater extent than that for cereals. Should this trend continue, profitability of rice production would decline and raising fish in ricefields would become more attractive. However, in recent years there have been indications that cereal prices in the world market are reversing their declining trend. If indeed rice production encounters problems of sustainability and no significant breakthrough in yields is achieved in the coming years, rice prices might go up again. It thus depends on the type of relationship between rice and fish production—competitive or complementary—whether fish production in ricefields stands a chance against rice monoculture. This relationship is discussed in Chapters 3, 4 and 5.

Income and nutrition in rural Philippines

The disparity between urban and rural areas with regard to income and nutrition is widely known. Average income in urban areas of the Philippines has been more than twice that of rural areas over the last decade (Table 2.1). And even though expenditures are also about twice as high, people residing in urban areas still manage to accumulate some savings.

Between 1980 and 1989, an average of 58% of the Philippine population lived below the poverty line. However, in the rural areas this share amounted to 64%, one of the highest among those Asian countries for which data are available (ADB 1993b). The perceived income discrepancy between urban and rural areas is the main reason why many people leave the rural areas in search of better jobs

Table 2.1. Income, expenditures and savings in urban and rural Philippines (Pesos).

	1985	1988	1991
Average income			
Urban	46 127	60 330	89 571
Rural	21 875	28 284	41 199
Average expenditures			
Urban	39 134	47 299	70 551
Rural	19 397	23 529	33 733
Savings			
Urban	6 993	13 031	19 020
Rural	2 478	4 755	7 466

Source: NSO 1993.

and higher incomes in the cities. Growing urbanization is a serious problem in many developing countries and is at least partly due to low income opportunities in rural areas. It is therefore imperative to create jobs and raise the income level in rural areas.

Furthermore, low income translates into inadequate nutrition, both in urban and rural areas. The most nutritionally at-risk occupational groups in the Philippines are subsistence or hired fisherfolk, hired or seasonal farm workers, domestic helpers, janitors, housekeepers as well as hunters and loggers. The nutritional risk becomes higher when these occupational groups come from the rural areas, have large family membership and/or low education (FNRI 1987)[13]. Based on three national nutrition surveys (FNRI 1981, 1984, 1987), food consumption patterns for the Philippines and relative changes between survey years are examined (see Appendix Table A2.1). While the years 1978 to 1982 were seen as a period of nutritional improvement for the Philippine population, political instability and economic dislocation in 1984-86 led to a decline in food consumption and nutritional status (Villavieja et al. 1989). Consumption of most food groups showed negative growth rates between 1982 and 1987.

According to these data, rice is the most important item in the Filipino diet, followed by vegetables, fruit and fish. As stated earlier, fish is the major source of animal protein for most Filipinos; even though meat consumption exhibited steady growth rates, daily consumption in 1987 was only one-third that of fish.

With regard to nutrient intake, the following developments can be identified (see Appendix Table A2.2):

- average national per-capita calorie consumption fell from 1 804 kcal/person/day in 1978 to 1 753 kcal/person/day in 1987; this is considerably below the recommended daily allowance for Filipinos of 2 032 kcal/person/day (de Guzman et al. 1988);
- protein consumption increased from 48 g/person/day in 1978 to 49.7 g/person/day in 1987. The recommended allowance for Filipinos amounts to roughly 50 g/person/day (de Guzman et al. 1988), so that for the national average an adequacy level of 99% was achieved;

13 Villavieja et al. (1989) found that low income groups in Metro Manila were at an even more nutritional disadvantage than the rural sector. This points to the high income inequality in urban areas but does not contradict the observation of inadequate nutrition in rural areas.

- in 1987, major deficits in the intake of energy, calcium, thiamin, riboflavin and vitamin C prevailed. The highest adequacy levels were achieved for niacin, protein and iron. While calcium is present in fresh and dried fish and other seafood, the lack of thiamin and riboflavin in the diet points to low consumption of meat and glandular organs of animals. This indicates that even though total protein requirements are met, protein sources are not well balanced to comply with other nutritional requirements. Animal protein seems to be especially lacking.

However, national averages do not adequately describe the nutritional situation in a country. Differences in nutritional status can be observed between urban and rural populations, between men, women and children, between people residing in lowland and upland areas and among occupational groups, to name only a few. The incidence of certain effects of nutrient deficiencies therefore needs to be taken into account when discussing food security[14] and nutrition.

Malnutrition is a widespread problem and protein-energy malnutrition (PEM), measured by the relationship of weight to height of pre-school children, is the most important and prevalent form of malnutrition in almost all developing countries (Latham 1990). The incidence of PEM in the Philippines in 1987 was alarming: 12.7 % of pre-school children were found to be underweight (FNRI 1987). In general, PEM is caused by inadequate intake of food, particularly of energy (or calories) and to a lesser extent of protein:

> "... the prevailing view was that most PEM, even in its moderate or mild forms, was caused by a protein-deficient diet. In the early 1970s, contrary to the then popular opinion, a series of important articles drew attention to the fact that protein deficiencies were less prevalent than energy deficiencies. This meant that a major effort to increase the consumption of protein-rich foods would have only a small impact on the prevalence of PEM ... The protein debate has now subsided but not ended, with a fair measure of agreement and a few unresolved questions. The outcome has very important implications for food and nutrition policy. There is now agreement that more emphasis needs to be given to the energy rather than the protein content of diets; that the PEM problem relates to total food (calories) not protein intake; and that when commonly consumed cereal-based diets meet energy needs, they usually satisfy protein requirements as well. Ample evidence from developing countries suggests that most children afflicted with PEM are consuming diets deficient in both energy and protein. If consumption was increased to satisfy energy needs, then most diets would usually more than satisfy protein requirements (Latham 1990)."

14 Food security has been defined as 'physical and economic access, by all people at all times, to the basic foods they need' (AGROVAC, FAO's thesaurus used for the International Information System for Agriculture Sciences and Technology [AGRIS]).

The importance of protein in the diet should not, however, be forgotten. Protein requirements of children are proportionately higher than those of adults and the tendency for children to get sick result in increased urinary nitrogen losses, which raise protein needs (Latham 1990). Not only the adequate supply of dietary energy, but also the supply of protein in general and animal protein in particular are therefore critical factors for the health and well-being of the people.

There is a close association between income and nutrition. Rising incomes will increase the demand for goods which have a higher income elasticity of demand relative to those with low or negative income elasticity of demand. Staple foods (cereals, roots and tubers, legumes) normally belong to the latter group while meat consumption increases over-proportionately with rising incomes. Relative fish expenditures decrease with rising incomes (NSO 1989, 1993), indicating that fish is the protein choice of low-income households. An increase in fish prices will therefore adversely affect those people most who already belong to the nutritionally at-risk groups—rural landless laborers, small-scale farmers and the urban poor, i.e. the vast majority of the Filipino people.

The widening gap between rice and fish prices poses a double problem to small-scale rice farmers: declining rice prices lead to falling incomes and increasing fish prices raise the amount of money needed for adequate nutrition. In addition, the degrading natural resource base makes it more and more difficult to sustain yield levels with a given set of inputs. On the other hand, this development also decreases the opportunity costs of producing fish. If fish is cultured in rice-based farming systems, there will be a greater supply of relatively cheap animal protein foods in rural areas and, especially in landlocked regions, the quality and freshness of fish supply will be improved. Thus, small-scale aquaculture can play an important role in improving both income and nutrition in rural areas of the Philippines.

Objectives of the study

The previous discussion has shown that rice farmers in the Philippines are facing three sets of problems that are closely interrelated: maintaining an adequate income, securing a balanced diet for their families and preserving their natural resource base for future agricultural production. A decline in the profitability of rice production leads to a sharp reduction in the welfare of rice producers. This process can be prevented by reducing the unit cost of rice production or by promoting the reallocation of resources from rice to other crop or non-crop, non-rice enterprises (Pingali 1992). Reduced unit costs of rice production can be achieved by increasing either farm yields or input use efficiency. At present, the prospects for increasing farm yields with current technology are weak. Reduced and more efficient use of fertilizers and pesticides seems to be an option in the long run because it can at least partially arrest the degradation of the natural resource base. IPM has been proposed as a way to improve rice crop management in an environmentally friendly way.

On the other hand, diversification into other crops (legumes, vegetables, fruit trees) would decrease rice cropping intensity and thus halt those processes of soil nutrient depletion and pest population build-up that are associated with rice monoculture. However, many farmers in lowland irrigated areas cannot freely choose which crops to grow because of their integration in the irrigation system and tenancy arrangements. The culture of aquatic organisms presents an option for diversification which can be implemented in existing rice-based farming systems.

The purpose of this study is to analyze the effects of small-scale rice-aquaculture in combination with IPM with the following aspects:

- contribution to household income;
- contribution to food security and nutrition;
- contribution to improved sustainability of rice production.

These effects will be analyzed by taking into account potential complementary effects between small-scale aquaculture in ricefields and IPM to assess the potential of a combination of both technologies.

Chapter 3

Small-scale aquaculture in rice-based farming systems

Ricefield ecology

Rice is grown in many different environments, ranging from the dry uplands to the deltas of several of the world's great rivers. A classification according to water regime, drainage, temperature, soils, and topography has been proposed that recognizes 18 categories of rice growing environments (IRRI 1984); however, a more widely used method classifies rice environments into five major categories, namely irrigated, rainfed lowland, deep water, upland and tidal wetlands (IRRI 1984). Each of these environments has its own type of ricefield ecosystem which is further characterized by its specific location. Heckman (1979) for example, describes in detail a particular ricefield in northeast Thailand which, although it is considered representative for the numerous fields in the vicinity, is certainly unique. For the purpose of this study, irrigated ricefields are of major interest because of their potential for rice-aquaculture and their present degradation due to intensification of rice production. The following discussion will therefore focus on the irrigated ricefield ecosystem.

The irrigated ricefield ecosystem

The irrigated ricefield (also called wetland or flooded ricefield) is "an artificial ecosystem characterized by extreme instability resulting from frequent destruction of the environment by farming practices"(Watanabe and Roger 1985). However, while there are instability and fluctuations on a short time scale (crop cycle), monocropping of rice has been possible for centuries, indicating stability on a long time scale (Watanabe and Roger 1985). The flooded soil-rice ecosystem can be divided into five major subsystems, namely floodwater, surfaced oxidized layer, reduced puddled layer, subsoil and the rice plant with its phyllosphere and rhizosphere (Watanabe and Roger 1985). They provide habitat for a variety of organisms that create a complex web of interactions in which human interventions can have unforeseen consequences. Of particular interest here is the floodwater because it is the habitat of aquatic organisms that can be utilized by humans.

Under irrigated conditions, the rice plants are submerged for varying periods during their growth. Depending on the duration of aquatic conditions in the field, an aquatic fauna develops which is in direct contact with the rice plants (Fernando et al. 1979, 1980). This aquatic fauna originated from the original marsh fauna of the area, or, where marshes did not exist, from temporary ponds, streams and lakes (Fernando et al. 1979, 1980). Since most ricefields are allowed to dry out periodically, the aquatic phase of the ricefield has to re-colonize the ricefield from extraneous sources like marshes, ponds, and streams, or from resistant and dormant stages of aquatic animals in dry ricefields (Fernando et al. 1979, 1980).

> "In composition, the aquatic fauna of ricefields spans the whole spectrum of freshwater fauna and may even include some brackish-water species in river deltas, e.g., polychaetes, penaeid prawns. In any locality the fauna can be quite diverse when land usage is not intensive to the point of elimination of marshes and when heavy machinery and biocides are not used (Fernando et al. 1980, p. 945). "

Potential human food sources among the aquatic fauna of ricefields

Ricefields are potentially a source of considerable amounts of protein, mainly in the form of fish. Wild species in Southeast Asian ricefields comprise predators like snakeheads (Ophicephalidae) and airbreathing fish, such as Anabantidae, Clariidae and Heteropneustidae (Fernando et al. 1980). Other aquatic organisms collected from ricefields and used as food include freshwater crabs, freshwater shrimp, estuarine shrimp, crayfish, frogs and aquatic insects (Fernando et al. 1980). In addition, ricefields can provide food for various water birds. Ducks are sometimes raised in ricefields.

There have been several reports on the utilization of aquatic organisms for food from ricefields: Setboonsarng (1994) reports that farmers in northeast Thailand perceive wild fish in ricefields (snakehead *Channa striata*, catfish *Clarias batrachus*, climbing perch *Anabas testudineus*) as highly valuable products, even though these are predatory fish and feed on fingerlings of species stocked by the farmers. These wild fish species, which traditionally inhabit the ricefields, are attracted to the fields by various methods and sold at twice the price of cultured fish species.

Also in northeast Thailand, Fujisaka and Vejpas (1990) found that wild fish catches of 26 farm families in a rainfed environment were ranging from 36 to 294 kg and averaged 134 kg per person per season. The catfish and snakehead were the main species caught. While larger fish are eaten fresh, small fish are fermented and stored in earthen jars. Families produced an average of five jars (24 kg/jar) per year. Some fish were dried (3-10 kg/person, reported by 50% of respondents) and about 10% of captured fish were sold, earning an average of US$ 18/respondent. In addition, all respondents reported catching frogs (*Rana limnocharis limnocharis*), at an average of 10.5 kg frogs per season. They are mostly eaten fresh, but some are sold or dried/smoked. The total fish catch (excluding the frogs) is equivalent to raising yields from 1.70 to 2.36 t/ha, a 36% increase.

Rajasekaran and Whiteford (1993) describe a rice-crab production system in Tamil Nadu state, India, where crabs are harvested from the bunds of ricefields. Crab yields in the study village can be as high as 236 kg during the peak season (24 June-27 July), providing up to 32% of the recommended daily allowance of protein to the diet. This rice-crab production system is threatened by the indiscriminate usage of chemical fertilizers and pesticides as well as by other changes in the village's socio-ecological environment.

Margraf (1988) mentions the use of snails, clams and fish from ricefields in Ifugao province, Philippines. The Japanese loach (*Misgurnus anguillicaudatus*), an airbreathing fish introduced from Japan, is highly appreciated by the local people. It lives in altitudes above 500 m and can migrate to neighboring fields during land preparation. Snakeheads are also trapped and eaten. This species is a voracious predator and a feared enemy of cultured fish in rice-fish systems. Tilapia species (*Oreochromis mossambicus and O. niloticus*) were only introduced to Ifugao in the 1960s and normally grow to a size not larger than 10 cm. They reproduce rapidly and have to be protected against predators (e.g., snakehead) which makes their culture in ricefields difficult under Ifugao conditions.

These reports indicate that capture systems of wild aquatic organisms from ricefields are widespread in South and Southeast Asia. They are an important traditional source of animal protein especially for marginal groups (Rajasekaran and Whiteford 1993). However, many of these capture systems have been severely affected by the onset of the Green Revolution in rice (Ali 1992; Fedoruk and Leelapatra 1992). Pesticides have been identified as the worst enemy of all aquatic organisms in ricefields. As early as 1980, Fernando et al. realized the danger that pesticide usage poses to the aquatic fauna in ricefields:

> "Many pests of rice are terrestrial and together with mosquitoes and some aquatic pests (both fauna and flora) pose problems of control in ricefields. The use of various chemicals to control weeds and animal pests has meant that the aquatic fauna is subjected to various degrees of poisoning. Also larger fauna feeding on the aquatic fauna which are resident or migratory in habit can accumulate lethal doses of various noxious chemicals (Fernando et al. 1980, p. 947)."

Koesoemadinata (1980) describes how the introduction of pesticides in Indonesia has led to a gradual decline in the area under rice-fish culture. He considers the use of pesticides as a major constraint to integrated agriculture-aquaculture farming.

Several systems integrating agriculture and aquaculture have been developed and tested under different conditions and with different requirements. These systems will be presented in the following section.

Definition and classification of aquaculture systems in rice

There are a number of different terms that describe the practice of managing aquatic organisms in rice-based farming systems. The most commonly used expression is probably "rice-fish culture"; indeed, fish is the most important organism in the ricefield which is used for food. However, since there are more aquatic organisms to be found in the ricefield than just fish, a broader term is needed. On the other hand, "integrated agriculture-aquaculture farming systems"does not restrict itself to rice-based farming systems and may also encompass the integrated production of livestock and fish. It is too diffuse a denotation for the types of systems discussed here. Therefore, the term "small-scale aquaculture in rice-based farming systems" (or shorter: "rice-aquaculture") was chosen from this point of the study onwards to define the management of all types of aquatic organisms in ricefields or in close association with ricefields (e.g., through on-farm water flows)[15]. This definition summarizes a multitude of systems which can be classified according to management intensity, growing period, field design, cultured species and stage in the production cycle (Figure 3.1)[16]. However, the first and foremost distinction that has to be made is between capture and culture systems. Capture systems are the most traditional form of utilizing aquatic organisms from ricefields. In these systems, wild fish and other aquatic organisms enter the flooded ricefields where they populate and reproduce. They

---

15 The term "rice-fish culture" will continue to be used if other authors are cited and in cases where it can be assumed that the discussion is restricted to the culture of fish in ricefields.

16 The culture of fish in deepwater rice areas will not be considered in this study due to its distinct production technology and unique set of problems.

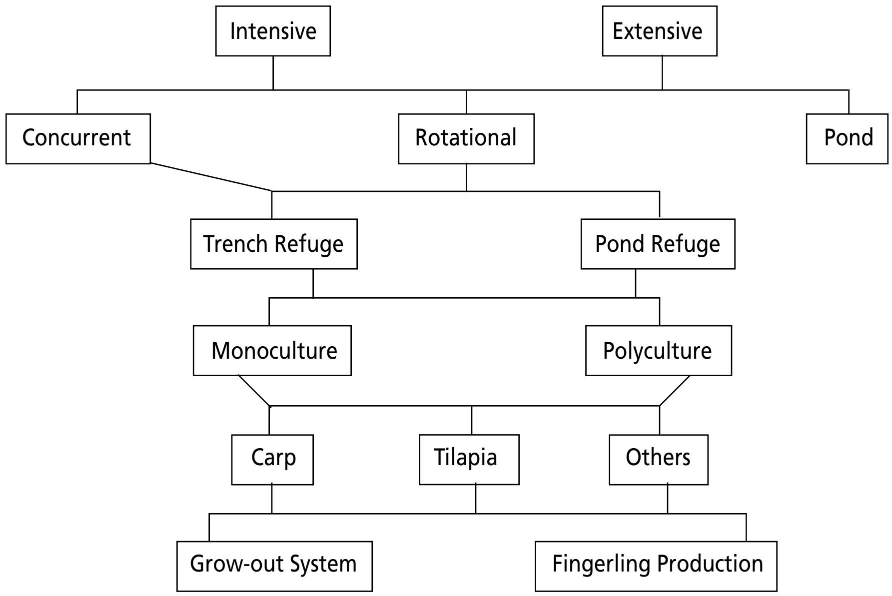


Figure 3.1. Classification of rice-aquaculture systems. Source: Own illustration.

are harvested at the end of the rice growing season. The only possible modifications in the fields are sumps which are dug in the lowest regions of a group of fields (Khoo and Tan 1980). Whereas culture systems have been developed mainly for fish, capture activities have encompassed all aquatic organisms in the ricefield that can be used for food (see section 3.1.2).

As the term implies, culture systems involve the deliberate modification of ricefields and their stocking with one or several species of fish or other aquatic organisms. The distinction between intensive and low-input culture systems refers to the use of external material inputs like feeds and fertilizers; it does not describe labor input which can be quite high in an otherwise low-input system. Feeds can either be on-farm resources like rice bran, animal manure or household wastes, or additional inorganic fertilizer can be applied to stimulate primary production in the water (Edwards and Kaewpaitoon 1984; McClellan 1991). This latter option, however, raises production costs compared to the use of on-farm resources as fish feed.

In general, two types of growing periods can be distinguished: rotational, i.e. between rice harvests and concurrent with the rice. The latter is often considered rice-cum-fish culture in the strict sense. However, fish may also be produced in ponds separated from the fields which nevertheless are connected to rice through on-farm water flows. Very elaborate three-tier systems have been developed in which poultry is raised above a pigsty over a fish pond. The poultry manure is eaten by the pigs and whatever is left unutilized is washed down to the pond together with the pig manure, both as fish food and fertilizer (Delmendo 1980). The fertile water of the pond in turn irrigates the ricefield. In Indonesia, three types of growing systems can be found which are characterized by the sequence of rice and fish in the cropping cycle. According to Ardiwinata (1957), fish were first grown as a secondary or fallow season crop (*palawija*). Later, when demand for fish grew, fish production was undertaken between rice crops (*penyelang* or intermediate cropping), mainly to produce seed fish for resale to pond owners. In addition, the concurrent cropping of rice and fish (minapadi) was initiated and extended so that up to three fish cultivation periods (for seed fish production) could be accommodated in one rice crop (Koesoemadinata and Costa-Pierce 1992).

In concurrent and rotational rice-aquaculture, various modifications of the ricefield are possible. Farmers can raise the dikes of the field, dig a trench with a depth of about half a meter or excavate a pond refuge with a depth of about one meter in a low-lying part of the ricefield. These modifications serve the purpose of providing the fish with the necessary water depth even in times of water scarcity. As a rule of thumb, it is estimated that the pond refuge takes away 10% of the field area that could otherwise be planted with rice (dela Cruz 1990). In recent years, the trench refuge has not been recommended as it was found to be too risky with water levels falling below the depth required by fish (dela Cruz 1990).

The most commonly cultured fish species are carp, tilapia, silver barb (*Puntius gonionotus*) and snakeskin gourami (*Trichogaster pectoralis*) (Lightfoot et al. 1992a). Both mono– and polyculture of these species are practiced, but they are not evenly distributed across countries. While carps are predominantly found in ricefields in Indonesia, India and China, tilapias occur in the Philippines, China and Thailand. The other two species are mainly cultured in Thailand (Lightfoot et al. 1992a).

A final distinction of production systems can be made with regard to their stage in the fish production cycle. Most rice-fish systems are growout operations, but the ricefields can also be used for nursery operations (Lightfoot et al. 1992a). In Indonesia, raising fingerlings in ricefields was shown to be more profitable than growout (Costa-Pierce 1992; Purba 1997).

History and current status of rice-aquaculture in Asia

Capture fisheries in ricefields are probably as old as rice culture itself (Khoo and Tan 1980). Fish and other aquatic organisms have always entered the ricefields with the floodwater and were trapped there when the water receded. Little modification of fields is necessary for this practice and no additional inputs are used. On the other hand, culture systems of fish in ricefields have a long tradition in parts of Asia. In fact, a ricefield model found in a tomb of the mid-Eastern Han Dynasty (25-220 AD) in China contained 18 pieces of miniature pottery of aquatic plants and animals including grass carp (*Ctenopharyngodon idella*) and *Carassius auratus* (Li 1992). This is the earliest known record of rice-aquaculture and places its roots in China. Other authors suggest that rice-aquaculture was introduced into Southeast Asia from India about 1 500 years ago (Khoo and Tan 1980). However, in most Asian countries, culture systems of fish or other aquatic organisms in association with ricefields were largely unknown until the mid-20th century when rice-fish culture started in Indonesia. The problems of food supplies during World War II provided an incentive for the extensive culture of fish in ricefields (Khoo and Tan 1980). However, the growing availability of sea fish together with the increase in chemical pesticide use in rice soon led to a decline of this practice (Khoo and Tan 1980). At present, only China and Indonesia have significant areas under rice-aquaculture (Lightfoot et al. 1992a). Even though between 11 and 50% of irrigated rice area in various Asian countries is estimated to be suitable for rice-aquaculture, only a very small percentage of that area is actually occupied by rice-fish systems (Table 3.1).

In the Philippines, Sevilleja (1992) reports that research on rice-fish farming systems started in 1974 at the Freshwater Aquaculture Center (FAC) of Central Luzon State University (CLSU). A technology package was developed for low-cost fish production in rice farms. Based on these research results, a national program for rice-fish culture was initiated in 1979 by the Department of Agriculture, covering 41 selected provinces in the 12 regions of the country. At its peak in 1982, the program had 2 284 cooperators with a total area of 1 397 ha. Since then, a general downward trend in total area and productivity of rice-fish culture could be observed. In 1986, the last year for which records are available,

Table 3.1. Potential and existing areas for rice-fish farming in Asia.

Country	Production environment	Ricefield area (000 ha)	Potential/ suitable area (000 ha)	Potential area in % of ricefield area	Existing area (000 ha)
Bangladesh	Total	10 229	615	6	Not known
	Irrigated	1 227		50	
	Rainfed	9 002			
China	Total	32 798	5 000	15	985.6 (1986)
	Irrigated	30 902		16	
	Rainfed	2 296			
India	Total	40 991	2 000	5	Not known
	Irrigated	14 349		14	
	Rainfed	26 644			
Indonesia	Total	9 889	1 570	16	94.3 (1985)
	Irrigated	6 230		25	
	Rainfed	3 659			
Korea	Total	1 229	127	10	0.1 (1989)
	Irrigated	1 118		11	
	Rainfed	111			
Malaysia	Total	647	120	18	Not known
	Irrigated	427		28	
	Rainfed	220			
Philippines	Total	3 426	181	5	1.4 (1982)
	Irrigated	1 473		12	0.2 (1986)
	Rainfed	1 953			
Thailand	Total	9 378	254	2.7	Not known
	Irrigated	1 313		19	
	Rainfed	8 065			
Vietnam	Total	5 691	326	6	Not known
	Irrigated	2 276		14	
	Rainfed	3 415			

Source: modified after Lightfoot et al. 1992a.

the number of cooperators had declined to 550, covering only 185 ha. Several reasons have been cited for the decline in adoption since 1982: irregular delivery of irrigation water, the perceived necessity of using pesticides in rice production, unavailability or small size of fingerlings and lack of exposure to rice-aquaculture all pose constraints to farmers who would otherwise be able to implement the technology (dela Cruz et al. 1992). In addition, a rapid appraisal of adopters and non-adopters of rice-fish farming in the Philippines revealed that the initial capital outlay, small fish size at harvest time and the danger of poaching can deter farmers from practicing rice-aquaculture (dela Cruz et al. 1992). However, most farmers seem to be aware of the benefits of this technology.

It is therefore worthwhile to look for ways to overcome the constraints to adoption of rice-aquaculture. The following section introduces current production technologies with their preconditions and requirements as well as the effects of aquaculture on the ricefield ecosystem.

Preconditions and requirements of aquaculture systems in rice

Pillay (1973, cited in Vincke and Micha 1985) reports that if only 30% of the 35.6 million ha of irrigated ricefields that existed throughout the world in 1967 were for rice-aquaculture, about 2.2 million tons of fish could be harvested (assuming an average harvest of 60 kg/ha). Since then, the area of irrigated ricefields has further expanded (IRRI 1995), thus increasing the potential area of rice-aquaculture. However, not all of these fields are really suitable for aquaculture purposes. A number of conditions beyond the availability of irrigation water have to be met for successful rice-aquaculture systems such as water control and quality, and supply and quality of fingerlings.

Certainly, the most important precondition for rice-aquaculture is reliable water control. There must be adequate water, both in flow and in depth during the whole fish production period, but the area must also be free from flooding to prevent fish from escaping (Khoo and Tan 1980). It should be possible to irrigate and drain the field independently. Normally, water control is better in irrigated areas than in rainfed environments, but rice-aquaculture has also been practiced successfully in the predominantly rainfed northeast of Thailand (AIT 1990; Edwards et al. 1990; Fedoruk and Leelapatra 1992). As rice continues to be the main crop in rice-aquaculture systems, irrigation schedules are often geared towards the requirement of the rice crop. This can be a major constraint; in parts of West Java, for example, the centrally controlled water supply is cut off completely during the fallow months (Ruddle 1982).

Water quality is a second critical point. Pesticides which are toxic to fish pose a severe constraint to rice-aquaculture (Koesoemadinata 1980; Cagauan and Arce 1992). Rice farmers at the end of an irrigation system often face the problem that the irrigation water has been polluted by pesticide applications of farmers closer to the main canal. For them, water quality is associated with the high transaction costs of convincing neighbors not to use chemical pesticides.

The topography should be relatively flat and soils should be able to retain the water for a sufficient period of time. Therefore, loamy or clay soils are preferred over sandy or stony soils (Edwards and Kaewpaitoon 1984). The pond or rice-fish field should be located close to the homestead so that daily observation of the fish does not take too much time and the danger of poaching is minimized (Edwards and Kaewpaitoon 1984). Ponds should not be constructed underneath trees because their shade would prevent sunlight from reaching the pond. Sunlight is important for primary production in the pond, thus providing feed for the fish (Edwards and Kaewpaitoon 1984).

Fingerling supply and quality are essential preconditions for a successful rice-aquaculture operation. Care has to be taken to eliminate predators of cultured species from the field; however, in the case of prolific fish species (e.g., tilapia), some population control by predators can increase fish yields by eliminating competition.

This list of requirements for rice-aquaculture systems gives an idea of the varying factors that influence the success of a rice-aquaculture operation. More detailed requirements as specified in a technology package for concurrent rice-aquaculture in the Philippines are presented in the following section.

Production technology for concurrent rice-fish culture in the Philippines

Production technology for rice-aquaculture is as varied as the systems that can be found throughout Asia. This is an indication of the fact that farmers adapt the technology according to their particular conditions and circumstances. For extension purposes, a technology package for concurrent rice-fish culture in the Philippines was developed in 1985 (Sevilleja 1992). This package will serve as the prototype of rice-aquaculture production technology to be described below.

Field modifications

The initial concurrent rice-fish technology developed at FAC used the trench refuge (50 cm wide and 40 cm deep) which was later evaluated to be too risky in times of water shortages (dela Cruz 1990). As a modification, the pond refuge has been developed and is now recommended for use in the Philippines (Figure 3.2). Depending on field size, one ricefield may have one or two small ponds of about 1 m depth, occupying roughly 10% of the field area (dela Cruz 1990). It is also possible to link several ricefields to one common pond refuge to reduce the ratio of pond area to the total rice-fish field area (dela Cruz 1990). Both trench and pond refuges serve as a place where the fish can retreat in times of water shortage. In addition, the pond is used as the catch basin at harvest. Capital needed for pond construction represents the major initial investment in rice-aquaculture. However, ponds are permanent (with an estimated useful life of 10 years) and only need some maintenance during land preparation in subsequent cropping seasons (dela Cruz 1990).

The development of the pond refuge solved some of the problems that were associated with the trench refuge (dela Cruz 1990). First, a greater amount of water can be impounded, thus lessening the problem of water availability and allowing the culture of fish before rice planting and after rice harvest. Second, the pond can be closed from the rest of the field by a small dike, thus allowing the application of pesticides even in rice-aquaculture. Third, the pond offers easy integration with other crops and livestock. Easily watered vegetables and/or fruit trees can be grown on elevated beds resulting from pond excavation. The pond area can be planted with taro, water spinach or other macrophytes. Livestock and fowl such as ducks can be housed above the pond so that their manure fertilizes the

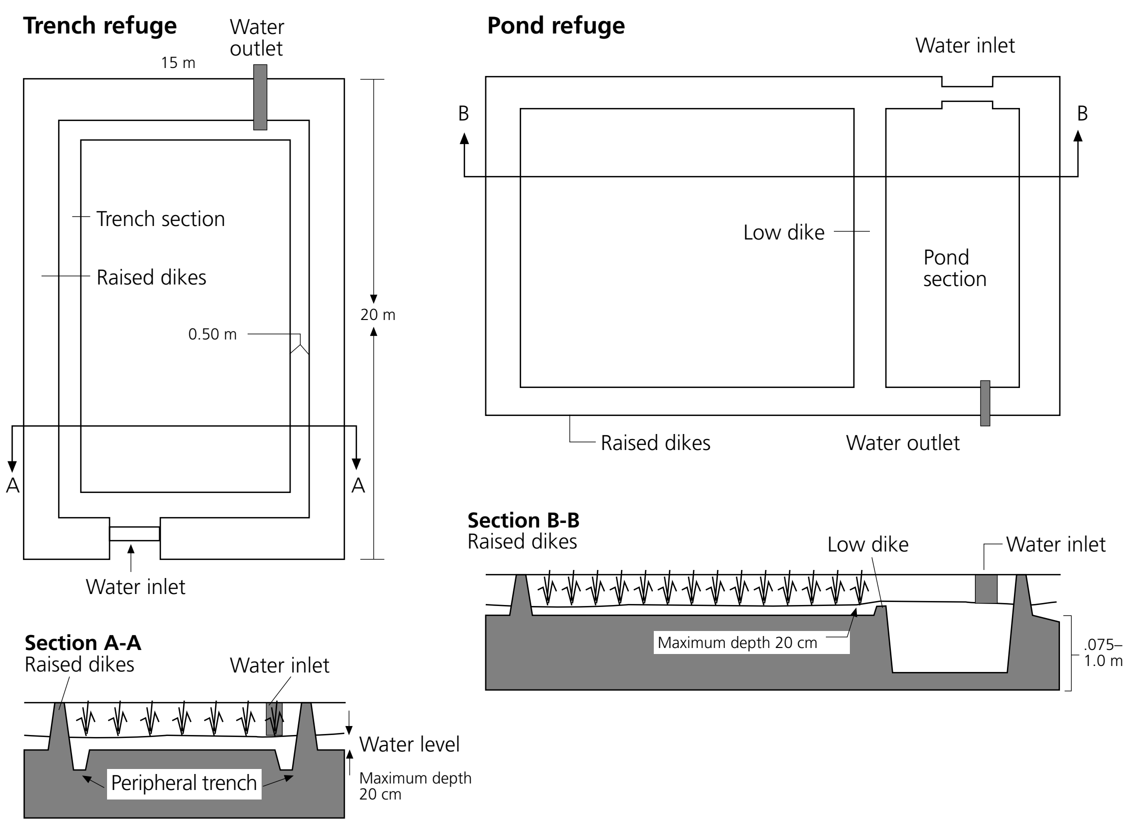


Figure 3.2. Rice-fish field layout. Source: dela Cruz et al. 1992, p. 200.

water which then spreads to the whole rice-fish area. The pond also facilitates supplemental feeding because fish learn to gather there at feeding time.

In addition to pond construction, dikes need to be raised during land preparation in every cropping season for ideal water depth in the field. Dike repair is crucial because it avoids water losses in normal times and prevents fish from escaping in times of flooding (Vincke and Micha 1985). Screens should be installed at the inlets and outlets to prevent wild predatory fish from entering and stocked fish from escaping.

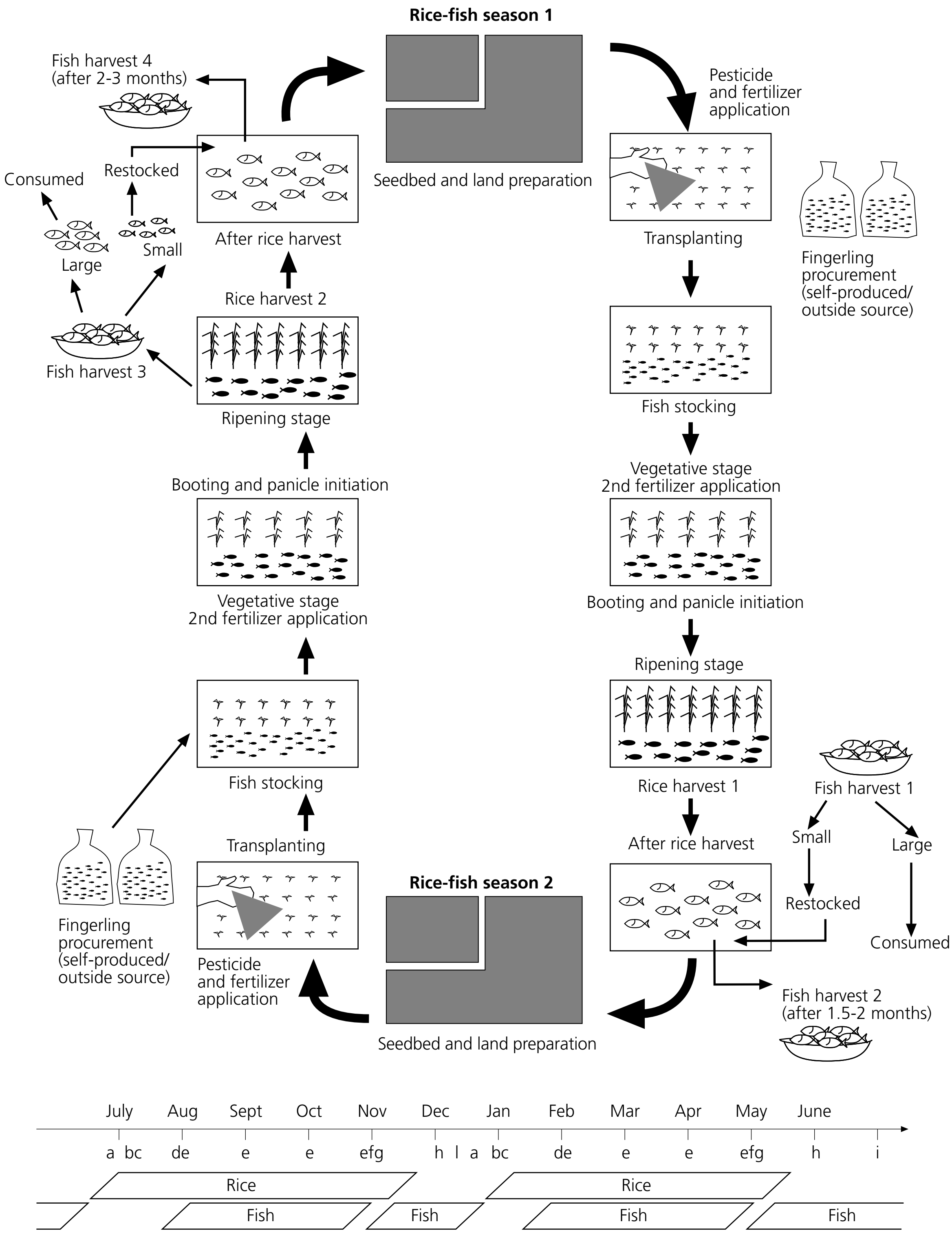
Management practices

A typical rice- fish production cycle together with a calendar of activities is presented in Figure 3.3. After seedbed and land preparation (including pond and dike maintenance) and basal fertilizer application, high-yielding varieties of rice are transplanted at a distance of 20 x 20 cm between hills. Herbicides are applied five days after transplanting. The field is irrigated and water level is gradually raised to 7-10 cm depth. Fish are stocked about one week after transplanting at a recommended stocking density of around 7 500/ha for monoculture of tilapia, or 5 000 to 7 500/ha at 1:1 or 2:1 tilapia to carp ratio. Although stocking size of 15-25 g is recommended (dela Cruz 1980), this is rarely followed because the usual available fingerlings are 5-10 g (dela Cruz et al. 1992). For consecutive fertilizer and pesticide applications, the field is drained and the fish gather in their refuge. Feeding of fish with rice bran and other available on-farm resources is recommended for better fish yields. As the rice plants grow, the water level is raised first to 10-15 cm and eventually to 20 cm depth. Approximately 100 days after transplanting, the field is drained and the fish are harvested (small fish may be retained in the pond for further growth), shortly followed by the rice harvest. A second fish harvest can take place after 1.5-2 months. Two rice-fish culture cycles can be accommodated in one year. With the pond refuge, fish will be available year-round because smaller fish will always be left in the pond at harvest time. On-station experiments using this technology package have produced an average yield of about 100-200 kg fish/ha (dela Cruz et al. 1992).

Effects of fish on the ricefield ecosystem

Even though a considerable portion of the income from a particular ricefield can be in the form of fish (Ruddle 1982), many farmers still perceive rice as the principal crop. Fish is still regarded as a by-product of rice production. Therefore, it is important to consider the effects that fish can have on the ricefield ecosystem in general and on rice yields in particular. It is often feared that fish production will decrease rice yields due to the space taken up by trenches or pond refuge, by direct damage of fish done to rice plants[17], and due to management practices in favor of fish (Lightfoot et al. 1992b). However, it has been reported that the cultivation of fish in paddies actually increases rice yields by as much as 15% (Ruddle 1982), although a review of 18 studies has not yielded such a uniform result and no adequate explanations for yield differences have been presented so far (Lightfoot et al. 1992b). In a study of 329 plots in Indonesia, Purba (1997) found no significant rice yield difference between plots with and without fish. Some authors claim that fish feed on rice pests including weeds. This issue will be discussed in Chapter 4.

17 There have been reports of carp uprooting rice seedlings if stocked too early (Khoo and Tan 1980).



a Land preparation, fish rice-fish season: ploughing/harrowing/levelling/manuring; trench/pond refuge **b** Seed fish procurement **c** Transplanting/fertilizer application **d** Fish stocking **e** Rice + fish culture **f** Field draining/fish harvest **g** Rice harvest followed by restocking fish in rice field **h** Fish culture in rice field **i** Fish harvest/land preparation for first/second rice-fish season.

Figure 3.3. Rice-fish production cycle and calendar of activities. Source: dela Cruz et al. 1992, p. 199.

Another possible mechanism by which fish can increase rice yields is the contribution of fish to soil fertility through various pathways (Lightfoot et al. 1992b):

- fish grazing on the aquatic biomass contribute to nitrogen accumulation at the soil surface through their feces;
- grazing of fish reduces the microbial biomass which helps keep the pH near neutral. This, in turn, reduces ammonia losses via volatilization;
- through increasing the aerobic layer at the soil-water interface by their feeding actions, fish slow the denitrification process that leads to volatilization of nitrogen.

Due to lack of experimental data, these hypothesized processes have been incorporated into a preliminary steady-state nitrogen model of a wetland ricefield ecosystem (Lightfoot et al. 1993). Results indicate that stocking ricefields with fish leads to greater efficiency in rice production because losses of nitrogen are minimized.

Fish movements are said to increase the aeration of the water, which appears to increase the rate of tillering of rice plants (Ruddle 1982). In addition, precise water management for successful fish culture will, through better weed and nutrient management, improve rice yields, whether there are fish present in the water or not (Lightfoot et al. 1992b). The same is true for the additional tillage given to ricefields for fish. However, incomplete data sets and confounding experiments prevent the drawing of a final conclusion as regards the impact of fish on rice yields (Lightfoot et al. 1992).

The selection and/or availability of fish species also has a substantial impact on successful practice. The following section introduces the fish which is most commonly found in rice-aquaculture systems in the Philippines[18] and gives an overview of its history in Philippine aquaculture.

Tilapia production in the Philippines

Culture of tilapia in the Philippines began with the introduction of the Mozambique tilapia (*Oreochromis mossambicus*) from Thailand in the 1950s (Guerrero 1985). However, until the mid-1970s, this species was regarded as a nuisance fish by producers and a low quality product by consumers. In fact, these attitudes still prevail in certain parts of the country (Smith et al. 1985).

Since then, three other species and several hybrids have been introduced. The introduction of the Nile tilapia (*Oreochromis niloticus*) in 1972 has led to a renewed interest in tilapia culture in the Philippines because of its faster growth and lighter color (Guerrero 1985). There has been an extremely rapid development of tilapia farming in lakes and ponds in the vicinity of Metro Manila (Yater and Smith 1985). In the 1980s, tilapia was second only to milkfish in terms of annual production (Guerrero 1985; Bimbao and Smith 1988). Possible reasons for this development are:

- the energy crisis in the 1970s shifted the emphasis of the government and the interest of the private sector from marine fishing to aquaculture (Guerrero 1985);
- technical innovations for the improved pond management of tilapia were developed (Guerrero 1985);

[18] Carp, the major species for rice-aquaculture in China, Indonesia and other countries are not common in the Philippines.

- commercial cage and pen culture of tilapia was taken up by small-scale fishers because of declining catch and catch per unit effort of numerous inland lake fisheries (Smith et al. 1985).

As in any booming industry, competition increased rapidly and led to fluctuations in prices and production. Between 1979 and 1986, a 5% downward trend in real prices of tilapia was observed (Bimbao and Smith 1988).

> "Depending upon economies of scale in production, small producers may face future difficulties in competing with larger-scale operators. Even in lakes where cages are suitable there is a tendency for the numbers to proliferate to the eventual detriment of all producers as overcrowding occurs. Several small lakes in the country (e.g., San Pablo Lakes) have passed through several cycles of profits, overcrowding, withdrawal by marginal producers, profits, and overcrowding again (Smith et al. 1985, p. 1)."

With regard to the market value of tilapia, there seems to be a regional division in the Philippines. Prices are higher in Luzon than in the Visayas and Mindanao. Tilapias are more commonly grown, reared and consumed in Luzon than in other parts of the country (Bimbao and Smith 1988). This is also reflected in the concentration of tilapia hatcheries in Luzon, which makes the availability of tilapia fingerlings very location-specific (Yater and Smith 1985). Whether this regional division is due to economic or cultural factors or whether marine fish is more readily available in the southern Philippines, is not known. However, tilapias seem to be a cheap source of protein especially for low-income groups: while annual per capita consumption for milkfish increased with income, this pattern is not so clearly observable for tilapia (Bimbao and Smith 1988).

The culture of tilapia in rice-based farming systems is not important enough to be mentioned in statistics on inland aquaculture. Naturally, the attractiveness of such rice-tilapia systems is directly influenced by the price of tilapia. But it is not only the declining price that has acted as a disincentive to rice-tilapia culture in previous years: tilapia are mouthbreeders and tend to reproduce rapidly if population size is not controlled. This uncontrolled reproduction leads to overpopulation in the field and thus to small fish sizes at harvest time. To avoid reproduction, all-male fingerlings have been used in some trials. However, this practice makes it impossible for farmers to grow their own fingerlings for next season's fish culture. While Nile tilapia are less prolific than the Mozambique tilapia, small harvest size is still a problem.

Chapter 4

Pest control in irrigated rice in Asia

Pest problems in irrigated rice production have increased tremendously with the introduction of MVs and the resulting increase in cropping intensity and chemical input use. The widespread use of chemical pesticides poses a threat to the environment and human health, in addition to bringing about problems of pest resistance and resurgence. This chapter provides information on various aspects of pest control and pesticide use, with special emphasis on IPM as a means to overcome the dependence on chemical pesticides. It closes by examining the role of rice-aquaculture in IPM and identifying areas where these technologies can be mutually reinforcing.

Some technical aspects of rice pests and pesticides

Pests are organisms that harm cultured plants or animals and therefore compete with people. Agricultural pests include insects, disease, weeds, fungus, snails, nematodes and rodents that reduce crop or livestock yield and/or quality. They can be controlled by various methods: chemical control (pesticides), biological control (pest predators), use of resistant varieties, mechanical control (harrowing or handpicking) and all types of cultural practices (crop rotation, land preparation, method of crop establishment, etc). Pesticides are chemical substances that kill pests. Major groups of pesticides are insecticides (to control insect pests), herbicides (to control weeds), fungicides (to control fungal diseases), molluscicides (to control snails), nematicides (to control nematodes) and rodenticides (to control rats). Although all pesticides have adverse effects on the environment, insecticides generally pose the most serious and widespread risks because of their acute and chronic toxicity to living organisms, persistence in the environment or cumulative properties (ADB 1987). In addition to botanicals (insecticides derived from plants or plant products such as nicotine, rotenone or pyrethrum), there are four main groups of synthetic organic insecticide compounds: organochlorines, organophosphates, carbamates and synthetic pyrethroids. This sequence corresponds roughly to the historical order of their development and use (Dehne and Schönbeck 1994).

An important distinction has to be made with regard to the hazard class of pesticides[19]. Many insecticides used in rice are extremely or highly hazardous class I chemicals (mostly organophosphates

[19] According to the FAO International Code of Conduct on the Distribution and Use of Pesticides, hazard is defined as the probability that a pesticide will cause an adverse effect or injury under the conditions in which it is used. The classification, which distinguishes between the various hazard classes of pesticide formulations (class Ia: extremely hazardous; class Ib: highly hazardous; class II: moderately hazardous; class III: slightly hazardous), is based on the acute oral and dermal toxicity of the active ingredient, its concentration in the formulation and its physical state (ADB 1987).

and carbamates). The use of class I insecticides has been increasing because they are cheaper than other types (Rola and Pingali 1993). These data give cause for considerable ecological and human health concern.

Herbicides have not attracted as much attention as insecticides with regard to their environmental and health effects. However, many important herbicides (e.g. paraquat and diquat) are very toxic to mammals when ingested (ADB 1987). In addition, discovery in the 1960s of a contaminant entering the manufacturing process of one group of herbicides and identified as an especially toxic dioxin has turned these compounds into the most controversial of pesticide chemicals since the early 1980s (Boardman 1986).

Since in most areas a combination of different pesticides is applied, it will be difficult to single out the effects of one particular chemical. Therefore, this chapter discusses rice pesticides as a whole with the main focus on insecticides. The following sections provide an overview of the Philippine pesticide market and pesticide use in rice, followed by a discussion of the economics of pesticide use and the problems associated with injudicious and unsafe use.

Development of the rice pesticide market in the Philippines

In the past, farmers in Asia grew traditional rice cultivars and used mainly cultural and mechanical methods of pest control. The yield potential of traditional varieties was too low to justify additional investments in the form of pesticides. With the spread of high-yielding rice varieties and associated changes in production practices, conditions for pests have improved (Reissig et al. 1986). Furthermore, the higher yield potential of the new rice varieties made pesticide applications economically attractive to farmers. While only few national statistics exist documenting the use of pesticides on rice, case studies and market shares of various pesticides can shed light on national rice pesticide consumption.

The Philippine agrochemical market was valued at US$ 80 million in 1992[20] (Wood Mackenzie 1993). The dominant crops harvested were banana (40%) and rice (30%), followed by fruit and vegetables (12%) and others (18%). In terms of pesticide product class, insecticides accounted for 63% of total sales, followed by herbicides (20%), fungicides (12%) and others (5%). Key products were endosulfan, azinphos-ethyl, monocrotophos and methyl-parathion (Wood Mackenzie 1993). The corresponding brand names are Thiodan, Gusathion, Azodrin/Nuvacron and Folidol/Fosferno. All of these products are insecticides. While endosulfan, an organochlorine, belongs to hazard class II (moderately hazardous), the other three products are organophosphates with hazard classes Ib (highly hazardous) for azinphos-ethyl and monocrotophos, or even hazard class Ia (extremely hazardous) for methyl-parathion (ADB 1987).

The agrochemical market in the Philippines has suffered in the 1990s due to the weakness of the economy and a lack of investment in agriculture (Wood Mackenzie 1993). While the market grew at an annual rate of 6.9% in dollar terms between 1982 and 1988, it declined at a rate of -2.9% p.a. between 1988 and 1992, because of the devaluation of the Philippine currency (Wood Mackenzie 1993).

20 The most recent data available when the study was written.

Pest management practices of rice farmers in the Philippines

The long-term growth in rice agrochemical markets reflects the increasing use of pesticides on rice by small-scale farmers. While in the 1950s few farmers used insecticides, the next decade saw a dramatic rise in insecticide use. Kenmore et al. (1987) point out that the sharpest increase in insecticide use in the Philippines took place *before* the introduction of MVs. They claim that neither the release of Green Revolution rice varieties nor the rice intensification campaign ('Masagana 99'), begun in 1973, were responsible for convincing the majority of irrigated rice farmers to use insecticides, but that aggressive advertising and promotion campaigns by chemical companies as well as by the government were the main reasons for this development. Nonetheless, insecticide use increased even further after the release of MVs so that by the mid-1980s, over 95% of irrigated rice farmers in the Philippines used insecticides on every rice crop. Kenmore et al. (1987), in summarizing various studies, give an impressive description of farmers' attitudes towards insecticides:

> "They [the farmers] believe that treating crops with insecticides is progressive, modern, effective, and necessary; that farmers who use insecticides are themselves progressive, modern, and hardworking; that farmers who do not use insecticides are lazy, old-fashioned, and ignorant; that insect pests can cause major yield losses, cause those losses before the insects are visible, and can be controlled by chemicals; and that using more insecticides ensures higher yields and profits even though insecticides are dangerous (Kenmore et al. 1987, p. 102)."

This corresponds to the finding of Pineda et al. (1984) who report that traditional insect control practices had been replaced completely by the use of insecticides in irrigated and rainfed rice farms in Nueva Ecija, Philippines, in 1979. Spraying was the most widely used insecticide application method and most farmers applied insecticides 3-4 times during the cropping season, usually in the early crop stages up to the booting stage.

Similar results are presented by Fujisaka et al. (1992) who report that in 1992, farmers in two communities in Nueva Ecija, Philippines, sprayed three to four times in the wet season and three times in the dry season. Most of the insecticides were applied in the vegetative stage of the rice plant. The costs of insecticide application (material and labor) amounted to roughly 10% of total rice production costs.

Waibel's results (1986) from three Philippine provinces lie within the same range. He shows that pesticide expenditures (insecticides, herbicides, rodenticides) in 1980 generally remained below 10% of total variable costs (materials only, excluding labor for pesticide application). However, many farmers employed lower dosages than recommended by the official extension service. Waibel reports that, contrary to common belief, most farmers did not apply pesticides on a routine calendar basis but based their decision for pesticide applications on the observation of the pests. Nonetheless, farmers did not actually carry out quantitative measurements in a strict sense. The control thresholds employed by those farmers who were able to specify such information were found to be lower than those recommended by the extension service. Therefore, chemical measures by the farmers can be regarded as prophylactic even though they are not calendar sprayings.

In a survey of rice farmers in Leyte, Philippines, Heong et al. (1992; 1994) found that the majority (89%) applied pesticides at least once in the wet season (WS) of 1991. About 60% of them used two to four sprays. Most of the pesticides (92%) used were insecticides. By considering their intended targets and timing of the sprays applied, more than 80% of the sprays applied in Leyte in the 1991 WS were found to be misused. Farmers placed emphasis on highly visible pests such as leaf feeders and rice bugs, which are usually not serious. In addition, most farmers (77%) applied their first sprays within 30 days after transplanting (DAT) because they observed damaged leaves. However, rice plants can usually recover from leaf damages that occur early in the cropping season. Insecticide application at these early crop stages are not only wasteful but can be damaging to the predator-prey balance and thus may lead to secondary pest outbreaks, such as the brown planthopper (Heong et al. 1994). Heong et al. (1992) conclude:

> "Information gaps between good pest management and what farmers seem to know are apparent... It is doubtful whether their efforts and expenses in chemicals were worthwhile... Their pest identification skills were poor and knowledge about the role of natural enemies and natural control are even poorer. Training to enable the farmers make better pest management decisions is clearly needed (Heong et al. 1992, p. 25)."

Farm-level economics of pesticide use in rice

In contrast to fertilizers, neither pesticides nor other pest control strategies can increase potential yields. They can only ensure that the maximum yield physiologically obtainable in a particular field and season will not be significantly reduced by pests (Reissig et al. 1986). The economics of pesticide use are therefore closely related to the crop loss that is prevented by pesticide applications. This, in turn, depends on various factors: the type of pest, the pest population size, the growing stage of the plant, the season, conditions in neighboring fields, control efficiency of the pesticide application, etc. The estimated crop loss will have to be contrasted with the cost of pest control to arrive at a profitability estimate from the individual farmer's point of view.

Crop loss assessment of pests in rice

There are few reliable estimates of how much rice is annually lost to pests and diseases. The most commonly quoted figure for Asia (excluding the People's Republic of China) is Cramer's estimate (1967) of 31.5% loss due to insects, 9.3% to diseases and 10.7% to weeds, which leaves only 48.5% of potential production to the farmer. However, in addition to the many assumptions underlying Cramer's estimation procedure, this figure was derived before the onset of the Green Revolution in rice in Asia and certainly before the development and spread of resistant rice varieties. Other studies have produced estimates which are more recent and more location-specific. They are summarized in Table 4.1.

Although there is a certain amount of variation among different studies, Cramer's figure lies among the highest estimates provided in the literature. Following on from Cramer is a study by Oerke (1994) who estimates global crop losses due to insect pests, diseases and weeds at 44%[21]. For rice production in the Philippines, he suggests that potential loss due to weeds could be as high as

[21] In this study, crop loss was defined as difference between attainable yield and actual yield, which disregards economic criteria. Thus, the resulting estimates are likely to be too high.

Table 4.1. Crop loss due to aggregate damage of pests in selected countries.

Country	Source of loss	Crop loss estimate (%)	Reference
East and Southeast Asia	Insects	23.7	Ahrens et al. (1982)
Philippines	Insects	20-25	Pathak and Dyck (1973)
Philippines	Insects	35-44	Pathak and Dhaliwal (1981)
India	Insects	35	Way (1976)
Philippines	Insects	16-30	Way (1976)
Philippines	Insects	8.6	Litsinger et al. (1980)
Philippines	Insects	8.9	Waibel (1986)
Philippines	Chronic pests	18.3	Litsinger et al. (1987)
Philippines	Weeds	11-65	Moody (1982)

Source: modified after Waibel 1986 and Rola and Pingali 1993.

65%, followed by animal pests and diseases with potential yield losses of 50% and 40%, respectively. However, crop loss assessments for specific rice pests vary widely by location and by year. For example, the crop loss caused by stemborer was estimated at 3% in India and 95% in Indonesia (Rola and Pingali 1993). Litsinger et al. (1987) found that yield loss variability was greater between fields than crops or sites, thus exemplifying the problem of determining average yield loss figures. By using evidence from multiperiod, multilocational trials, Waibel (1986) came to the conclusion that crop losses due to insect pests, depending on location, are much lower than generally perceived, amounting to just over 10% on the average and rarely exceeding 20%. Therefore, care has to be taken in generalizing findings from individual studies:

> "Pest-related yield losses depend on agroclimatic conditions, cropping intensity, varieties used, land and crop management practices, and pest control methods. Single-period assessments done at one spot cannot be generalized over time and place. Long-term loss assessments have generally shown modest yield losses to insect pests (Rola and Pingali 1993, p. 11)."

Therefore, the use of crop loss information as the only criterion leads to a very partial assessment of the costs and benefits of pesticide use. Waibel and Fleischer (1996) point out the shortcomings of this approach:

- it is often based on the attainable yield which is higher than the economic yield;
- estimates are mainly based on data from experiment stations, where yield levels and potential losses are higher than in farmers' fields;
- no difference is made between resistant and non-resistant varieties;
- the interplay between different pests and beneficial organisms in the ricefield ecosystem is neglected if loss estimates are generated for single pests;
- pest population densities and their reasons are ignored;
- direct and indirect pesticide subsidies are not taken into account;
- no alternative control methods are considered.

All these aspects lead to an overestimation of the benefits of pesticide use. In addition, subjective perceptions of crop losses and pesticide impact are often also exaggerated.

Perceptions of pest damage and impact on pesticide use

Perceived crop losses (on which the decision to use a pesticide or other control measure are based) are usually higher than the actual situation. This has been found true for farmers as well as for researchers and policymakers (Rola and Pingali 1993). Farmers tend to base their decisions on experiences made in years of major infestations (Rola and Pingali 1993). In a survey of farmers in the Philippines and in Thailand, most farmers expected losses to pests of more than 35% in the Philippines and more than 50% in Thailand (Waibel 1990). These are intolerable levels. Therefore, farmers tend to overuse pesticides by spraying too often, either because they observe insects in the field (but mostly without employing any quantitative decision rule), or for other reasons:

> "Farmers believe calendar-based treatments are preferable, but cannot afford them and so treat instead at the first sight of an insect; they believe modern, usually insect resistant varieties require more treatment than previous varieties; that if their neighbor treats, they should, regardless of pest population; that their whole farm should be treated even if pests are confined to one paddy or less than 10% of their area; that they should treat their fields after fertilizer applications; and that insecticides are always more effective than natural enemies (Kenmore et al. 1987, p. 102)."

On the other hand, while the frequency of insecticide applications is often too high, the dosage is often too low, thus reducing the effectiveness of the application (Litsinger et al. 1980; Pineda et al. 1984; Waibel 1986). In addition to being ineffective and wasteful, use of sublethal dosages can cause pest resurgence (Chelliah and Heinrichs 1984).

Researchers base their perceptions of pest-related yield loss on experiments or surveys. Only few yield-loss studies have covered a sufficiently long period of time to allow researchers to generate probability distributions of damage (Rola and Pingali 1993). Therefore, researchers' perceptions are usually based on generalizations from single-period or short-term experiments and results continue to be used for years, even if varieties and crop management practices have changed in the meantime (Rola and Pingali 1993). As a general tendency, researchers also tend to overestimate crop losses due to pests, leading to decision criteria that favor pesticide use.

Policymakers still believe that modern rice production is not possible without high levels of chemical pest control (Rola and Pingali 1993). This perception is based on the high crop losses from the early MVs that were susceptible to pest damage and has led to the promotion of pesticide use through subsidies and credit programs. For example, the rice intensification program (Masagana 99) in the Philippines provided agricultural production loans partly in the form of fertilizers and pesticides, thus prescribing their use on a regular basis, regardless of actual need (Binamira 1991).

The impact of varietal resistance on the profitability of pesticide use

High perceived crop losses resulted from the time when MVs were still susceptible to pest attack. However, most varieties released after the mid-1970s are highly resistant to a broad spectrum of pest infestations, thus reducing the necessity of chemical pest control (Rola and Pingali 1993). The crucial role of pest resistance in the economics of pest control is further supported by a number of studies on the profitability of different pest control strategies.

Herdt et al. (1984) analyzed data from experiments conducted at four Philippine research stations during the 1972-74 dry seasons. They compared three levels of insecticide application[22] using moderately resistant versus nonresistant varieties. In their economic analysis, the marginal benefit-cost ratio (MBCR) is most attractive for the lowest level of insecticide application. However, there is a marked difference between moderately resistant and nonresistant varieties: while there is no incentive to go beyond the lowest level of insecticide application with the moderately resistant rice varieties, there is some profit involved in applying even the maximum level of insecticide application on the nonresistant rice varieties.

The same experiment with three levels of insecticide application using resistant varieties was conducted in farmers' fields in five Philippine provinces (Herdt et al. 1984). In all five sites, only the lowest level of insecticide application could generate sufficiently high rates of return greater than 2:1. Average MBCRs for the other two treatments are less than 1.0 in all sites and are even negative in most cases.

Kenmore et al. (1987) cite two studies which compared farmers' crops from treated and untreated fields in the Philippines between 1976 and 1984. In only 50% of all cases was there a measurable yield loss due to insects. If resistant varieties were planted, the proportion of fields showing yield loss to insects dropped to 42%. This means that while about 97% of farmers used insecticides, less than half got higher yields from using them.

The same authors report the results of a comparison of farmers' practice and IPM using action thresholds from 43 farmers in five regions of the Philippines during the wet season of 1984 (Kenmore et al. 1987). On average, IPM preserved the same yield, while reducing total costs of pest control by more than 50%, or reducing cash costs (excluding imputed labor cost) by 80%.

Waibel (1986) found that the economic feasibility of chemical control was definitely lower in resistant than in susceptible varieties. If the opportunity costs of cash are taken into account, chemical control on resistant varieties will in most cases cease to be economically feasible. Waibel stated that 'the economic feasibility of crop protection measures therefore depends to a great extent on the probability of varietal resistance breaking down' (1986). This probability is likely to decrease in the future due to progress in genetics and biotechnology (Rola and Pingali 1993).

Rola and Pingali (1993) report that the use of resistant rice varieties has not influenced the frequency of pesticide applications among rice farmers in Laguna, Philippines. Most of the insecticides applied to rice in that province were therefore wasted.

In summary, the development of resistant rice varieties has had a significant negative impact on the profitability of pesticide use. As early as 1984, Litsinger proposed that Philippine rice production could easily be maintained at current levels with half the insecticide then used at the time if it was applied effectively. Since then, a number of rice varieties with even better resistance against pests have been released (Rola and Pingali 1993), thus reducing further the need for insecticide application.

Pesticide effects on aquatic vertebrate and invertebrate organisms

In addition to not being profitable in rice production, a number of negative external effects have been associated particularly with the use of insecticides. These relate to the development of pesticide

[22] The lowest level of insecticide application was termed "economic threshold" (ET) even though different treatments are subsumed under this term. The other two levels are called "next higher" (NH) and "maximum protection" (MP). The economic comparison using the marginal benefit-cost ratio (MBCR) is always with respect to the next lower level: ET compared to zero application, NH compared to ET, and MP compared to NH (Herdt et al. 1984).

resistance by pest organisms, the increased hazard to nontarget organisms (including humans) and environmental pollution (e.g. Carson 1962; Chelliah and Heinrichs 1980; Metcalf 1984; Sutrisno 1987; Kenmore et al. 1987; Rola and Pingali 1993; The Pesticides Trust 1993). For the purpose of this study, only the negative impact on aquatic oligochaetes and other soil and floodwater vertebrates and invertebrates is considered.

Unfortunately, much of what is known about the impact of pesticides on the vertebrate and invertebrate organisms in the paddy comes from laboratory or controlled experiments. According to Pingali et al. (1992), the following conclusions can be reached from the existing literature:

- the absolute number of aquatic vertebrate and invertebrate organisms declines rapidly with pesticide use, mortality usually occurs within the first 5-7 days after pesticide application;
- for the surviving populations, the level of detectable residues is generally small.

Cagauan (1990) and Cagauan and Arce (1992) studied the effects of pesticides on fish in a rice-fish system. They found that from all pesticide groups, insecticides were most toxic to fish, followed by molluscicides and herbicides. Among the insecticides, carbamates and organophosphates were less toxic to fish than organochlorines and synthetic pyrethroids. However, residues of pesticides were not detectable in water and fish tissues at seven days after application in ricefields.

Lim and Ong (1987) point out that frogs and snakes are also commonly observed to be affected by pesticides in paddy fields. The frogs are particularly susceptible to pesticides, large numbers having been found dead after the use of monocrotophos and dieldrin.

Synopsis

The previous review of the relevant literature has raised serious doubts as about the profitability of pesticide use (particularly the use of insecticides) in rice. Perceived crop losses are often higher than the actual situation, pests are not correctly identified, pesticides are applied at the wrong time, for the wrong target and at the wrong dosage. No appropriate quantitative decision rules are employed and knowledge about alternative control methods is poor. The development of resistant varieties has further reduced the returns to pesticide application. It can thus be concluded that current farmers' practices as regards pesticide use are not profitable in the long run. In addition, pesticides have a negative impact on the environment and on human health. The rate of return to research that reduces pesticide use may be underestimated when health effects are not accounted for. For example, if IPM technology leads to the reduction of pesticide use, any associated improvements in health or environmental quality should be counted as benefits from the adoption of IPM. The estimated rate of return to IPM research would be correspondingly higher (Pingali et al. 1992). The following section will provide an introduction to the concept of IPM and present the latest development in IPM research and extension for rice in Southeast Asia.

Integrated pest management in rice—the emergence of a new paradigm

The concept of IPM is older than the term itself. For example, there are reports that IPM was used for the control of boll weevil on cotton in the United States in 1923 (Flint and Van den Bosch 1981). The first publish report defining 'integrated control' was by Stern et al. (1959), and this publication is considered the starting point of IPM (van de Fliert 1993).

Over the years, IPM has been defined in various ways by different authors as:

- a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population at levels below those causing economically unacceptable damage or loss (FAO 1968);
- an ecologically based pest control strategy that relies heavily on natural mortality factors such as natural enemies and weather and seeks out control tactics that disrupt these factors as little as possible (Flint and Van den Bosch 1981);
- a strategy or plan that utilizes various tactics or control measures—cultural, plant resistance, biological and chemical—in a harmonious way. Control actions are based on frequent monitoring of pests (Reissig et al. 1986);
- the process of combining multiple methods for managing pest populations with other components of a crop management system. The emphasis in IPM systems is on including all efficient forms of resource management to control pest numbers and damage rather than, necessarily, killing all pests. In some cases individual farmers or groups of farmers can completely eradicate pest species from certain areas but usually pest management involves suppressing pest populations in an economically efficient manner to enhance long-term profitability (Carlson and Wetzstein 1993).

The common denominator in all these definitions is the ecological approach to pest management and the combination of all available control techniques, with the implicit objective of reducing pesticide use to an absolute minimum and treating it as a last resort when all other control methods have failed. In addition, the concept of control, which during the pesticide era meant total elimination of pests, has been replaced with the concept of management, where the goal is to reduce pest populations to levels which are uneconomical to control (Reissig et al. 1986). Low pest populations are not only tolerated, they are even desireable because they serve as food sources for beneficial organisms.

The shortest description of IPM simply says 'Integrated Pest Management is information' (Kenmore 1978). Indeed, the techniques and methods employed in IPM require accurate information on pest and natural enemy densities in the field as well as on a broad range of other factors such as damage symptoms, growing stage of the plant, varietal resistance, etc. This definition illustrates the difference between hardware-oriented technologies such as a new rice variety or a new tractor and software-or knowledge-based technologies such as IPM. It is therefore somewhat misleading to talk about the adoption or non-adoption of IPM as if it were an object. Pest management decisions will differ from locality to locality and from year to year. Two farmers can both 'practice IPM' although they will choose their methods by different decision-making processes.

This understanding of IPM as improving farmer decision-making is indicative of a change in paradigm which has emerged since the beginning of the 1990s (Table 4.2).

The main feature of the new IPM paradigm is the empowerment of farmers to manage their crops without dependence on any outside agents. This basically corresponds to the definition of IPM as being information, since information is the basis for good decision-making. Instead of searching for the 'best mix' of control measures, a concept that had failed to reach the farmers, IPM has evolved into a series of activities (Kenmore et al. 1995):

- Grow healthy crops.
- Visit crops in fields regularly.
- Understand biological control agents and the agro-ecosystem.
- Make farmers IPM experts.

Table 4.2. A comparison between elements of old and new paradigms in IPM in rice in wet tropical Asia.

	Old paradigm	New paradigm
1.	IPM involves integrating different methods of control	IPM looks at a problem and finds out why there is a problem and solves it
2.	IPM is simply finding out when to spray 'appropriate' insecticides and if insecticides are ineffective, change to new ones	IPM looks at a problem from a purely empirical/ scientific point to discover causes of pest problems and provide a basis for solving them
3.	Biological control is too unreliable for IPM	Biological control is the core of IPM
4.	Difficult to use biological control agents due to lack of rearing facilities	Biological control already exists in the field and should be conserved
5.	Farmers cannot understand ecosystem and biological control is too complicated for them	Farmers understand biological control and can carry out ecosystem analysis
6.	IPM should be a centrally controlled activity under the charge of scientists	IPM is by farmers and not for farmers
7.	IPM should be developed by scientists and given to farmers as a package	Researchers should work with farmers to develop IPM together
8.	IPM should be an insecticide resistance management package developed for farmers to follow rigidly	IPM is an ecological approach where farmers understand the ecosystem and make appropriate pest management decisions
9.	Pest problems arise due to lack of proper spray equipment	Pest problems usually result from inappropriate use of insecticides
10.	IPM is too complicated and too laborious for farmers to follow	IPM based on understanding the ecosystem encourages farmers to take charge of all decisions on pest control
11.	Farmers can be taught in classrooms using color slides and picture books	IPM is a field activity and learning should be in the field using live specimens
12.	Natural enemies often arrive after the pest has caused damage	Natural enemies exist in the field even before the crop is planted and act as sentinels of field crops
13.	Insecticide is an integral part of IPM	Insecticides cause pest outbreaks by killing beneficial insects that keep pests in check naturally
14.	Botanical insecticides are safer and can be used in IPM as an alternative to chemical insecticides	As with all insecticides, some botanicals can cause similar problems, besides being more toxic to human beings, more expensive, laborious to prepare and being less stable are less effective

Source: Kenmore et al. 1995.

Under the old paradigm of IPM, the main concept was the economic threshold (ET), the pest population level at which control measures should be taken to prevent crop losses costing more than control (Stern et al. 1959). From an economist's point of view, ET is the 'break-even point' below which a control measure is not profitable. ETs therefore depend on the cost of control (i.e., the pesticide material used), the control efficiency of the pesticide used and the loss caused by the particular pest.

The various problems associated with ETs can be divided into conceptual (problems pertaining to the definition of the ET) and practical (problems regarding the practical application of ETs in the field). Conceptual problems arise because recommended ETs for irrigated rice are often not well defined. Levels are usually based on single pests rather than on the most frequent pest combinations found in the field (Waibel 1987). Only recently have there been attempts to come up with multiple-pest economic thresholds for rice (Palis et al. 1990). In addition, the ET for a given pest changes throughout the cropping season, depending on the growth stage of the crop. Dynamic or fluctuating threshold levels have been defined which take crop development into account (Zadoks 1987), but they are not available for all crops and all environments. ETs should be country-specific or even region- or province-specific (ADB 1987). Soil type and fertilizer usage as well as the production level or expected yield have implications for the ET which are normally neglected (Zadoks 1987). Finally, ETs only consider the population dynamics of rice pests while neglecting those of the natural enemies of the pests (Palis et al. 1990).

Practical problems mainly arise because the ET-strategy requires a high degree of knowledge and it is laborious and time consuming. Farmers have to be able to monitor crops periodically, identify pests and beneficial organisms correctly, know the applicable threshold level and to correctly apply appropriate pesticides when the economic threshold is reached. In addition, there is a high degree of uncertainty about output prices at the time when the control decision has to be made (Zadoks 1987). Zadoks (1987) claims that the calculations supporting a decision to treat and the choice of chemical have become so complicated that they have to be made by computer. This, of course, is not practical for small-scale farmers in developing countries. Therefore, not many farmers have been found to observe threshold levels in their spray decisions (Rola and Pingali 1993).

IPM activities in rice in the Philippines were initiated by the Food and Agriculture Organization (FAO) in the late 1970s (Binamira 1991; Rola and Pingali 1993). At that time, the 'Masagana 99' rice production program of the Philippine government was already in full swing. Under this program, which aimed at rice self-sufficiency, production loans were made available to farmers and were linked to the adoption of technology packages consisting of MVs and high levels of farm inputs. Thus, farmers were exposed to contradicting incentives and recommendations—the government on the one hand promoting the use of pesticides through their credit policies and extension recommendations, and the first IPM trainings on the other hand which were funded by FAO but conducted by the Crop Protection Division of the Bureau of Plant Industry (Binamira 1991). 'Masagana 99' terminated in 1983 and was replaced by a transitory lending program, the Integrated Rice Production Program (IRPP). This program was abruptly phased out when the new government took over in 1986 (Binamira 1991). Even though existing policies regarding pesticide registration, pricing, importation and usage remained unaltered, IPM was declared as the national crop protection policy of the Philippines in that year. This brought major operational and funding support from the Philippine government for IPM training (Binamira 1991). Between 1986 and 1988, more than 90 000 irrigated rice farmers and 8 000 government extension workers in major rice producing regions were trained under the Philippine National IPM Program (Binamira 1991). However, the following years saw a decline in training efforts and interest in IPM. In 1990, only 8 000 additional farmers were trained, the lowest number since 1985 (Binamira 1991). At the same time, a major restructuring of the Department of Agriculture caused the reassignment of trained extension workers and IPM specialists to mostly non-IPM jobs, thus leading to a deterioration in the quality of farmers' training (Binamira 1991).

Until 1993, IPM in practical Philippine agriculture was almost non-existent. In that year, however, there were renewed efforts to revitalize the National IPM Program by expanding its coverage to include rice, corn and vegetable crops and by modifying the training methodology from a 2-3 day activity to a season long session (Rola 1994). Training sessions were designed after the FAO-developed Farmer Field School (FFS) which had been successfully implemented in Indonesia (Kenmore 1991).

As an alternative to the top-down approach promoted in traditional extension, a non-formal approach to education was adopted under the new paradigm of IPM in which farmers learn by conducting their own experiments (Kenmore et al. 1995). A FFS extends over the course of a cropping season and about 25 farmers from the same village or the same area attend the 12 to 15 sessions that are held per season. Once a week, an IPM facilitator visits the FFS. Farmers study sprayed and unsprayed fields and conduct field experiments and agro-ecosystem analysis. Based on the findings, farmers decide whether any interventions are necessary. Additional experiments are carried out to understand the impact of insecticides on beneficial organisms, the number of prey eaten by each predator, food preferences and how predators survive when no rice pests are available (Kenmore et al. 1995). Through the FFS, new research findings, such as nutrient management and improved cultural practices can reach the farmers quickly. Thus, in addition to the farm-specific knowledge that farmers usually possess, scientific knowledge is provided which enables the farmers to make informed decisions on pest management in their fields. Kenmore (1983) claims that the crop protection practices of trained farmers become 'more conscious, more considered, more controlled and conversely less mystified or automatic, less visceral or hyperreactive, and less dependent on resources from outside'.

This new approach to IPM, which will subsequently be called 'farmer-driven IPM' is likely to be sustainable because it does not depend on external inputs. There is also a good chance that trained farmers will share their knowledge and experiences with untrained farmers, thus contributing to the spread of IPM. However, to speed up the process, additional incentives may be needed to convince farmers not to use pesticides. This is where fish and other aquatic organisms have a role.

The role of rice-aquaculture in IPM

Even though there are some recommendations on how pesticides can be used in rice-fish systems (Heinrichs and Aquino 1978; Cagauan and Arce 1992; Kyaw Myint Oo 1993), in most cases the use of pesticides is regarded as a constraint to rice-aquaculture.

> "...pesticide-using farmers trade off a higher quantity of protein supply from the paddy for a higher and more stable rice output. Deliberate interventions to increase protein supply from the paddy, through rice-fish farming for instance, would only be successful with advances in pest management technology that minimizes the above trade-off (Pingali et al. 1992, p. 15)."

Therefore, a pest management system that minimizes the application of pesticides creates a favorable environment not only for fish but for all aquatic organisms in the ricefields and in the adjoining irrigation canals. In particular, the concept of IPM as being 'ecosystem management' recognizes the positive impact that species diversity can have on the pest-predator balance in the field. If this concept is extended to include the aquatic component of the ricefield ecosystem, fish can play an important role in IPM for two reasons: fish help to control pests and fish serve as an additional incentive for farmers not to use pesticides.

Fish as a control agent of pests

Fish (particularly carp) in ricefields have been reported to prey on a wide spectrum of rice pests, including insects, snails and weeds (Table 4.3). In addition, fish can help to control malarial mosquitoes and water-borne diseases (Nalim 1994) . Even though a direct comparison of treatment effects is impossible because of varying numbers of pesticide applications, there is a strong indication that pest abundance and damage are lower in rice-fish culture than in rice monoculture (Halwart 1994b).

The extent to which fish can help to control rice pests depends on the feeding habit of the particular species. Younger fish are generally more omnivorous and insects often form part of their diet (Halwart 1992). In its natural habitat[23], common carp is described as a benthic omnivore and the Nile tilapia as a planctivore filter feeder (Halwart 1994b). Some fish species are herbivorous (e.g. *Tilapia rendalli, T. zillii*) and thus help in controlling weeds (Vincke and Micha 1985).

The pest control mechanisms of fish are varied. Halwart (1992) proposes that fish can:

- feed on newly hatched snails;
- feed on dispersing stemborer larvae;
- feed on hoppers that fall on the water surface;
- feed on caseworm larvae while floating on the water;
- feed on floating sclerotia;
- control weeds by direct feeding. In addition, increased turbidity and constant flooding also control weeds.

In a study on the impact of fish on arthropod communities in irrigated rice in the Philippines, Halwart (1994a) found that fish consumed all guilds that were found to be of importance in the ricefield, regardless of aquatic, semiterrestrial or terrestrial life cycle of the arthropod species. However, significant differences in arthropod abundance or damage between rice-fish and rice treatments

Table 4.3. Literature overview on the impact of different species, sizes, and densities of fish in ricefields on occurrence or damage of various insect pests as compared to rice monoculture.

Pest organism	Fish species			Farming system			Source
	Species	Size (cm)	Density (no /ha)	Measured parameter	Rice mono-culture	Rice-fish culture	
Stemborer	*Cyprinus carpio*	6.6	n.a.	Deadhearts (%)	0.37	0.33	Ji and Yu 1987, in Xiao 1992
Stemborer	Carp polyculture	n.a.	1 905	Deadhearts (%)	0.50	0.10-0.30	Liao 1980 in Spiller 1986
Stemborer	Carp polyculture	n.a.	1 905	Whitehearts (%)	0.50	0.25-0.25	Liao 1980 in Spiller 1986
Planthopper	*Cyprinus carpio*	6.6	n.a.	Abundance ('000/ha)	23 400	15 900	Ji and Yu 1987, in Xiao 1992
Planthopper	Carp polyculture	n.a.	1 905	Abundance (no /hill)	8	3-5	Liao 1980 in Spiller 1986
Leafhoppers	n.a.	n.a.	n.a.	Abundance (no /area)*	11 414	1 408	Liu 1987 in Xu and Guo 1992
Leafhoppers	Carp polyculture	n.a.	1 905	Abundance (no /hill)	8	2-6	Liao 1980 in Spiller 1986
Leaffolder	*Cyprinus carpio*	6.6	n.a.	Rolled leaves (%)	4.40	1.59	Ji and Yu 1987, in Xiao 1992
Leaffolder	Carp polyculture	n.a.	1 905	Rolled leaves (no /100 hills)	50	12-44	Liao 1980 in Spiller 1986

Source: Halwart 1994b
n.a.= information not available, *size of area not given.

23 Both the common carp and the Nile tilapia are exotic to the Philippines. Common carp was introduced around 1915 from China and Nile tilapia around 1970 from Thailand and Israel (Halwart 1994b).

could only be detected for stemborer damage (whiteheads) which were reduced by 3% in the tilapia and by 5% in the carp treatment.

Hendarsih et al. (1994) report that in a screenhouse experiment, the capacity of fish to prey on brown planthopper appeared to be dependent on the density of the hoppers. Higher population would cause more planthoppers to hop on the water where they could be caught by the fish.

Cagauan et al. (1994) found that in an experiment which compared the effects of fish and pesticides on certain parameters of the ricefield ecosystem, total abundance of weeds was reduced by 67% from 2 103 kg/ha in the fish treatments. Total weed abundance and fish density and size were negatively correlated (r = -0.50 to -0.52). In contrast, herbicide application also reduced weeds, but nonsignificantly, by 18.3% from 1 538 kg/ha.

Halwart (1994b) focused on the role of fish as control agents for the Golden Apple snail (*Pomacea canaliculata* Lamarck), a freshwater snail that was introduced to the Philippines and Taiwan from Florida and South America by private entrepreneurs. The snail, which initially was grown for food, escaped and spread rapidly through natural waterways and irrigation canals. Eventually, it invaded ricefields and developed into a serious pest (Acosta and Pullin 1991). Many farmers reacted by experimenting with pesticides that were not registered for use against molluscs in freshwater ecosystems (Cruz 1991). The severe health impairments associated with the unprotected application of organo-tin compounds: peeling toe and fingernails, headaches, skin disorders and blindness, stressed the importance of finding other ways to manage the snail problem (Halwart 1994b). In a number of aquarium experiments, it was found that both common carp and Nile tilapia consume juvenile Pomacea snails, with common carp being more efficient predators of snails than Nile tilapia (Halwart 1994b). Field experiments more or less confirmed these findings. This suggests that common carp could be successfully used as biocontrol agents of *Pomacea* snails in ricefields[24].

In summary, fish in ricefields are part of the army of natural enemies of rice pests. Even though evidence for the role of fish as control agents of insect pests is somewhat ambiguous, the positive effect of certain fish species on the control of weeds and snails seems to be well established. While fish alone cannot completely control rice pests, their significant contribution should not be overlooked.

Fish as an additional incentive to practice IPM

In addition to actively controlling rice pests, fish can serve as an incentive for farmers not to use pesticides in the ricefields. Traditionally, the central message of IPM is: do not spray. However, as discussed above, if perceived crop losses are high and alternative control methods are either not known or laborious and complicated, this message is not likely to reach the farmers.

> "Insecticides amount to between 3.8 and 6.2 percent of the total variable cost of rice production which would be about 100 to 150 Pesos, or about 5-8 US$ per ha. It may be difficult to convince a farmer to save this amount of expenditure on insecticides and instead to follow rather laborious sampling techniques. This is only likely if there is a high yielding investment alternative for the money he can save by not spraying insecticides. IPM, therefore, should

[24] Halwart (1994b) cautions that common carp cannot consume large snails, thus a combination with other control methods to reduce larger-sized snails is recommended.

> emphasize not only insect problems, but take into account the entire production process. Thus IPM would contribute to an optimal allocation of scarce farm resources like cash and labor rather than only aiming at reducing insecticide inputs (Waibel 1987, p. 195-196)."

One such high yielding investment alternative could be the stocking of fish in the ricefields. Using empirical data from the Philippines and Indonesia, Waibel (1992) shows that the chance of an insecticide application becoming necessary moves close to zero when the opportunity costs from fish are included in the calculations of economic thresholds. While more empirical data are needed to verify this relationship, the crucial parameter in the equation are the net fish yield and the relative price of fish. Net fish yield can be expected to improve with technical progress in aquaculture. As has been discussed in Chapter 2, the price of fish relative to the price of rice is likely to increase, thus the stocking of fish in areas where the costs of production are not prohibitive can offer an attractive alternative or augmentation to currently accepted IPM practices.

In summary, the discussion of rice-aquaculture and IPM has revealed that both technologies can be mutually reinforcing. Aquatic organisms in the ricefield can help to control pests and act as an additional incentive for farmers not to spray. On the other hand, IPM creates a favorable environment for aquatic organisms through the reduction of pesticide use. The new approach to IPM emphasizes an understanding of ecosystem processes which can easily be extended to aquatic organisms in the field. Thus, a combination of rice-aquaculture and IPM seems to be a natural and desirable move towards sustainable rice production.

Chapter 5

Theoretical foundations of farming systems development

The theoretical background for this study is provided at different levels: first, development strategies are discussed which have had an impact on rice-based farming systems as they can be found throughout Southeast Asia today. This is the level of the overall policy environment which, by providing certain incentives to farmers, shapes the resulting farming systems and influences the potential of different technology options. Next, the theoretical foundations of integrated farming are examined and particular reference is made to the factors influencing the integration or diversification of farming systems in Southeast Asia today. Finally, agricultural production theory and the theory of the farm household are applied to the problem of resource allocation among different enterprises in the farm-household system. Decision making rules of farmers are derived to assess the comparative advantage of different technology options at the farm-household level. In addition, the concept of sustainability is incorporated in the theory of the farm household to analyze how long-term considerations can have an impact on the choice of enterprises by the farm household.

This theoretical background will help to answer two basic questions with regard to rice-based farming systems in Asia:

1. What theoretical concepts can explain the present state of rice-farming? and
2. What future development is likely by applying the decision rules to the current state of rice farming?

By combining the results of the problem analysis with the relevant theoretical concepts, hypotheses are derived with regard to the potential of rice-aquaculture and IPM which will serve as a research guideline for the following empirical part of the study.

Different approaches in development economics

Today's irrigated rice-based farming systems in the lowlands of Asia are characterized to a large extent by the Green Revolution technology of rice production (see Chapter 2). In retrospect, many of the promises and objectives of the Green Revolution have not been achieved. A number of problems surfaced which contributed to a reorientation in rural development thinking. The historical, political and economic forces of the Green Revolution are analyzed as a basis for the evolution of more recent approaches to rural development, of which rice-aquaculture and IPM can be seen as examples.

The theoretical foundation of the Green Revolution

The Green Revolution originated in the 1960s when increasing emphasis was given to agriculture by donor agencies and governments of low-income countries. While in the 1950s agricultural development efforts were characterized by the attempt to transfer agricultural technology and extension models directly from high-income to low-income countries (an approach which Ruttan (1990) termed, the 'diffusion model' of agricultural development), it was increasingly recognized that structural barriers such as highly concentrated political power and asset ownership inhibited the expansion of agricultural output (Staatz and Eicher 1990). In addition, several studies showed that contrary to common belief, farmers in developing countries are responsive to economic incentives and allocate their resources efficiently, given existing technology. The most important proponent of this 'poor but efficient' hypothesis was T.W. Schultz in his highly influential book 'Transforming traditional agriculture' (Schultz 1964). Schultz argued that if farmers do not respond to extension messages, it might be due to the lack of profitable technology options and the skills needed to exploit this technology, i.e. the lack of investment in human capital.

The shift from agricultural extension towards investment in agricultural research and human capital that was called for by this book led to the adoption of a new model of agricultural development, the 'Green Revolution' or 'high-payoff input model' (Staatz and Eicher 1990). The development of high-yielding varieties (HYVs) of rice and wheat can be seen as a response to the demand for profitable technologies for small-scale farmers in developing countries. The new grain/fertilizer technologies were found to be highly divisible and scale-neutral, allowing them to be incorporated into existing systems of small-scale agriculture (Staatz and Eicher 1990). Griffin (1989) describes the mechanisms by which the Green Revolution was meant to contribute to overall economic growth:

> "One purpose of the strategy is to increase the supply of food, especially grains, the most important wage good. An abundant supply of grains will force down the relative price of food and this, in turn, will help to lower unit labor costs. Low unit costs will raise the general level of profits in non-agricultural activities and this should permit higher savings, more investment and a faster rate of overall growth. A second purpose of the strategy is to help industry directly—particularly those located in rural area—by providing raw materials (for instance, for the textiles and food processing industries), by stimulating the demand for agricultural inputs, capital and intermediate goods (fertilizer, irrigation pumps, construction materials) and by creating a larger market for simple consumer goods consumed in the countryside (bicycles, radios). Many of these industries tend to be more labor intensive than the industries promoted under an industrialization strategy and hence greater employment opportunities are created in both rural and urban areas (Griffin 1989, p. 29-30)."

Thus, it becomes quite clear that the theoretical foundations of the Green Revolution can be found in the development thinking of the 1960s when the interdependence between agriculture and industrial growth started to be recognized and an increase in agricultural productivity was regarded as a precondition for growth in the rest of the economy. The employment effects mentioned by Griffin already point to a revised Green Revolution strategy as conceived by Mellor (1976), which will be discussed in the next section. However, heavy emphasis is placed on productivity increases, since the main development objective during the 'early Green Revolution' was the growth in average per capita income. Further, industry was still regarded as the leading sector which to a certain extent depended on agricultural productivity growth.

In addition, Griffin (1989) puts a political touch to the Green Revolution by classifying it as an alternative to land reform programs implemented in other parts of the world (notably in South Korea, Taiwan, Japan and China). Land reform, characterized by a redistribution of land from large landowners to small peasants, implies profound social and political changes which are seldom welcomed by those who control the state (Griffin 1989). Therefore, an alternative strategy which makes land reform unnecessary is very much in the interest of the ruling elite and their foreign supporters.

This 'technocratic' approach to development (Griffin 1989) did not always produce the desired effects. Various critics of the Green Revolution argued that the new varieties often benefited mainly landlords and larger farmers in ecologically favored areas, while they frequently impoverished small farmers and tenants, particularly those in upland areas (Staatz and Eicher 1990). The example of the Philippines, the "home of the Green Revolution in rice" as described by Griffin (1989), shall serve as a case in point:

> "Looking back over the last two decades or so it is clear that technological change has not been a substitute for institutional change in the Philippines. Public investment programs in transport, irrigation and power have supplemented the efforts of the plant breeders, but even so, social conditions have deteriorated. Unrest in the countryside has grown by leaps and bounds. The incomes of some groups have fallen. Organized rural violence by Muslim insurgents in Mindanao and by the New People's Army in other parts of the country has received increasing moral and material support from poor tenants and landless workers. Pressure for a radical redistribution of land continues to mount. Indeed, land reform remains very much on the political agenda and the future of the Green Revolution as a strategy of development is uncertain (Griffin 1989, p. 156). "

Thus, it was recognized that in order to achieve rural development, more is needed than improved varieties. This is reflected in more recent approaches to development which are discussed below.

Changing paradigms in the post-Green Revolution era

The 1970s brought a reorientation in general development policies[25], as expressed in the famous speech of then former president of the World Bank, R. McNamara (1973) that marked the beginning of the ''growth-with-equity period'. In addition to productivity increases, greater attention was now given to employment, income distribution, and "basic needs" such as nutrition, health, and housing (Staatz and Eicher 1990). By 1970, it had become apparent that urban industry in most countries could not expand quickly enough to provide employment for the expanding rural labor force. Hence, the concern of development planners shifted to finding ways to keep people in the countryside (Staatz and Eicher 1990). This implied a much more important role for agriculture in development programs and generated a number of theoretical and conceptual debates over the 1970s. Mellor's (1976) revised Green Revolution strategy is a first indication for the change in development objectives since it is explicitly employment-oriented. He emphasized that linkages between agriculture and other sectors of the economy could lead to expanded employment both in agriculture and non-agricultural sectors. Of particular importance is the increase in effective demand for labor-intensive goods (dairy products,

---

[25] This reorientation came about for at least three reasons: the radical critique of Western economics, deleterious side effects of rapid economic growth in some countries and the growing awareness that benefits of economic growth often were not trickling down to the poor. This raised the argument for greater explicit attention to be paid to employment, income distribution and 'basic needs', such as nutrition and housing (Staatz and Eicher 1990).

fruit, other consumer products and agricultural inputs) generated by an increase in farm incomes through high-yielding varieties. However, this revised strategy includes more than high-yielding, fertilizer-responsive food grains. Mellor suggested that in addition to food crops, cash crops should also be included and that varietal resistance to pests and diseases as well as drought tolerance and the ability to thrive in poor soils and under uncertain weather conditions should become explicit breeding objectives. Irrigation is emphasized as a "leading input" next to fertilizer use. A much more important role is assigned to the government by demanding substantial public-sector investment for infrastructure, rural electrification, communications, input supply systems and rural education.

While the 1970s witnessed a rapid expansion of micro-level research on agricultural production and marketing, farmer decision making, the performance of rural factor markets, and rural non-farm employment (Staatz and Eicher 1990), thus leading amongst others to the development of Farming Systems Research and Extension (FSR/E), sustainability of agricultural production arose as an issue in development economics in the 1980s[26]. At the local level, increasing population pressure on fragile environments led to worries that existing farming systems were no longer sustainable in the long run (Staatz and Eicher 1990). At the regional level, there was a growing concern about the externalities of agricultural production such as pesticide residues in the environment and the impact of siltation from dams on local fisheries, while at the national level concerns were raised whether poor countries could meet the foreign exchange requirements to maintain high-input agriculture (Staatz and Eicher 1990). These considerations led to a renaissance of the “conservation model” of agricultural development which, following Ruttan’s (1990) classification, was the only approach to intensification of agricultural production until well into the twentieth century. The conservation model emphasizes the development of increasingly complex land- and labor-intensive cropping systems, the production and use of organic manure, recycling of resources within the farming system, and labor-intensive capital formation (e.g. drainage, irrigation) to more effectively utilize land and water resources (Ruttan 1990). This model provides the theoretical background for the growing emphasis on integrated farming in the 1970s which includes the rediscovery of rice-aquaculture and the growing interest in IPM. However, rates of growth in agricultural production within the framework of the conservation model normally fall in the range of 1.0% per year while rates of growth in the demand for agricultural output typically fall in the 3-5% range in the less developed countries (Ruttan 1990). The challenge which is faced by proponents of integrated, low-external input farming such as IPM and rice-aquaculture is to increase agricultural productivity and to sustain these productivity gains in the long run.

Determinants of integrated farming systems

In order to analyze the potential of changes in rice farming, such as rice-aquaculture or IPM, the factors that have influenced the development of certain types of farming systems need to be understood. The dichotomy of interest here can be called specialized versus integrated farming, e.g. rice monoculture on the one hand versus rice-aquaculture and IPM on the other hand. The following section will present the theoretical foundations on which this choice can be based.

---

26 Sustainable agriculture was only one of the important themes in development economics in the 1980s. The field was also dominated by macroeconomic reform, food security and income generation (Staatz and Eicher 1990).

Integration or specialization—the result of competing forces

The theoretical foundations of integrated farming go back to the basic research of von Thünen (1842) and Brinkmann (1922). Von Thünen was the first to recognize that farming systems and factor use intensity change with the distance from the market. Brinkmann (1922) explicitly distinguished between integrating and differentiating forces which determine the optimum organization of a farm and lead to the formation of entire farming systems which are specific to particular areas.

Differentiating forces lead to specialization. These are the forces which make it more profitable to produce one type of goods in location A and another type of goods in location B. While the concentric circles in von Thünen's isolated state describe a specialization at the regional level, Brinkmann was more concerned with specialization or integration at the farm level[27]. Following Waibel et al. (1994) and Waibel and Waters-Bayer (1996), the main factors favoring a specialization of agricultural production are:

- natural production conditions (soil quality, climate, water, species diversity);
- level of economic development (demand for agricultural products and available agricultural technology);
- integration with product and factor markets;
- agricultural policy interventions in favor of particular commodities;
- objectives and ability of farm household decision makers.

The level of specialization rises with a decreasing distance from the market, with an increase in the level of agricultural technology, with increasing integration into product and factor markets[28], and with growing skills and preferences of farm household decision makers for a certain product (Waibel and Waters-Bayer 1996).

Integrating forces, on the other hand, induce a diversification of the production system. The main reasons for integration, as stated by Waibel et al. (1994), are:

- advantages linked to the elimination of seasonal labor peaks;
- dependence of agricultural (and aquacultural) production on the ecosystem[29];
- dependence of agricultural production on the social system at community level;
- complementary effects of two commodities resulting in economies of scope.

Economies of scope describe the situation when the combined production of two goods leads to a decrease in average production costs for at least one of these goods (Schmitt 1993a) or in other words, when there are cost-saving externalities between product lines (Tirole 1989)[30].

---

27 Transport costs, the main location factor in Von Thünen's model, can act as an integrating force e.g. in areas where they make it more profitable to produce organic manure instead of purchasing fertilizer; on the other hand, they can have the opposite effect in areas where due to high land rents all efforts are concentrated on producing high-value crops so that commercial fertilizer is purchased.

28 Strong market integration leads to a substitution of external, purchased factors of production for on-farm resources (Waibel and Waters-Bayer 1996).

29 The dependence of agricultural production on the ecosystem favors the integration of various farm activities because this will lead to a more diverse utilization of natural resources such as soil nutrients, climate, water, and beneficial insects (Waibel and Waters-Bayer 1996). In addition, diversification will spread the risk of crop failure due to adverse environmental conditions.

30 Schmitt (1993a) points out that economies of scope are not limited to the combined production of several outputs within one enterprise, but can also arise from the vertical integration of production processes.

Economies of scope require the existence of sharable inputs between product lines. These are inputs which, once procured for the production of one good, would also be available (either wholly or in part) for the production of other outputs (Panzar and Willig 1981)[31]. Examples include elements of productive capacity (electric power generators, transmission facilities) usable at different times for different outputs, indivisible equipment usable for more than one production process, heat sources only partially depleted by their primary uses, human capital applicable to the production of more than one output, or inputs (such as sheep) which inevitably offer by-products (such as mutton) from their primary production (such as wool) (Panzar and Willig 1981).

In addition, economies of scope in agriculture or aquaculture can arise because of synergistic biological effects between product lines. For example, in the case of rice and fish, increased fertilizer application for rice will stimulate the growth of fish feed (algae, plankton). Conversely, fish excreta can serve as a source of organic fertilizer for rice, and herbivorous fish can control weeds, thus leading to higher rice yields.

Integrating and differentiating factors in Southeast Asian rice production

The question that needs to be asked with regard to the potential of rice-aquaculture and IPM in Southeast Asia is whether in this particular context the integrating forces are dominant over the differentiating forces, thus favoring a move towards more integrated and diversified rice-based farming systems in the future.

Market integration, infrastructure development, increased mobility of inputs and a high dependence on external inputs have in many cases led to a growing specialization of agriculture (Waibel and Waters-Bayer 1996). Pingali and Rosegrant (1995) claim that the farm level determinants of increasing commercialization (which implies the gradual decline of integrated farming systems and their replacement by specialized enterprises for crop, livestock, poultry and aquaculture products) are the rising opportunity costs of family labor and increased market demand for food and other agricultural products.

However, following Waibel et al. (1994) and based on the background information on rice production and the crisis of marine fisheries provided earlier, there are factors which indicate that a diversification of rice-based farming systems with aquaculture as an additional farm enterprise offers a potential solution to the present problems of rice farming in the region.

The following factors favor an increased integration in rice-based farming systems:

- sustainability problems of intensive rice production, as indicated by the decline in the yield frontier (see Chapter 2);
- realization of the negative health effects of chemical-based rice production, resulting in defensive expenditures by farm households (see Chapter 4);
- decrease in wild fish populations and other open-access protein sources (see Chapter 3);
- change in the rice/fish price ratio in favor of aquatic organisms (see Chapter 2);
- technical change in aquaculture (faster-growing fish species, improved methods for hatchery, nursery and grow-out operations) leading to growing opportunities for fish production for rice farmers (see Chapter 3).

[31] An input is defined as sharable between two product sets if 'the joint production of these outputs enables some of the input to be conserved, vis-à-vis separate production, while the utilization of all other inputs were not expanded' (Panzar and Willig 1981, p. 269).

Thus, there seems to be a considerable potential for a move towards integrated rice-based farming systems in Southeast Asia. Clearly, there will be location-specific differences in the relative advantage of different technologies and rice-aquaculture can be seen as only one option among many. Whether or not small-scale aquaculture is a viable option for small-scale rice farmers furthermore depends on some basic considerations of farm production theory and the theory of the farm household which will be discussed in the following sections.

The allocation of resources in farm production theory: the two-product case

While rice-aquaculture implies the introduction of a new 'crop' into an existing rice-based farming system, IPM requires a change in cropping practices which may or may not include additional crops. In both cases, however, a re-allocation of resources (particularly of labor, but also of land and capital) among the various components and enterprises of the system is likely to occur. It is therefore important to understand the theoretical background of resource allocation by the farm household. The following section will present a brief overview of farm production economics as regards the choice of enterprises, which shall serve as an entry point to the more specific discussion of the allocation of resources in the theory of the farm household.

The basic decision a farmer has to make in the case of rice-aquaculture is how to allocate his or her land, labor and capital among different enterprises or production technologies, namely rice monoculture and rice-aquaculture. Neoclassical production theory offers the 'product-product model'as an analytical framework to answer the question, 'What combination of enterprises should be produced with a given group of resources?' (Boehlje and Eidman 1984). The maximum quantities of output that a manager can produce with the resources available are summarized in the product-product frontier[32]. This frontier depicts the maximum amount of one product (Y_1) that can be produced for alternative levels of a second product (Y_2) with a specified set of resources (X). The most profitable combination of products is obtained where the revenue foregone from producing one unit less of one product equals the revenue added from producing one additional unit of the other product (Boehlje and Eidman 1984). This rule can be expressed as

$$\Delta Y_2/\Delta X * P_{Y2} = \Delta Y_1/\Delta X * P_{Y1} \qquad \text{(Eq. 5.1)}$$

where P_{Y1} and P_{Y2} are the net revenues per unit of Y_1 and Y_2, respectively[33]. The expressions $\Delta Y_2/\Delta X$ and $\Delta_{Y1}/\Delta X$ are the marginal physical products of one unit of input used in the production of Y_1 and Y_2, respectively.

32 Other terms used for this relationship are either the production possibilities frontier or the iso-resource frontier (because each point on the curve represents combinations of outputs that can be produced with an equal amount of inputs) (Boehlje and Eidman 1984).

33 The net revenue per unit of product should be used instead of the product price in selecting the optimum allocation of resources because it is the objective to maximize net returns to the limited resources. Therefore, the value of variable inputs must be subtracted from gross receipts to obtain net revenue per unit of output (Boehlje and Eidman 1984).

To determine the profit-maximizing level of net return to the limited resources, a net-revenue function for Y_1 and Y_2 is derived from

$$NR = P_{Y1} * Y_1 + P_{Y2} * Y_2 \quad \text{(Eq. 5.2)}$$

which can be rewritten as

$$Y_2 = NR/P_{Y2} - P_{Y1}/P_{Y2} * Y_1 \quad \text{(Eq. 5.3)}$$

This equation is also referred to as the isorevenue line since it is the locus of all combinations of Y_1 and Y_2 which result in an equal level of net revenue to the limited resources. Note that the slope of the isorevenue line is indicated by the ratio of net revenues P_{Y1}/P_{Y2}[34]. The profit-maximizing combination of products or enterprises can be found in that point on the product-product frontier that is tangent to or just touches the highest isorevenue line.

Reformulating Equation 5.1 as

$$(\Delta Y_2/\Delta X)/(\Delta Y_1/\Delta X) = P_{Y1}/P_{Y2} \quad \text{(Eq. 5.4)}$$

which states that the ratio of the marginal physical products must equal the ratio of net revenues for the enterprise and cross-multiplying the equation, it can be written as

$$P_{Y1} * (\Delta Y_1/\Delta X) = P_{Y2} * (\Delta Y_2/\Delta X) \quad \text{(Eq. 5.5)}$$

or

$$VMP_{X*Y1} = VMP_{X*Y2} \quad \text{(Eq. 5.6)}$$

where VMP reads the value of the marginal product of X used in producing either Y_1 or Y_2. Thus, the general rule is to allocate a limited amount of a variable input to its most profitable use until the value of the marginal product is equal in all of its uses. This principle is frequently referred to as the equal marginal return principle (Boehlje and Eidman 1984).

Depending on the technical relationship between products, the product-product frontier can have one of several general shapes (Steinhauser et al. 1982). The first distinction that has to be made is between supplementary, competitive, or complementary enterprises. In a supplementary relationship, increasing the output of enterprise 1 has no effect on the amount of output produced by enterprise 2 with a given set of resources. The basis for this relationship is that the supplementary enterprise makes use of otherwise unused resources. However, all supplementary enterprises become competitive, when the supply of the unused resources is exhausted. A competitive relationship is characterized by a decrease in the amount of output produced from enterprise 2 when the output from enterprise 1 is increased with a given set of resources. This is generally the case in agriculture, but the second important distinction that has to be made regards the rate at which this decrease occurs. The product-product frontier can be linear, indicating that each unit of the limited resource that is shifted from production of $Y_1$to Y_2 results in the same reduction in output of Y_1 and increase in output of Y_2.

34 Both the slope of the product-product frontier (i.e., the MRPS) and of the isorevenue line are negative. However, the sign is usually ignored in practical analyses (Boehlje and Eidman 1984).

In this case, the Marginal Rate of Product Substitution (MRPS) is constant. Or the competitive relationship can exhibit an increasing MRPS, as indicated by a convex product-product frontier. This results from the diminishing marginal productivity of the limited resource that is shifted from Y_2 to Y_1 (Boehlje and Eidman 1984).

A complementary relationship exists when increasing the output of enterprise 1 increases the amount of enterprise 2 that can be produced with a given set of resources. In this case, one enterprise produces an input that enhances the output level of the other enterprise (e.g., fish faeces act as fertilizer for rice production), resulting in a positive MRPS. However, if the assumption of diminishing marginal productivity for the use of the input produced is maintained, all complementary relationships become competitive at some level of output (Boehlje and Eidman 1984).

Regardless of whether two enterprises are supplementary, competitive, or complementary, the profit-maximizing combination is always found in the competitive range following the decision rule described above. The only modification of that rule is required for enterprises having a constant MRPS, since no point of tangency can be defined between a linear product-product frontier and a linear isorevenue line (Boehlje and Eidman 1984)[35]. Therefore, the most profitable alternative will occur at the maximum output of either Y_1 or Y_2.

Applying this framework to the choice between rice monoculture and rice-aquaculture and using the background information provided in earlier chapters, especially with regard to IPM, the situation can be delineated as follows (Figure 5.1).

The axes are defined as the gross margin from rice production (horizontal axis) and from aquaculture (vertical axis) per hectare. A fixed amount of land, labor and capital is available. Curve A_1R_1 describes the situation when rice and aquatic organisms are produced in monoculture. The farmer either plants rice or converts all or parts of his/her fields to ponds. The MRPS is assumed to be increasing,

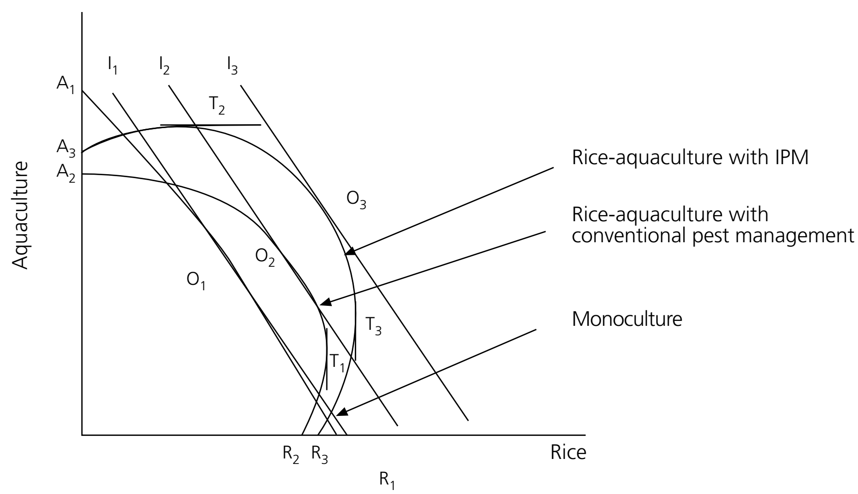


Figure 5.1. Product-product frontier of rice and aquaculture with and without IPM (see text for details). Source: Modified after Waibel et al. 1993.

35 Only in the case of equality between the MRPS and the net revenue ratio of the two products will every possible combination represented by the product-product frontier produce the same returns. Thus, the economic optimum in this case is indetermined (Steinhauser et al. 1982).

indicating diminishing marginal returns to the set of limited resources. The relative net revenues of rice and aquatic organisms determine how much land is planted with rice and how much land is converted to ponds (the optimum is found in the point of tangency of the product- product frontier with the isorevenue line for rice and aquaculture, point O_1 in Figure 5.1).

Curve A_2R_2 depicts the integration of rice and aquaculture under conventional pest management. There will be management decisions which prevent the maximum of either rice or aquatic organisms in monoculture being reached with this technology (e.g., parts of the field are converted to a pond refuge and can therefore not be planted with rice; the field is not excavated to the same depth as it would be in the case of ponds). Starting from the situation when only rice is produced under these conditions (point R_2 in Figure 5.1), increasing the gross margin from aquaculture will initially increase the gross margin from rice because aquatic organisms are said to minimize nitrogen losses, lead to better aeration of the water, and provide additional fertilizer through their faeces (see Chapter 3)[36]. Thus, the product- product frontier exhibits a complementary segment between R_2 and T_1 in Figure 5.1. Further increases in the gross margin from aquaculture lead to a decrease in the rice gross margin due to competition for space and nutrients as well as for labor and capital. On the other hand, if all the fields are stocked with aquatic organisms (point A_2 in Figure 5.1), increasing the gross margin from rice will immediately lead to a decrease in the gross margin from aquaculture because the use of pesticides in rice has a detrimental effect on aquatic organisms. However, it is assumed that because of the complementary segment, a higher isorevenue line can be reached through the integration of rice and aquaculture than under monoculture conditions (point O_2 in Figure 5.1).

Curve A_3R_3 stands for rice- aquaculture integration in combination with IPM (aquaculture-IPM). In this case, the same comments apply as for Curve A_2R_2, except that increasing the gross margin from rice will not immediately lead to a decrease in the gross margin from aquaculture. On the contrary, the fertilizer applied to rice can enhance primary production and thus increase the amount of feed for aquatic organisms available in the field. Therefore, Curve A_3R_3 exhibits another complementary segment between A_3 and T_2 in Figure 5.1. The renunciation of pesticide use under IPM leads to a higher gross margin from rice than under conventional pest management, indicated by the shift from R_2 to R_3 on the horizontal axis. The same is true in the case of aquaculture: pesticides applied to control predators will be eliminated under IPM, leading to a shift in gross margin from aquaculture from A_2 to A_3.

Both the complementarity between rice and aquaculture as well as the increase in gross margins, make it possible to reach a higher isorevenue line under this scenario than under the two scenarios discussed before (point O_3 in Figure 5.1). However, Curve A_3R_3 has to be seen as only one example among a number of different curves for IPM. As has been pointed out in Chapter 4, IPM is not a fixed technology but differs among seasons and places. The increase in rice gross margin depends on the costs of alternative control measures employed and can, in extreme cases, be negative.

The integration of rice and aquaculture offers a powerful incentive to cease using pesticides. By employing the concept of economic thresholds, the value of aquatic organisms lost due to pesticide application has to be added to the cost of pest control, thus raising the threshold to a level which is very rarely reached by pests (Waibel 1992). Following Waibel (1992), the economic threshold level can

[36] This does not mean that the culture of aquatic organisms in ricefields increase rice yields, which is a controversial issue (see Chapter 3). It only means that the same amount of rice can be produced with less external inputs such as fertilizers.

be expressed in terms of units of the crop that is attacked by the pest, e.g. rice. This is done by dividing the cost of a control measure by the price of the crop, dividing this ratio by the damage coefficient, and further dividing the result by effectiveness of the control measure since this will never be 100%:

$$ET_1 = (c/p) * (1/d) * (1/e) \qquad \text{(Eq. 5.7)}$$

where ET_1 = economic threshold level (pests/crop unit);
c = cost of control;
p = price of rice;
d = damage coefficient (crop units/pest); and
e = effectiveness of control.

If a farmer stocks aquatic organisms, the loss from these organisms due to pesticide application has to be considered as additional cost of pest control, leading to a shift of the threshold level to ET_2 (Figure 5.2).

The threshold can now be recalculated as follows:

$$ET_2 = ET_1 + ([Y_f * s - c_f]) * (p_f/p_r) \qquad \text{(Eq. 5.8)}$$

where ET_2 = economic threshold level including net yield from aquatic organisms;
Y_f = potential yield of aquatic organisms;
s = survival coefficient of aquatic organisms;
c_f = cost of aquaculture production;
p_f = price of aquatic organisms; and
p_r = price of rice.

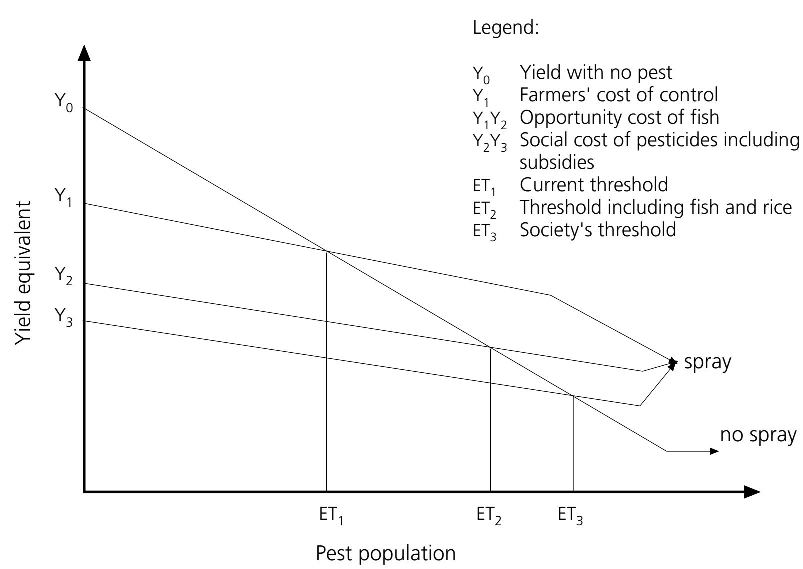


Figure 5.2. Economic threshold levels using pesticides in rice-aquaculture. Source: Waibel 1992, p. 252.

If external effects which are usually associated with pesticide use are included, the threshold will increase even further to ET_3 in Figure 5.2. With every upward shift in the threshold, the probability of a pest population reaching its threshold will decline at an increasing rate (Waibel 1992).

Farm household theory and the choice of enterprises

Up to this point, the theoretical framework only considers production-related aspects such as the respective production functions, the technical relationship between products and their net revenue ratio as determinants for the choice of enterprises. Aspects of home consumption as well as of better nutrition or environmental sustainability, which might be significant in the case of rice-aquaculture and IPM, cannot be analyzed within this framework. In addition, the fact that almost all rice production in Southeast Asia is organized in family farms requires a valuation of family labor and an understanding of the time allocation of farm households among household, farm and non-farm off-household activities. Thus, in order to gain a more comprehensive understanding of farmer decision-making, the analysis has to be extended to include the concept of the farm household.

Consideration of other income possibilities

While in neoclassical production theory the unit of analysis is the firm (or, in the case of agriculture, the farm), with the allocation of resources among different farm activities as one of the main decision problems and profit maximization as the main objective, the theory of the farm household recognizes the close connection between farm and household which is typical for ‘peasant agriculture' (Ellis 1988)[37]. The household is defined as an economic entity which may consist of one or several members but which is represented by a single decision maker, commonly referred to as an altruistic or benevolent dictator (Folbre 1986). The theory of the (farm) household merges aspects of factor supply or income generation on the one hand, and consumption on the other hand (Luckenbach 1978). For the generation of income, the household supplies labor (i.e., time) and capital, while the remaining amount of time and capital[38] is used for the consumption of goods and services. The allocation of time and capital among their different uses can therefore be seen as the main decision-making problems faced by the farm household.

In addition to farm production activities, the farm households allocate their working time to household production and to the production of non-farm goods and services outside the household (Schmitt 1993b). Corresponding to the principle of equal marginal returns introduced above, an equilibrium is achieved if the marginal factor value product is equal in all activities of the household (Schmitt 1993b). This has implications for the adoption of labor-intensive technologies such as rice-aquaculture and IPM, which have to compete for family labor not only with other farm activities but also with household production and non-farm off-household activities. Thus, the total income possibilities of the household represent the reference system against which a change in farming practices has to be judged.

---

37 Schmitt (1990) claims that the distinction between peasants (i.e. developing country farmers) and farmers (i.e. industrialized country farmers) as drawn by Ellis (1988) is not very meaningful but that all family farms share the same characteristics of low transaction costs in the coordination of their activities.

38 The allocation of land, which can be regarded as a special case for the farm household, is not explicitly considered in household economics. If land markets are functioning and peasants have flexible access to land, it can be regarded as a specific type of capital so that it would be included in the analysis of capital allocation.

For the introduction of rice-aquaculture and IPM into rice monoculture systems, the situation is described in Figure 5.3. Adoption of these technologies leads to an upward shift in the total value product (TVP)-curve, implying higher returns to labor than under rice monoculture. In the model, it is assumed that the household has a fixed amount of time which can be divided between work (farm work, off-farm work, household production) and leisure. The minimum amount of working time is determined by the subsistence needs of the consumers in the household, while the maximum amount of working time derives from the number of producers in the household (Ellis 1988). The optimum combination of work and leisure will normally fall in between these extremes. The existence of a competitive labor market means that a wage cost line (W_1, W_2, W_3) is introduced into the model. This wage cost line represents the opportunity cost to the household of alternative uses of family labor time (Ellis 1988).

For the rural areas in developing countries, it is typical to find initially higher but diminishing returns to labor in agriculture so that at a certain point they are equaled and then exceeded by the off-farm wage rate. The point of tangency between the TVP-curve and the wage cost line determines the optimum labor use in agriculture. Whether or not a household will be willing to commit this amount of labor depends on the shape of its indifference curve for leisure and income. However, with the existence of a labor market, optimum labor use in agriculture can be achieved regardless of the household's preferences, by either employing hired labor (provided that transaction costs are not prohibitive) or by gaining additional income through off-farm work. In the situation described below (Figure 5.3), optimum labor input in agriculture increases with the adoption of conventional rice- aquaculture, and further increases with the practice of IPM, as represented by the shift from L_{A1} to L_{A2} and then to L_{A3}. However, the shape of the household's indifference curve between income and leisure (I_1, I_2, I_3) is such that the additional amount of labor the household is willing to supply is not enough to meet the additional requirements (L_{H1}, L_{H2} and L_{H3}, respectively). Therefore, the amount of hired

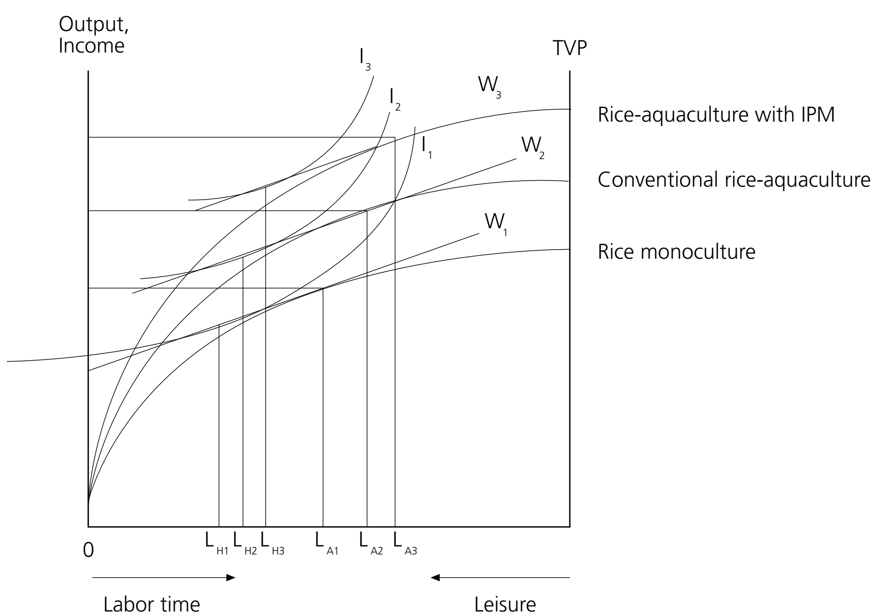


Figure 5.3. Time allocation under different technology options. Source: Own illustration.

labor employed by the household, which is the difference between L_A and L_H, increases with the uptake of aquaculture and IPM[39].

Instead of only comparing profits and treating family labor as the residual, a comparison of different farming practices or production technologies such as rice-aquaculture and IPM therefore has to value family labor at its opportunity cost and take explicit account of other income possibilities. A change in the off-farm wage rate can have a profound impact on agricultural practices and may therefore not be neglected.

The non-market values of aquatic organisms—better nutrition, pleasure and prestige

If, as stated in the literature (e.g. Tagarino 1985) and supported by own observations (see Chapter 7), a major part of the fish and other aquatic organisms grown or gathered in ricefields in the Philippines is consumed in the household or given away to friends and neighbors, it is not only the market value of these organisms that might induce a farmer to adopt this technology. Rather, it can be hypothesized that the household derives additional utility from the contribution of aquatic organisms to better family nutrition, from the pleasure associated with culturing and catching these organisms and from the prestige associated with being able to offer fish to visiting friends and neighbors or donating it to the village fiesta.

In the theoretical framework of the farm household, the 'health effect' of aquaculture via increased consumption of aquatic organisms can be taken into account by incorporating a health variable both in the utility function (people prefer to be healthy) and in the production function (a healthy individual is more productive) of the household (Singh et al. 1986). Combined with a production function for health, which says that health depends on nutrition and other factors, this extension of the basic household model allows us to estimate the effects of improved nutrition on the probability of illness, which in turn may affect productivity and farm profits (Pitt and Rosenzweig 1986)[40]. Even though an empirical estimation of this health production function will not be possible in most cases due to data constraints, a comparison between rice monoculture and rice-aquaculture should attempt to incorporate the effects that aquaculture can have on the nutritional situation of the farm household.

An alternative approach which can be used for improved health as well as for the prestige and pleasure associated with aquaculture builds on the concept of 'Z-goods' which replace the standard market goods in utility maximization as follows:

> "Households will be assumed to combine time and market goods to produce more basic commodities that directly enter their utility functions. One such commodity is the seeing of a play, which depends on the input of actors, script, theater and the playgoer's time; another is sleeping, which depends on the input of a bed, house (pills?) and time. These commodities will be called Z_i and written as $Z_i = f_i(x_i, T_i)$ where x_i is a vector of market goods and T_i a vector of time inputs used in producing the ith commodity (Becker 1965, p. 495)."

---

39 This is only one example of how a household can adjust its labor supply under different technology options. Differently shaped indifference curves might lead to an increase in family labor input so that no hiring of labor would be necessary.

40 The same line of reasoning can be applied to the case of IPM, where the non-use of pesticides contributes to farmers' health. This effect could be incorporated in the health production function as one of the 'other factors' mentioned above.

For a subsistence farmer who consumes part or all of his/her produce, the consideration of basic commodities becomes relevant in the decision of what crops to grow. In the case of rice-aquaculture, "prestige through offering fish to friends" can be seen as such a basic commodity which consists of the fish and the time spent in fish preparation as well as in eating the fish and entertaining friends. Another Z-good would be the pleasure associated with culturing and catching the fish, which requires fish, feeds and catch equipment as inputs as well as the time spent in aquaculture.

Through the concept of Z-goods, consumption activities by the household are transformed into production activities of basic commodities, so that the same principles apply as in production theory. Analogous to the product-product frontier in production theory, a production possibility frontier can be defined for the basic commodities which defines the efficient combination of commodities that the household can attain with the time and market goods available. The household maximizes utility by selecting the point on the commodity frontier which is tangent to its utility function. For a subsistence farmer, the adoption of rice-aquaculture can be interpreted as an outward shift of the production possibility frontier for such basic commodities which require fish or other aquatic organisms as an input (Figure 5.4). A comparison of rice monoculture and rice-aquaculture for the basic commodities prestige and pleasure suggests that through the availability of fish from rice-aquaculture, a higher utility level can be reached than through rice monoculture.

Especially in cases where the market value of rice-aquaculture production does not significantly exceed that of rice monoculture, the indirect or non-market benefits of aquatic organisms may become decisive in the decision of farmers of whether or not to adopt this technology. Following the logic of farm production theory presented above, one could imagine a monetary valuation of these non-market benefits[41] so that they could simply be added to the market price of aquatic organisms. This would increase the net revenue from aquaculture, leading to a comparative advantage of rice-aquaculture compared to rice monoculture.

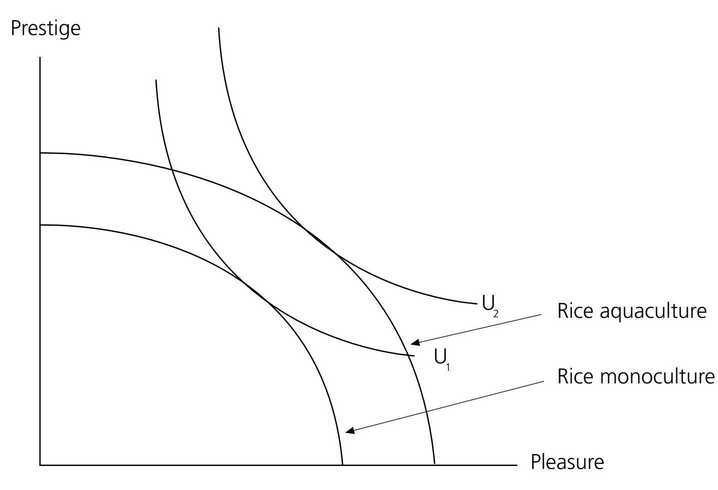


Figure 5.4. Maximizing Z-good production under different technologies. Source: Own illustration.

41 For example, the effect of better nutrition could be valued based on increased labor productivity or lower medical expenses, similar to the estimation of health costs due to pesticide use (see Rola and Pingali 1993). However, it will always be difficult to single out the effects of individual parameters and to establish a rigorous cause-effect relationship.

Incorporating sustainability considerations into enterprise choice

Another benefit of rice-aquaculture and IPM which cannot be captured through market prices alone is the impact of these production technologies on the long-term sustainability of agricultural production. Any discussion of sustainability issues must be preceded by a definition of sustainability in the relevant context. The previous chapters have emphasized sustainability problems associated with present methods of rice production, particularly the detrimental effect of pesticides on the environment, but also the reliance on external inputs and the effect of higher cropping intensity on the self-regenerating capacity of the soil. Thus, the most appropriate level at which sustainability should be analyzed in the present context is that of the agroecosystem. Hailu and Runge-Metzger (1993) define a sustainable agroecosystem as one that:

- maintains or enhances environmental quality;
- satisfies future demands of society for food and fibers;
- assures the economic and social well-being of producers (i.e., of the aggregate of producers, not necessarily of any individual farmer).

In order to determine the impact of sustainability considerations on farmers' choice of enterprises, it has to be assumed that the farmer is aware of the relationship between his or her farming practices and the future production potential of the agroecosystem[42]. Then, the easiest way of incorporating sustainability considerations in a framework of enterprise choice would be similar to the treatment of non-market values of fish—the farmer is assumed to derive additional utility from maintaining the productivity of the agroecosystem. However, this approach is not very satisfactory and does not lend itself to empirical estimation. Sustainability is an intrinsically dynamic concept and the choice between farming practices which are more or less likely to be sustainable has to be seen in a dynamic framework.

Curve IPP in Figure 5.5 represents an intertemporal production possibility curve (IPP), the slope of which represents the rate at which present production can be transformed into future production, given the current state of technology and a fixed resource base (Zilberman et al. 1993). If all resources are devoted to present consumption, O_{Yt} can be produced and consumed. Conversely, saving all resources for the future period would yield a consumption level of O_{Yt+1}. S is an indifference curve between consumption now (C_t) and consumption later (C_{t+1}), so that the slope of S describes the time preference of the farmer[43]. Under the assumption of imperfect capital markets[44], an equilibrium is achieved at the point of tangency between S and IPP (point A). At this point, the farmer maximizes the present value of future utility streams.

42 For the following discussion it is assumed that land tenure has no impact on farmers' decisions of whether or not to maintain the production potential of the agroecosystem. While land tenancy conditions are important in the context of sustainable agriculture, it is beyond the scope of this study to elaborate on this aspect. For a summary of the relationship between land tenure and sustainable natural resource management see for example Okoth-Ogendo (1995).

43 For a comprehensive treatment of the concept of time preference as well as for an attempt to estimate the time preference of farmers in the Philippines see Wesseler (1995, 1997).

44 If capital markets are assumed to be perfect, the optimum is no longer solely determined by curve IPP and curve S, but the household can now borrow or lend money at a fixed market interest rate. This enables the household to separate its investment (i.e., production) and consumption decisions and reach a higher indifference curve. However, capital markets in developing and even in developed countries can hardly ever be assumed to be perfect (see Wesseler 1997 for a summary of the literature).

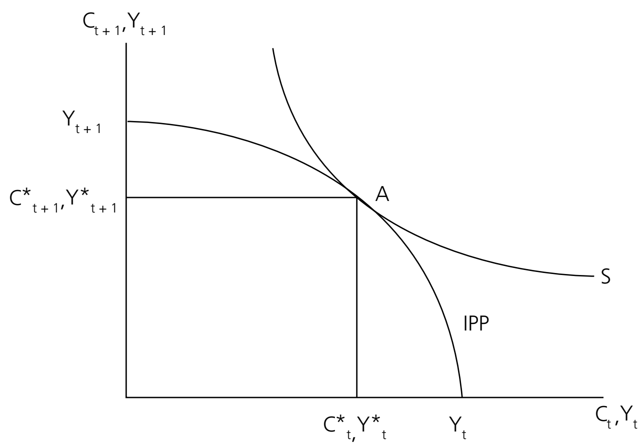


Figure 5.5. Intertemporal production possibilities. Source: Zilberman et al. 1993, p. 71.

The case of two alternative technologies can be described with two different IPP-curves[45]. Both technologies start with the same resource base, thus they allow the same maximum consumption level now (Y_t). However, one technology (for example rice-aquaculture) maintains the production potential of the agroecosystem while the other one (say, rice monoculture) leads to its depletion and degradation in the long run. Thus, Y_{t+1} will be higher for rice-aquaculture than for rice monoculture. The farmer will prefer that technology which allows him or her to reach a higher indifference curve. This decision depends on two parameters:

- the slope of the IPP-curves between Y_t and Y_{t+1}, and
- the slope of the indifference curves, i.e. the farmer's time preference.

For the IPP-curves, two situations can be imagined (Figure 5.6): If they do not intersect, i.e. if the rice-aquaculture curve (IPP_{RF}) runs above the rice monoculture curve (IPP_{R1}) for the whole length of the diagram, there is no doubt that rice-aquaculture is the dominant technology regardless of the farmer's time preference. However, if initially the rice monoculture curve (IPP_{R2}) has a greater slope than the rice-aquaculture curve (possibly due to the rapid exploitation of soil micronutrients) but then levels off, so that an intersection between the two curves can be observed, the choice between the two technologies depends entirely on the slope of the indifference curves (S_1, S_2) and no definite statement with regard to the optimum solution can be made. Non-adoption of rice-aquaculture could thus be explained by a high rate of time preference of the farmers and an initially higher income from rice monoculture.

45 For the sake of simplicity, it is assumed that the two technologies are mutually exclusive, i.e. the farmer decides to practice one or the other, without any possibilities of combining them. While this seems to contrast the discussion within the framework of farm production theory where the farmer is able to devote a part of his land to rice and the other to rice-fish, the interpretation runs along the same lines. The first decision that the farmer has to make is whether he or she wants to switch to a method of rice production that enables the culture of fish in ricefields. This decision concerns the whole farm area as long as the individual plots are connected through on-farm water flows. It is this decision, represented by a new product-product frontier in the production theory framework, which is described here with the two different IPP- curves. The decision of how much land to allocate to rice and rice-fish culture under the new rice production technology is described only within the framework of production theory and cannot be incorporated into the present dynamic model.

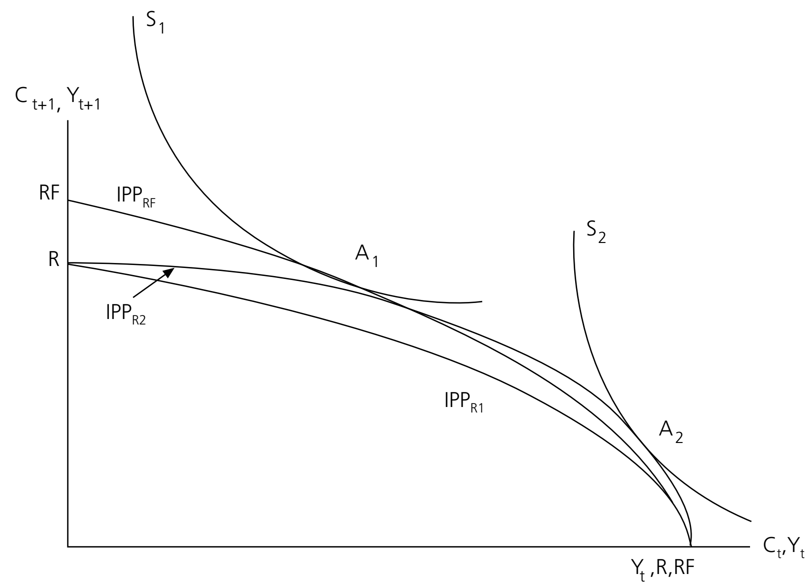


Figure 5.6. Intertemporal production possibilities with two alternative technology options.
Source: Own illustration.

The major difference between the environmental aspects associated with rice-aquaculture and IPM on the one hand, and their non-market benefits such as improved health and nutrition on the other hand, is that the latter occurs mainly to the farm household itself while the former can be seen as a benefit to the whole society. Therefore, the practice of these technologies might be desirable from a social point of view, even if the farmer finds it more attractive to grow rice in monoculture with the use of chemical pesticides. Apart from government interventions such as the banning or restriction of certain pesticides, society can provide incentives to farmers to adopt the more environmentally compatible technologies, for example by paying a premium for organically produced rice. However, due to lacking market opportunities, such possibilities are limited. Therefore, long-term environmental factors are unlikely to play a significant role in farmers' decision-making, at least in the short run.

The impact of risk and uncertainty on enterprise choice

Within the framework of household economics, risk and uncertainty are also important factors in the allocation of resources among different enterprises. In particular, the variability of prices or the probability of crop failure as perceived by the farmers can have a profound impact on farmer decision making. By employing the expected income-variance (E, V) criterion[46], a risk-averse[47] farmer will tend to select a production technology or enterprise which displays a higher yield variability only if the associated expected income were also greater, and this compensation must increase at an

46 The E,V decision rule comes to the same results as expected utility theory if a farmer has a quadratic utility function. While this functional form bears some fundamental problems, such as increasing absolute risk aversion and declining marginal utility of income beyond its maximum, it can provide an excellent second-order approximation to more desirable functions (Hazell and Norton 1986).

47 For the majority of farmers in developing countries it can be assumed that they are at least moderately risk-averse (Ellis 1988).

increasing rate with increases in the variance (Hazell and Norton 1986). In other words, the risk-averse farmer will tend to select those enterprises or farm activities for which the income variances are minimum for given expected income levels.

In rice-aquaculture, the main risk factors are natural hazards such as floods or droughts, and poaching of fish by other people (Israel et al. 1994). While the former can also have adverse impacts on rice monoculture, rice-aquaculture is more susceptible to these hazards because aquatic organisms can tolerate fewer changes in water levels than rice[48]. In Chapter 9, an attempt to assess the effects of output risk on farm income and technology adoption by Israel et al. (1994) will be described. While the results remain somewhat inconclusive, there are indications that rice-fish culture is a more risky enterprise than rice monoculture. It is beyond the scope of this study to derive additional estimates of the risk associated with either rice-aquaculture or IPM. Instead, changes in output and prices are simulated in Chapter 9 to identify the optimum farm plan under different environmental conditions. Since no information is available on the probability associated with each scenario, this exercise can only help to identify the stability of the optimal solution but does not account for risk-averse behavior on the part of the farmers. For the following analyses, it should be kept in mind that an increase in expected income from rice-aquaculture might not be sufficient to compensate for the additional perceived risk associated with that technology. This could explain a non-adoption of rice-aquaculture even though it would lead to an increase in expected income.

Complementarity between technology and enterprises—are there positive externalities of IPM?

In Chapter 4, the role of aquaculture in IPM was discussed. This discussion focused mainly on technical and/or economic aspects which can be captured with the theoretical concepts presented above. However, there is one point of overlap between these two technologies which does not fall into these concepts easily. It originates from the new paradigm of IPM (see Table 4.2) which stresses the importance of human capital formation in IPM. Farmers learn about ecological processes in order to make appropriate pest management decisions and to take charge of all decisions on pest control. Correspondingly, Aquatic Life Management (ALM) has been defined as the management of all kinds of organisms in the aquatic component of the ricefield ecosystem, based on ecological criteria (Horstkotte et al. 1992). ALM in rice is a special form of rice-aquaculture which minimizes the use of external inputs such as pesticides. It can be seen as a complement to the 'farmer-driven IPM' which until now has focused mainly on the rice plant and the complex of pests and beneficial organisms surrounding it. Taking IPM and ALM together, one arrives at a holistic concept of ecosystem management (EM) which recognizes the interactions among the various components of the system (aquatic, semi-terrestrial and terrestrial) and tries to maintain a balance between harmful and beneficial organisms, nutrient input and output and to conserve soil and water quality. This balance would allow to maximize the long-term productivity of the system both in terms of rice and in terms of aquatic organisms.

48 While rice can survive during certain periods of drought, fish depends on the proper construction of refuges if water levels fall below a certain limit. Conversely, rice can recover from flooding while fish can escape from the field and are lost to the farmer.

IPM and ALM are built on the same principles: knowledge about ecosystem processes and observation of the field, in order to make informed decisions on management steps and interventions. While these skills are currently being taught in field schools for IPM, no such schools exist for ALM. However, it can be expected that knowledge about ecosystem processes acquired in an IPM field school can be extended to the aquatic component of the ricefield ecosystem. If this is the case, one could expect farmers trained in IPM to arrive at a holistic ricefield EM on their own.

In order to illustrate this point, a conceptual framework was developed which is presented in the following diagram (Figure 5.7):

The vertical axis represents farmers' proficiencies and skills in IPM, whereas the horizontal axis ranks farmers' proficiencies and skills in ALM. Points A, B, and C on the diagram represent the "typical" groups of farmers. Point A stands for farmers who follow the conventional recommendations of rice monoculture, with high chemical input use. Farmers represented by point B might have learned to appreciate and culture aquatic life in their fields but still use high amounts of chemical pesticides on their ricefields. In point C, farmers have learned tand applied IPM without any consideration of the aquatic organisms in their ricefields. Point D stands for the optimal situation where farmers have combined IPM and ALM.

Farmers are hypothesized to move up both scales simultaneously—as they become more skilled in one technology, they start to see more options with regard to the other technology. Farmers who are trained in IPM will gradually change their perceptions towards aquatic life in a positive way and will start to make management decisions in favor of aquatic organisms. Farmers who already practice some form of aquatic life management are hypothesized to react accordingly—the more skilled they become in aquatic life management, the more they will change their pest management strategies towards IPM. Both developments are seen as a complementary and natural process in which the adoption of IPM goes hand in hand with an advanced level of ALM skills so that a move towards position D seems to be the most natural and desirable development (Horstkotte et al. 1992).

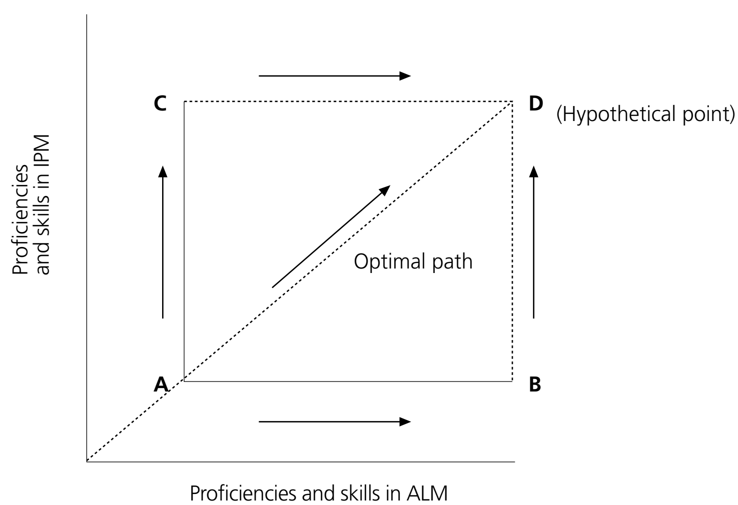


Figure 5.7. Hypothesized relationship between IPM and ALM. Source: Horstkotte et al. 1992

Hypotheses

The problem analysis has led to the identification of three sets of difficulties faced by small-scale rice farmers in the Philippines, which relate to income, nutrition and environmental sustainability. To combat these problems, two technologies have been proposed, namely rice-aquaculture and IPM. These technologies appear appropriate under the current economic, political and environmental conditions in the Philippines. Based on the theoretical concepts discussed in this chapter, the following hypotheses can be derived for the empirical part of this study:

1. In certain locations, income from rice-aquaculture is higher than from rice monoculture[49], i.e., there are niches for rice-aquaculture within existing rice-based farming systems.
2. This economic benefit is even higher if rice-aquaculture is practiced in combination with IPM.
3. The nutritional situation of farm households can be improved through the culture and use of aquatic organisms from ricefields.
4. The new approach to IPM with its emphasis on human capital formation and on the understanding of ecosystem processes leads to a move towards ALM by farmers who have been trained in IPM. The additional benefit derived from aquatic organisms is an incentive to practice IPM and thus contributes to the sustainability of rice production.

---

49 Fish monoculture, although theoretically possible and included in the presented framework, is not considered in the remainder of the study because it is of no practical relevance in the study area.

Chapter 6

Description of farm–household systems in the study areas

Empirical work for this study was undertaken in two Philippine provinces, namely Nueva Ecija and Antique (Figure 6.1). Nueva Ecija is a landlocked province in the Central Luzon region (Region III) of the Philippines, characterized by a predominantly flat terrain. Sixty seven percent of the total agricultural area in the province is irrigated (NSO 1995). Two crops of rice are grown in most irrigated areas, although some farmers prefer to grow onions or other vegetables as a second crop. Average annual per capita income in this province amounted to PhP 10 747 [50] in 1991 (the latest year for which data are available), which is below the national average of PhP 13 788 and also below the average per capita income of PhP 15 558 for Region III (NSO 1994b). However, the relative proximity to the National Capital Region provides a favorable background for agricultural production[51] as well as flourishing opportunities for off-farm employment, so that increasing opportunity costs for labor can be expected in the long run.

In contrast, Antique is located along the west coast of Panay island in the Western Visayas region (Region VI) of the Philippines. It is a relatively long and narrow province, which is dominated by a mountain range running from north to south. Located between the narrow coastal plains and the mountain range, it is characterized by rolling, hilly terrain. Only 32% of the total agricultural area is irrigated, concentrated in the coastal plains. Rice is the dominant crop and some areas can produce up to three rice crops per year. However, poor infrastructure and distance from the closest major port (Iloilo) impede the trade in agricultural inputs and produce. The province lacks a major commercial center, thus opportunity costs for labor are likely to remain stagnant or even decline with high population growth rates. Average annual per capital income only came to PhP 8 777 in 1991 (NSO 1994b).

These two provinces represent typical cases of irrigated rice production environments in the Philippines. In addition, the selection of study areas was due to the following reasons:

- The province of Nueva Ecija has a fairly long history of research in integrated rice-fish culture, starting in the early 1970s. The presence of the Freshwater Aquaculture Center (FAC) of Central Luzon State University (CLSU) and its work with farmer collaborators is the major reason why the technology is more widely spread here than in other provinces of the Philippines. The only established rice-fish systems in the irrigated lowlands of the Philippines can be studied in this province[52].

---

50 PhP 1 = 0.036 US$ in 1991 (FAO 1994).

51 Because of its proximity to Manila, Nueva Ecija supplies most of the rice requirements of the metropolis. Farm gate prices of rice are higher than in the other regions of the country and input prices are relatively lower. Thus, it is more profitable to produce rice in commercial quantity in Central Luzon than in any other region of the country (Rola and Pingali 1993).

52 As mentioned earlier (Chapter 3), the Philippine national program for rice-fish culture was not very successful. However, a few farmers in the vicinity of FAC continue with this practice and can serve as model farmers for others who may become interested.

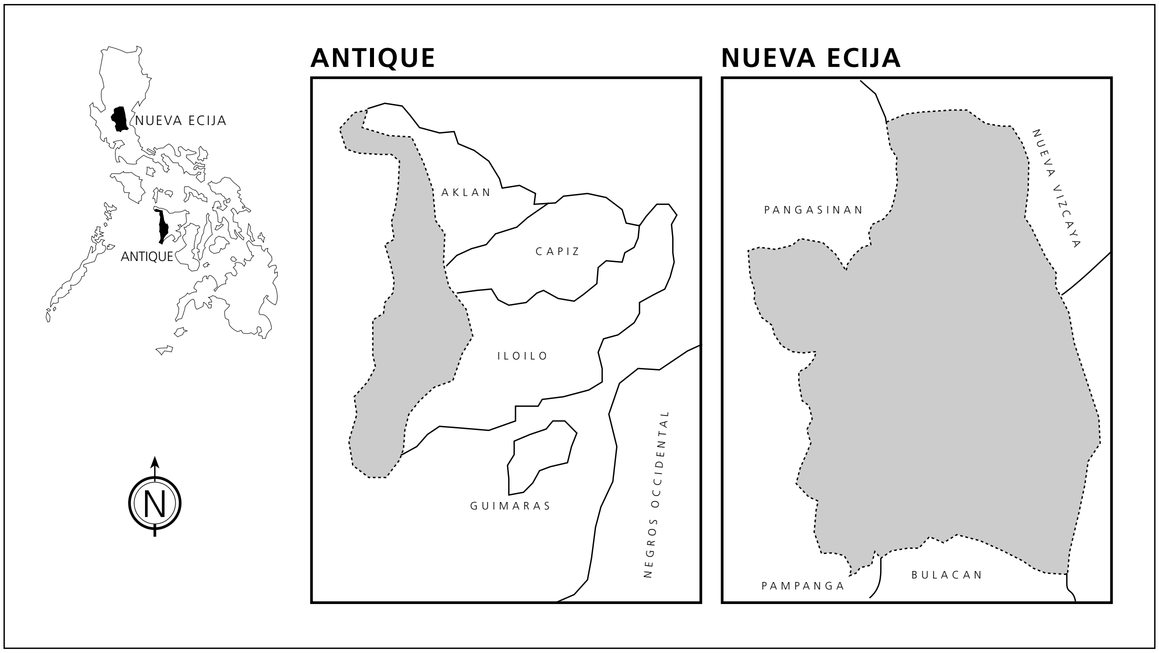


Figure 6.1. Location of study areas in the Philippines. Source: NSCB 1992/93.

- The province of Antique on Panay island has only recently experienced major training efforts on IPM. Farmer field schools (FFS) are being conducted by the Antique Integrated Area Development (ANIAD) Foundation, Inc., in collaboration with the FAO Intercountry Programme on Integrated Pest Management in Rice. Therefore, Antique offers the opportunity to study the attitude towards ALM among groups of trained and untrained farmers.

Due to its location on Luzon, the largest island of the Philippines and its extensive share of irrigated rice lands, a wealth of secondary data exists on rice farming in Nueva Ecija. Both IRRI and the Philippine Rice Research Institute (PhilRice) have conducted several studies in this province, so that many aspects of irrigated rice production can be based on established research findings. This is not the case in Antique where only few studies have been conducted, mainly in the context of the ANIAD project. Therefore, most of the empirical data for this study were collected only in Antique. To improve clarity, the various surveys, monitoring activities and data sets employed in this study are listed in Appendix 3. It should be kept in mind that no systematic comparison between the two provinces is intended. Rather, they should be understood as case studies among a variety of comparable cases.

It is assumed that rice-based farming systems in different irrigated lowland areas of the Philippines show a high degree of similarity which allows a generalization of conclusions with regard to the potential of rice-aquaculture. Where important variations are observed, such as farm size, household size or off-farm employment opportunities, these are treated as variable factors leading to different scenarios under which rice-aquaculture may or may not be a viable alternative for rice farmers. While these scenarios are analyzed and discussed in Chapter 9, the following section presents a brief overview of irrigated rice production in the Philippines, followed by a description of irrigated rice-based farming systems in the two provinces. Next, the labor requirements for different activities in rice production and the additional labor requirements of rice-aquaculture and IPM are discussed. The chapter ends with an analysis of the time allocation of farm families in Antique. In short, this chapter provides the basic technological and socio-economic information on rice-based farm-household systems in the Philippines. This information serves as the starting point for the economic analysis of rice-aquaculture integration, the technical requirements of which have been introduced in Chapter 3 and will be further specified in Chapter 9. Taken together, this information is utilized for the formulation of farm models in Chapter 9.

Rice production technology

Data for this section are predominantly derived from the following sources:

- results of several surveys conducted by PhilRice in various provinces of the Philippines in the late 1980s and early 1990s, as reported in the cited literature;
- data of 132 farmers in the Central Luzon Region, collected by the IRRI Social Science Division over five seasons between 1979 and 1988[53], subsequently referred to as the 'IRRI data set';
- results of a survey of 229 farmers in irrigated areas of Antique province conducted by the author in November 1993, subsequently called the 'Antique IPM/ALM survey'[54].

Rice is the dominant crop in Philippine agriculture, accounting for roughly 17% of agricultural gross value added and a cultivation area of about 3.5 million ha in 1989 (ADB 1991). While rice is grown in many different environments, a considerable portion (approximately 50%) of Philippine rice land is irrigated, allowing two or even three crops of rice per year. Modern high-yielding varieties are planted on more than 90% of the irrigated ricelands (BAS 1991). Thus, it is not surprising that two-thirds of total rice production in the country come from irrigated areas (ADB 1991). Average yields per ha irrigated land amounted to about 3 metric tons between 1981 and 1987 (BAS 1988). Compared to other Asian countries, notably Japan, Republic of Korea, China, and Indonesia, this yield level is surprisingly low. A sharp drop in irrigation investments in the early 1980s, leading to a low efficiency of water delivery, as well as a decline in fertilizer use during the same time period are possible reasons for this phenomenon in the country that has been called the 'home of the green revolution' (Pathak and Gomez 1991).

Within the Philippines, rice is grown in all regions. However, the main 'rice bowls' of the Philippines are Region III (Central Luzon[55]) and Region VI (Western Visayas[56]), with more than 600 000 and 500 000 ha planted to rice, respectively (NSO 1994a). Since these are also the regions in which the two study areas are located, they will be at the center of the following discussion.

---

53 This data set was made available for this study by Dr. P.L. Pingali, former Head of the Social Science Division, International Rice Research Institute.

54 The main topics of this survey relate to IPM and aquatic organisms in ricefields and will be discussed in greater detail in Chapter 8. However, it also included general information on rice farming practices which can be utilized here.

55 Region III (Central Luzon) comprises the provinces of Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac and Zambales.

56 Region VI (Western Visayas) consists of the provinces Aklan, Antique, Capiz, Iloilo and Negros Occidental.

Rice farming in the Philippines is characterized by small production units. The average rice farm size was 1.7 ha in 1991 (NSO 1994a). While rice farms in Region III are slightly larger (2.3 ha/farm), farms in Region VI correspond exactly to the national average. These small farm units are mainly operated by family labor, although hired labor is commonly used for certain tasks such as transplanting, weeding, and harvesting/threshing. Average household size among rice farmers in the two regions was slightly higher in Region VI (6 persons/household) than in Region III (5 persons/household) during the late 1980s (Rola et al. 1991; Quintana et al. 1991b).

The dominant tenurial status under which rice farms are operated in Region III is land ownership (63% of parcels), followed by leasehold (15%), share tenancy (13%) and rent-free cultivation (8%). Region VI shows a lower proportion of owned parcels (49%) but a larger share of tenanted (19%) and rent-free (17%) operations. Fourteen percent of parcels in this region are leased at a fixed rent (NSO 1994a). The larger share of owned plots in Region III indicates that this region has been the main focus of the land reform program in the Philippines, which has been going on for decades under different political leaderships, with very limited success (IBON 1988).

In areas with sufficient water, two or even three crops of rice are grown per year. This leaves relatively little time for land preparation, which is leading to the gradual displacement of the carabao (water buffalo) by the handtractor as the dominant method of land preparation (Samonte et al. 1993)[57]. Use of the handtractor, in turn, causes a higher dependence on hired labor in land preparation, since owners of handtractors will be asked to perform the work for others who cannot afford their own tractor.

Transplanting was still the most common method of crop establishment in the late 1980s, practiced by 86% and 53% of rice farmers in Regions III and VI, respectively (Samonte et al. 1993). However, direct seeding of rice is becoming more and more popular. In the Antique IPM/ALM survey, 99% of all farmers stated that they practiced direct seeding in 1993. While direct seeded rice requires less labor in crop establishment, it is more susceptible to snail damage and often goes hand in hand with an increased use of herbicides in order to give the rice an advantage over the weeds.

Almost all farmers in the irrigated rice areas of the Philippines apply mineral fertilizer. An analysis of the IRRI data set yielded the following results with regard to fertilizer use (Table 6.1).

More fertilizer is applied in the dry season than in the wet season and the quantity of fertilizer applied per hectare has grown continuously over the years. Farmers normally split their application into two portions, giving one at the seedling stage (15-20 days after seeding) and the second at the booting stage (around 45 days after seeding) (results of the Antique IPM/ALM survey and Rola et al. 1991). The most commonly used fertilizer is urea, followed by 'complete' (14-14-14), ammonium sulphate (21-0-0) and ammonium phosphate (16-20-0) (results of the Antique IPM/ALM survey and Rola et al. 1991).

In terms of weed control, a marked difference could be observed between Region III and Region VI in the late 1980s. While 48% of rice farmers in Region III applied herbicides, only 17% of rice farmers in Region VI resorted to this practice (Samonte et al. 1993). Here, most farmers (58%) practiced

---

[57] Own observations in Antique have shown that a combination of carabao and handtractor is the most common method of land preparation. While the handtractor is used for the plowing and harrowing of the center of the field, plowing of the sides of the field is still mainly conducted by carabao. Also, the carabao is used for the final leveling of the field, especially in areas with direct seeded rice. Proper leveling is important for weed control and the best results are achieved with a wooden board drawn by the carabao.

Table 6.1. Fertilizer use among rice farmers in Central Luzon, 1979-1988.

	kg N/ha	kg P/ha	kg K/ha	number of applications
wet season 1979	54.27	19.91	11.67	1.68
wet season 1985	74.09	22.05	11.25	1.95
dry season 1980	78.90	25.95	13.97	1.87
dry season 1986	93.77	26.93	13.82	2.00
dry season 1988	98.83	22.38	15.72	2.05

Source: Own computations, based on the IRRI data set.

manual weeding and a considerable proportion (17%) did no weeding at all. On the other hand, manual weeding was practiced by 29% and no weeding by 20% of rice farmers in Region III. The greater use of herbicides points to the higher opportunity costs of labor and the better access to input markets in Region III compared to Region VI. However, the survey results reported by Samonte et al. (1993) refer to all rice-growing environments, including irrigated, rainfed and upland. A disaggregation of herbicide use by agro-climatic environment was conducted by Quintana et al. (1991a) for Region VI. It showed that in the late 1980s, more than 80% of rice farmers in the irrigated and rainfed areas used herbicides, compared to only 34% in the upland areas. Own results from the Antique IPM/ALM survey showed that by 1993 more than 71% of the interviewed farmers in Antique used herbicides. It can thus be assumed that the use of herbicides spread rapidly during the late 1980s and early 1990s (together with the increased adoption of direct seeding as method of crop establishment) and has by now become the dominant method of weed control in irrigated rice production. Herbicides are normally applied once, during the first week after seeding. The most commonly used herbicides in Region VI are butachlor and 2,4-D ester (Quintana et al. 1991a) as well as pretilachlor (results from the Antique IPM/ALM survey). No data on herbicide type are available for Region III.

For the control of insect pests, the majority of farmers in Regions III (77%) and VI (88%) applied chemical insecticides in the late 1980s (Samonte et al. 1993). The average frequency of application was three times per cropping season for irrigated areas of Region VI (Quintana et al. 1991a) and Region III (own computations based on IRRI data set). This average frequency was also reported by Heong et al. (1992) for a sample of 300 rice farmers in Leyte, Philippines (Region VIII). In contrast, among the 229 farmers interviewed in the Antique IPM/ALM survey, only 10 stated that they applied insecticides twice per cropping season. The remaining 81 farmers who used insecticides reported only one application per cropping season[58]. The most commonly used insecticides in Region VI in the late 1980s were endosulfan and monocrotophos (Quintana et al. 1991a); however, in 1993 parathion-methyl became the second most popular insecticide after endosulfan (own observations from the Antique IPM/ALM survey). While endosulfan is an organochlorine compound classified as moderately hazardous (class II) by the World Health Organization (WHO), both parathion-methyl and monocrotophos are organophosphate compounds classified as extremely hazardous (class Ia) and highly hazardous (class

58 Farmers might have been induced to report low frequencies of insecticide applications because they were aware of the focus on IPM in the Antique IPM/ALM survey. Therefore, two insecticide applications per cropping season were assumed to be a realistic estimate for conventional rice farmers in Antique. This is the frequency used in the model formulations in Chapter 9.

Ib), respectively. Cypermethrin, a synthetic pyrethroid not classified as hazardous, is also used to a considerable extent. These insecticides are normally applied with a knapsack sprayer and people wear relatively little or no protective clothing.

Harvesting is done manually in all rice-producing regions of the Philippines (Samonte et al. 1993). Together with transplanting and weeding, this is the farming activity that relies most on hired labor. The rice is threshed immediately after the harvest, mostly by use of the mechanical thresher. Harvesters and threshers are normally paid in kind, depending on the amount of rice harvested and threshed.

Before storage or marketing, the rice is dried. Solar drying on roads, basketball courts, back yards or other flat and dry places is the common method all over the Philippines. Drying takes between two and seven days, depending on the weather and the initial moisture content of the rice. The rice is then filled in sacks and stored before it is finally sold or consumed.

Seasonality of rice production depends on the start of the rainy season which comes a few weeks earlier in the southern parts of the Philippines than in the north (Table 6.2). Appendix Table A4.1 provides a seasonal calendar of factors related to rice-aquaculture as they can be observed in Antique.

Seasonality is more pronounced in Region III, where only two crops of rice can be grown, than in Region VI where the production process is staggered and where neighboring fields can be in completely different stages of rice growth at the same time. Since they do not necessarily correspond to wet and dry seasons, the different crops in Region VI have been called 'first', 'second' and 'third', as is the common practice among farmers in those provinces. The cropping cycle presented here is typical for many farmers in Region VI but may be shifted forwards or backwards by a month or two. With

Table 6.2. Rice production activities over the course of the year[59].

	Region III	Region VI
June (wet season)	land preparation for wet season crop	land preparation and crop establishment for first crop
July (wet season)	land preparation and crop establishment for wet season crop	crop care activities for first crop
August (wet season)	land preparation and crop establishment for wet season crop	crop care activities for first crop
September (wet season)	crop care activities for wet season crop	harvesting of first crop
October (wet season)	crop care activities for wet season crop	land preparation and crop establishment for second crop
November (wet season)	peak harvesting month for wet season crop	crop care activities for second crop
December (end of rains)	land preparation for dry season crop	crop care activities for second crop
January (dry season)	crop establishment for dry season crop	harvesting of second crop
February (dry season)	crop establishment and crop care for dry season crop	land preparation and crop establishment for third crop (if possible)
March (dry season)	crop care activities for dry season crop	crop care activities for third crop (if possible)
April (dry season)	crop care and harvesting of dry season crop	crop care activities for third crop (if possible)
May (onset of rains)	peak harvesting month for dry season crop	harvesting of third crop (if possible)

Source: Own illustration.

59 Information for Region III is derived from Lanzona (1988) as well as from monitoring farm activities of seven farmers in Nueva Ecija between March 1993 and February 1994 ('Farm activity monitoring', see Appendix 3). The classification for Region VI is based on a survey of 30 farmers in the village of Catungan IV, Sibalom, Antique in August 1994 (the 'Antique rice labor survey' discussed below).

the onset of the rains (normally around May/June), land preparation activities start and the wet season rice crop is established by mid-June in Antique and within the month of July in Region III. The following two months are characterized by crop care activities (field monitoring, water management, fertilizer and pesticide application, weeding, etc.).

Depending on the rice variety planted, harvesting takes place between 90 and 120 days after seeding. Thus, peak harvest time is by the end of September in Region VI and in November in Region III. The second rice crop is planted in October in Region VI and harvested in January, followed by a third crop between February and May in those locations with sufficient water. In contrast, in Region III where only two crops of rice can be grown, the dry season crop is established in January and harvested in May[60].

Diversity in rice-based farming systems

Most farms consist of more land than is planted to rice. There might be pasture land, forest, or land planted to permanent crops such as coconut or fruit trees. A farmer may grow other crops on the riceland for certain periods of time, engage in livestock production or off-farm/non-farm activities[61]. Waste or by-products of certain enterprises may be used as inputs in other enterprises. All these components interact and compete in their requirements for the farmer's land, labor and capital. An understanding of the whole farming system is therefore vital for an assessment of the potential of any new farm activity. In order to make the description of the farming system relevant to the farmers' concepts and understanding, a participatory research method was employed called RESTORE (Research Tool for Natural Resource Management, Monitoring and Evaluation), developed at ICLARM from the early 1990s (Lightfoot and Pullin 1994; Lightfoot et al. 1996). Instead of perceiving a farming system as a collection of separate enterprises, this method utilizes the concept of integrated resources management, building on indigenous categories of natural resource types (NRTs) which form the basis for decision making at the farm-household level. NRTs comprise the lands and waters available to the farmers and their biotic contents (Lightfoot et al. 1996). Thus, they extend beyond the farm fields and can include common property and open access land and water resources:

> "Farmers the world over commonly categorize their environment (the landscape, village and farm) into discrete resource or management units. Over time, farmers have learned where different crops perform best and how to manage the soil, plant and water interactions in each area. As a result, each resource type usually has well-defined boundaries and is associated with a particular production and management strategy. A river, a hillside, the

60 In addition to rainfall, seasonality in irrigated rice production depends heavily on the type of irrigation system. Large-scale gravity irrigation systems (typical for parts of Nueva Ecija) have fixed schedules which dictate the cropping seasons. On the other hand, small-scale communal irrigation systems (river diversion, typical for Antique) or pump irrigation (found in parts of Nueva Ecija) leave room for individual adjustments.

61 While off-farm activities refer to agricultural labor outside the own farm, non-farm activities consist of non-agricultural labor such as construction work, carpentry, handicrafts, etc.

cultivated portion of a swamp, the homesite, flooded ricefields and a fishpond are examples of natural resource types. These categories go beyond those of the soil scientist, the ecologist, or hydrologist and parallel more closely those of the land-use planner. Like land-use planners, farmers consider not only topography, soil characteristics, vegetation and hydrology, but also management and functional attributes. This allows the farmers to separate, for example, a sacred grove from the rest of the forest (Lightfoot et al. 1996, p. 2). "

The first step in the description of farming systems following this method[62] is the identification of all NRTs in the village under study. This is accomplished by means of a village walk together with several farmers who point out the various NRTs as they go along. A village transect is then constructed which includes topographical sketches of NRTs, information on soil type, water sources, and enterprises (crops and livestock) found in each category. Village transects were developed for four villages in Antique and two villages in Nueva Ecija[63] in 1994 (see Appendix Figure A4.1 for the village transect of Catungan IV, Sibalom, Antique). They provide an overview of the village resource base and summarize the production activities in the village, differentiated by NRTs. All of the six village transects exhibit a large degree of variety. Between seven and ten NRTs were identified per village, two or three of which were usually aquatic resources (river/creek, irrigation canal, fishpond, sea), often with an open access or common property character. Villages which at a first glance seem to be producing mainly rice turned out to include upland and midland areas on which roots and tubers as well as vegetables and fruit are grown. Some of these plots serve as pasture for livestock. The homestead or home garden is used for fruit and vegetable production and even the lowland areas are grown to crops other than rice for certain parts of the year. It also became clear that ricelands can be of different quality, depending on the soil type, water source and drainage. These are factors that have to be taken into account when proposing changes in farming systems such as rice-fish culture.

However, while village transects can be seen as a summary of resources and activities at the village level, they do not provide information on the presence of specific NRTs in individual farms, their use for different production activities as well as the linkages among enterprises in a farm-household context. To gain insight into these issues, farmer cooperators were found in each of the six villages willing to participate in a more detailed farming systems analysis (the data set derived from this analysis is subsequently called the 'Antique/Nueva Ecija farming systems data set', see Appendix 3). Selection criterion for these farmers was mainly their willingness to participate. The samples are therefore not representative for the respective villages but have to be treated as case studies. In Nueva

---

62 It should be pointed out that the method was originally developed as a tool for farmer participatory research and experimentation at the farm and village levels. For the purpose of this study, however, only the descriptive part of the method was utilized. It turned out to be a very practical and convenient tool for the portrayal of different farming systems based on farmers' conceptions.

63 Village selection was based on the following criteria: (a) for Antique, the villages should be located at a varying distance from the sea, to represent the whole range of the irrigated coastal strip; (b) for Nueva Ecija, villages with existing rice-fish farmers were chosen to describe environments which are suitable for this technology. The selected villages were (a) for Antique: San Antonio, Palma and Igpalje in the municipality of Barbaza and Catungan IV in the municipality of Sibalom; (b) for Nueva Ecija: Maragol and Rangayan in the municipality of Muñoz.

Ecija, a total of 50 farmers (25 from each village) participated, covering the wet season of 1994 (June-October). In Antique, a similar sample size was aimed for. However, because of a time lag in the date of interviews and the option to grow three rice crops per year, only 27 farmers chose the wet season of 1994 as their reference period for interviews. In order to avoid seasonal differences, all farmers who referred to other seasons were eliminated from the sample. The remaining 27 farmers are distributed fairly evenly across the four villages[64]. Table 6.3 provides an overview of some socio-economic indicators representing the two groups of farmers.

While average farm and household size are more or less equal in both groups of respondents (slightly different from the data reported in Chapter 6), farmers in Antique are on average older than their colleagues in Nueva Ecija. It is somewhat surprising to see that farmers in Nueva Ecija claim to spend less time in farming but derive a larger share of their total income from farming than those in Antique. These values are rough estimates provided by the farmers at the beginning of data collection activities and may be misjudged. Since no information on the allocation of time to other uses is available from this data set, it can only be guessed that Nueva Ecija farmers spend more time on non-productive activities such as leisure. The considerably higher income reported from this province points to a higher land and labor productivity and/or a better integration in the market, with lower input- and higher output prices as a possible consequence.

For each of these farmers, a farm transect was compiled. Farm transects are subsets of the village resource transect and list only those natural resources utilized by the farmer in a particular cropping season. In addition, they include the area of the NRTs in each individual farm, a first step towards quantification. Table 6.4 gives a summary of the natural resource types utilized by the two groups of farmers.

For all farmers, the homestead is a very important resource which is used for various purposes, as shown further below. Farmers from both provinces have access to three types of agricultural land, namely upland, midland and lowland. These are sometimes further differentiated, depending on water and soil properties, but will here be grouped for the sake of comparability. While the proportion of farmers using lowland areas is fairly similar among the provinces, upland and midland use varies. However, this might also be due to local differences in the definition of terms.

Table 6.3. Socio-economic characteristics of sample famers, wet season 1994.

	Antique	Nueva Ecija
Number of respondents	27	50
Average age (years)	54	48
Average household size (persons)	5.4	5.4
Average farm size (ha)[65]	2.58	2.60
Average time spent in farming (%)[66]	74	63
Average share of income derived from farming (%)	76	92
Estimated total income (US$)[67]	556	1804

Source: Own computations.

64 San Antonio: 8 respondents; Catungan IV: 7 respondents; Igpalje: 6 respondents; Palma: 6 respondents.

65 This comprises all parts of the farm, including non-rice plots (e.g. upland parcels) and is therefore larger than the average farm size stated for Region III and Region VI in the previous section.

66 Based on recall data for the wet season 1994, as reported by the farmers.

67 Based on recall data for the wet season 1994, as reported by the farmers.

Table 6.4. Number of farmers reporting the use of various NRTs.

NRT	Antique		Nueva Ecija		Total	
Homestead	27	(100)	50	(100)	77	(100)
Upland	11	(41)	38	(76)	49	(64)
Lowland	18	(67)	30	(60)	48	(62)
Midland	20	(74)	7	(14)	27	(35)
Irrigation/river/creek	20	(74)	1	(2)	21	(27)
Fishpond	3	(11)	8	(16)	11	(14)
Roadside/dikes	6	(22)	2	(4)	8	(10)
Rice-fish area	—		4	(8)	4	(5)
Average number of NRTs per farmer	4.3		3.26			

Source: Own computations; figures in parentheses are percent of respondents from the respective provinces.

In Antique, farmers make extensive use of all kinds of open access water bodies such as irrigation canals, rivers and creeks, as well as of the roadside. This is not the case in Nueva Ecija. Here, a slightly larger share of farmers has fishponds, and four farmers reported the practice of rice-fish culture. While this area could be considered part of the lowland NRT, the farmers perceived it as a separate NRT with distinct features that set it apart from other NRTs. On average, farmers in Antique utilize or have access to more NRTs than farmers in Nueva Ecija. Particularly those NRTs with open access or common property character such as the roadside, dikes and water of irrigation canals, rivers, and creeks are utilized more commonly in Antique than in Nueva Ecija.

In order to arrive at the production structure of the farm, the associated enterprises were noted under each NRT in the farm transect. For the purpose of this study, a farm activity is defined by the combination of enterprise and NRT, e.g., rice production in a lowland area is considered different from rice production in the uplands. This definition resulted in an average number of about 30 activities per farmer in Antique and 14 in Nueva Ecija. As can be seen from Table 6.4, one possible explanation for this difference is the larger number of NRTs used per farmer in Antique. However, also the number of cultured plants and animals is greater in Antique than in Nueva Ecija. In Table 6.5, these activities are grouped into different enterprise categories and the average number of activities per farmer per enterprise category is presented.

A greater number of activities per enterprise category indicates a greater variety, either in cultured species or in NRTs where these species are produced. Apart from the forage category, variety is greater for all groups of enterprises in Antique than in Nueva Ecija. This difference in variety is most pronounced for fruit, followed by vegetables and aquatic animals. These are also the enterprise groups which exhibit the greatest overall variety in Antique. They are predominantly used for subsistence purposes, together with the roots and tubers which are much more prevalent in Antique than in Nueva Ecija. These enterprise groups often occupy only small parcels of land, they can be found on the dikes of irrigation canals, on the roadside or in open-access water resources. In contrast, market-oriented enterprise groups such as cereals, livestock and poultry display the smallest differences in variety. They are commonly produced in the same NRTs, with a concentration on the same major species. However, average livestock and poultry numbers per farmer are considerably larger in Nueva Ecija than in Antique (Table 6.6).

Table A4.2 in the Appendix lists the various species included under each enterprise group as well as the number and percentage of farmers reporting the culture or use of the particular species. It becomes evident that in addition to the greater number of NRTs used by farmers in Antique, they also culture a larger number of plants, particularly vegetables and fruit. The greater diversity in Antique

Table 6.5. Average number of activities per farmer per enterprise category.

	Antique	Nueva Ecija
Cereals	1.48	1.38
Livestock	1.70	1.42
Poultry	1.04	1.02
Roots & tubers	2.30	0.20
Vegetables	4.15	1.16
Fruit	10.19	5.06
Trees	2.44	1.84
Aquatic animals	3.33	0.56
Forage	0.89	1.54
Others	0.33	0.02
Average number of activities per farmer	29.56	14.20
Total number of activities observed	752	710

Source: Own computations.

Table 6.6. Average livestock and poultry numbers per farmer.

	Antique	Nueva Ecija
Pigs	0.93	1.4
Cattle	0.63	0.96
Water buffaloes	0.63	0.76
Goats	0.11	0.72
Chickens	8.78	10.28
Ducks	0.85	4.1

Source: Own computations.

farming systems, together with the widespread use of open access or common property resources indicates that farming in this province is more subsistence-oriented than in Nueva Ecija.

For an assessment and comparison of farming systems over time as well as across farms, four indicators were developed by Lightfoot et al. (1996) which capture different aspects related to the sustainability of the farm. These are:

- diversity, the total number of cultivars and animal species grown by or utilized by the farm household;
- recycling, the number of flows of biomaterials from within a single farming system, whereby nutrients are recycled between enterprises and natural resource types;
- farm capacity, or production, expressed in terms of tonnes per hectare; and
- economic efficiency in terms of net profit of the farm over the cost of production (Lightfoot et al. 1996).

These indicators are relatively easy to measure; however, in case they are computed from recall data, the latter two in particular need to be treated with care.

Average values for these indicators for the two groups of farmers are presented in Table 6.7. The sample for Nueva Ecija was further divided into the two villages since an initial look at the data revealed significant differences between them.

The greater diversity of farming systems in Antique has already been discussed above. More surprising is the observation that the degree of recycling is higher for farmers in Nueva Ecija than for farmers in Antique. Recycling refers to the re-use of biomaterial outputs (including both by-products/residues and primary produce) and involves the physical movement of biomaterials between enterprises and NRTs. Recycling is often labor-intensive and can be regarded as a means to save on cash for external inputs. Intuitively, one would thus assume that farmers in the more subsistence-oriented, less commercialized Antique would practice more recycling than in Nueva Ecija. However, recycling is often connected to animal husbandry. By-products of crop production can be fed to animals and their manure can be used as a fertilizer on almost any crop. Higher average livestock numbers in Nueva Ecija (see Table 6.6) indicate that animal husbandry is more prevalent in this province than in Antique, which explains the higher degree of recycling.

Capacity, defined as 'the total biomass output in tons per hectare from all enterprises and natural resource types within the entire farming system, including both primary produce and by-products' (Lightfoot et al. 1996, p. 42), is a problematic indicator since most of the products have never been weighed. Farmers were asked to furnish estimates of biomass production for the whole season, a very demanding task which often leads to doubtful values. For example, an average capacity value of 14.20 t/ha for farming systems in Antique, which consist mainly of riceland, implies a grain yield of 7 100 kg/ha (at a grain/straw ratio of 1:1). This is much higher than the average 3 t/ha from irrigated lands in the Philippines (BAS 1988) and thus quite improbable. Much more realistic are the 6.52 t/ha reported from Maragol, which correspond to an average rice yield of 3 260 kg/ha. (Dalsgaard and Oficial (1998) outline a range of approaches to obtain more reliable estimates of biomass).

Efficiency, the net profit/cost ratio, is likewise problematic. One set of difficulties refers to the definition and estimation of net profit or income. First, income estimates can be based on farmers' recall data for the whole cropping season as in the present study. Most likely, in such case, farmers will recall any fixed income (salary) as well as proceeds from the sale of their main crop, rice. Smaller sales of fruit and vegetables are less likely to be included. The same is true for wages from occasional jobs. Second, only cash income will probably have been considered. Own consumption of grains, fruit, vegetables and animal products can be significant, leading to a downward bias of income estimates in subsistence-oriented economies. Equally important, many wage payments are made in kind, which is often not included in income computations. Third, farmers are always reluctant to state their full income for fear of being taxed. They will thus provide underestimates of their true income. While RESTORE tackles some of these problems, for example by explicitly asking for individual products and non-cash payments, some areas such as home consumption and family labor remain difficult to quantify and value in retrospect. Nonetheless, certain components of the cost and income calculation can give valuable insights in the economic situation of the sample farmers (Table 6.8). Problems with recall data can be addressed through application of RESTORE as a monitoring tool, which is what it was designed for.

Table 6.7. Sustainability indicators for sample farmers, average values.

Indicator	Antique	Nueva Ecija		
		Maragol	Rangayan	Total
Diversity (no.)	19.08	14.40	12.36	13.38
Recycling(no.)	3.68	7.16	5.64	6.40
Capacity (kg/ha)	14.20	6.42	11.67	9.00
Efficiency (profit/cost)	0.48	0.70	-0.14	0.28

Source: Own computations.

These cost and income estimates, even though they are still far from perfect, show the main similarities and differences between the three groups of sample farmers. They differ considerably from the income estimates provided by the farmers when asked without special reference to individual income sources (see Table 6.3). Divided by the average farm size, farmers in Antique stated that they would earn US$ 215.50/ha per cropping season, which comes close to the net farm income of US$ 226.38/ha computed above, not considering other sources of income. However, Nueva Ecija farmers estimated their income to be US$ 693.80/ha per season while more detailed computations arrived at an average total income of only US$ 55.61/ha per season. This difference is mainly due to the negative net income realized by farmers in the village of Rangayan because of their extremely high costs for hired labor. The negative income value for Rangayan has to be regarded as atypical since these farmers seem to be doing quite well, judging from their assets (houses, machinery, livestock

Table 6.8. Average cost and income structure of sample farms (in US$ per hectare), wet season 1994.

	Antique	Nueva Ecija		
		Maragol	Rangayan	Total
Cash costs[68]	128.09	206.86	226.64	216.75
Hired labor (cash)	48.53	52.02	404.59	228.30
Total cash costs	176.62	258.87	631.23	445.05
Noncash costs	370.62	343.45	566.46	454.96
Hired labor (noncash)	68.74	116.67	557.35	337.01
Total noncash costs	439.36	460.13	1 123.82	791.97
Total costs for hired labor	117.27	168.69	961.94	565.32
Total costs (cash and noncash)	615.98	719	1 755.05	1 237.02
cash as % of total	29%	36%	36%	36%
noncash as % of total	71%	64%	64%	64%
Gross income (cash and noncash)[69] from farming	888.80	1 105.76	1 450.69	1 278.23
Net income (cash and noncash) from farming	272.82	386.76	-304.35	41.20
Imputed value of family labor[70]	46.44	52.81	81.03	66.92
Family labor as % of total labor	28%	24%	8%	11%
Farm income net of family labor	226.38	333.95	-385.38	-25.72
All other income (incl. remittances)	84.31	87.45	75.21	81.33
Total net income	310.69	421.40	-310.17	55.61

Source: Own computations.

68 Cost figures (both cash and noncash) include materialsí rent and fees. Hired labor costs are listed separately.
69 Cash income includes sales, noncash income comprises output consumed at home, used on the farm or given away.
70 Amount of family labor valued at the prevalent wage rate of hired labor.

numbers). Therefore, average cost and income values for the province of Nueva Ecija have to be separated for the two villages.

Total cash costs were lowest for Antique farmers. Maragol farmers spent on average 47% more on cash inputs, while cash expenses of Rangayan farmers were more than 250% higher than in Antique, due to hired labor costs.

Non-cash costs were higher than cash costs in all three villages, indicating that home consumption and payments in kind account for a large share of overall costs. They were lowest for Antique, but similar to those in Maragol. Rangayan again had very high non-cash costs, mainly due to hired labor expenses. The relatively large share of non-cash costs in total costs in Antique (71% as compared to 64% for both villages in Nueva Ecija) suggests that home consumption and payments in kind play a more important role in this province than in Nueva Ecija.

Antique farmers realized the lowest gross income from farming but earned slightly more income from other sources than farmers in Rangayan. Their share of family labor in total labor was greatest (the absolute value of family labor was greatest in Rangayan; however, due to their extensive use of hired labor, the relative share of family labor is small in this village). Farmers in the village of Maragol realized the highest net income, which is also reflected in their high efficiency value (Table 6.7). Net income from farming was higher by about 42% in Maragol than in Antique, total net income by roughly 36%.

Corresponding to the general description of the provinces provided at the beginning of this chapter, two types of rice-based farming systems emerge as a general pattern from these discussions. The first type resembles the farms found in Nueva Ecija, which operate with relatively high levels of external inputs, greater use of hired labor, greater market integration as indicated by the gradual replacement of non-cash transactions by cash transactions, greater livestock numbers and less diversity of species cultivated. These farmers spend less time in farming, yet derive a higher income from their farms. The use of open access and common property resources especially for aquatic organisms has been replaced by culture systems. On the other hand, farms of the second type are exemplified by the group of farmers from Antique. They culture and utilize a great variety of species, both plant and animal, from many different NRTs, including open access or common property resources. Non-cash transactions are of greater importance than in the first farm type and a larger share of farm labor is performed by family labor. Cash costs for farming are lower than in the first farm type.

Based on these broad farm types, which will subsequently be termed the 1. 'market-oriented' and 2. 'subsistence-oriented' type, different scenarios of integrated rice-aquaculture will be constructed in Chapter 9. However, more information is needed for the development of farm-household models. A modification of rice production technology, in this case by IPM and/or rice-aquaculture, will have an impact on the allocation of labor and capital in the farm-household system[71]. While capital requirements of rice-aquaculture are discussed in the first part of Chapter 9, the remainder of this chapter deals with labor-requirements of conventional rice production, additional requirements for IPM and rice-aquaculture and the time allocation of farm families.

71 The allocation of land as the third factor of production is the main outcome of farm-household model computations in Chapter 9 and is therefore discussed in that context.

Labor requirements for rice production activities

In order to arrive at a generalized estimate of labor requirements for the individual tasks in rice production, two complementary approaches were adopted. On the one hand, data provided in the IRRI data set mentioned above (132 farmers in Central Luzon, 1979-1988) were analyzed with regard to labor requirements for rice production. This data set describes the changes in labor use for different rice production tasks over time and can thus help in detecting exceptional years which might lead to unrealistic estimates of labor input. On the other hand, a survey on labor use in rice production was conducted among 30 farmers in one village in Antique (Catungan IV in the municipality of Sibalom) in August 1994, to obtain more recent labor data which are applicable to the situation in Antique (subsequently called the 'Antique rice labor survey'). Both data sets distinguish between family labor and hired labor. In the IRRI data set, activities are already grouped into four broad categories (land preparation, crop establishment, crop care, harvesting/threshing)[72]. While this level of aggregation can also be reached with the Antique data set, this survey initially distinguished between 12 different activities to obtain more precise information from the farmers[73].

In Central Luzon, total labor use in rice production has remained more or less constant between 1979 and 1988, except for the dry season of 1986 when crop care activities were higher than in other years, leading to higher overall labor input (Figure 6.2). No difference can be detected between dry seasons and wet seasons. The most labor intensive were formerly crop establishment and harvesting/threshing; however, labor requirements for crop establishment have declined over time, probably due to the replacement of transplanting by direct seeding as the dominant method of crop establishment. In contrast, labor requirements for land preparation and crop care show an increasing trend while labor input for harvesting/threshing has remained more or less constant. The situation in Antique shows generally lower labor figures (possibly due to differences in data collection methods), an extremely low value for crop establishment (due to the prevalence of direct seeding among respondents) and a relatively high value for crop care. The value for harvesting/threshing is probably underestimated, as explained above.

Hired labor in Central Luzon is predominantly employed for crop establishment and harvesting/threshing (Figure 6.3). While the use of hired labor for harvesting/threshing shows no clear trend, hired labor for crop establishment has decreased over time (corresponding to total labor use, see above). In contrast, hired labor for land preparation has increased slightly, possibly due to the greater use of handtractors as explained earlier. In Antique, almost no hired labor is employed for crop establishment because of the dominance of direct seeding. However, much more hired labor is used for crop care than in Central Luzon. This is mainly due to the damage done by the Golden Apple snail which feeds on young rice seedlings and can destroy large parts of newly seeded ricefields. Direct seeded rice is much more susceptible to snail damage than transplanted rice. Empty spots in the field

---

72 The original survey by IRRI distinguished between a greater number of different activities. However, the available data set has already been processed so that details can no longer be identified.

73 Activities included in the Antique survey are: 1. fixing the dikes, 2. plowing the sides of the field, 3. plowing the main part of the field, 4. harrowing, 5. levelling, 6. making canals and broadcasting seeds, 7. picking snails, 8. replanting empty spots, 9. applying fertilizer, 10. spraying insecticides, 11. spraying herbicides, 12. harvesting. Activities 1-5 can be combined under 'land preparation', activity 6 stands for 'crop establishment', activities 7-11 represent 'crop care' and activity 12 corresponds to 'harvesting/threshing'. Since threshing was not explicitly included in the Antique survey, it can be expected that the value for 'harvesting/threshing' will be smaller in Antique than in Central Luzon.

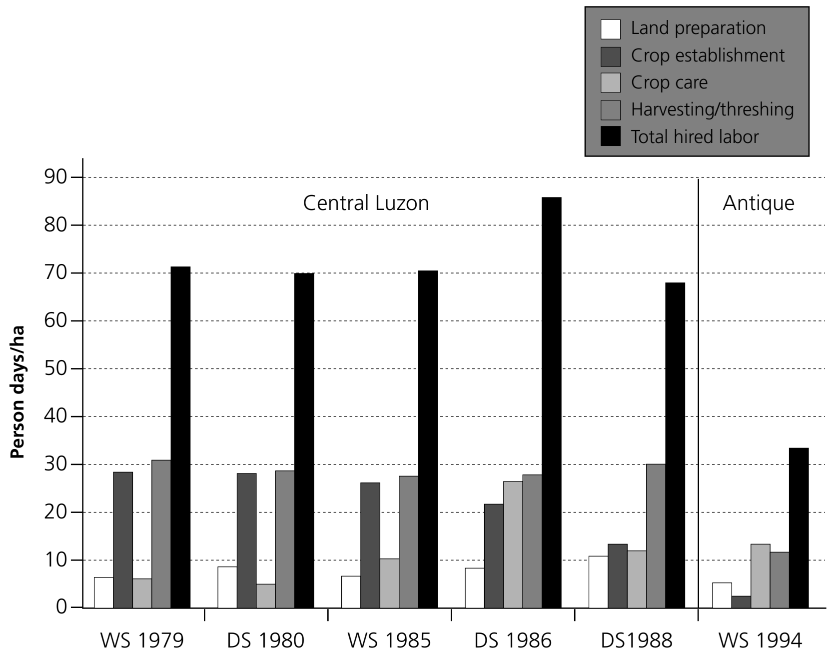


Figure 6.2. Total labor spent in rice production, Central Luzon 1979-1988, Antique 1994. Source: IRRI data set for Central Luzon and own survey data for Antique.

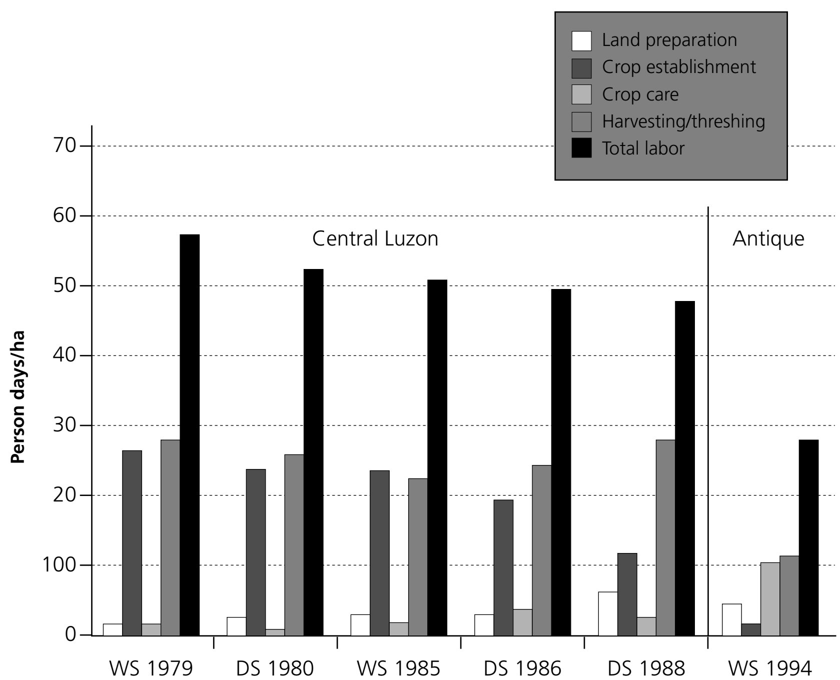


Figure 6.3. Hired labor spent in rice production, Central Luzon 1979-1988, Antique 1994. Source: IRRI data set for Central Luzon and own survey data for Antique.

caused by snails have to be replanted with extra seedlings within the first month after seeding in order to obtain a uniform harvest. For this purpose, farmers in Antique often employ hired laborers.

The most striking observation with regard to family labor in Central Luzon is the extremely high value for crop care in the dry season of 1986 (Figure 6.4). There must have been an exceptional situation such as a pest outbreak or a typhoon which caused this strong increase in family labor. If it is assumed that in a ‘normal’ year the value for crop care would have fallen between the values for the wet season 1985 and the dry season 1988, family labor input in Central Luzon shows an increasing trend until 1986 and a slight decrease in 1988.

Dominant activities for family labor are land preparation and crop care. This is also true for the group of respondents in Antique, who again spend much less time than their counterparts in Central Luzon and leave the harvesting/threshing jobs entirely to hired laborers (supervision time was probably neglected).

In order to identify gender- and time-specific labor constraints that could act as impediments to the adoption of rice aquaculture, it was necessary to distinguish between as many activities as possible since most of them involve different people, different wage rates and different contractual arrangements. The individual tasks in rice production were allocated to the respective months in which they are most likely to be performed (see Table 6.2). Based on the Antique rice labor survey as well as on key informant interviews and own observations, it was decided whether the task is normally carried out by family or hired labor or by a combination of both. If hired labor can be employed, it is assumed that for every day of hired labor activities, half day of family labor is needed for supervision purposes. Person days/ha, wage rates and contractual arrangements for different

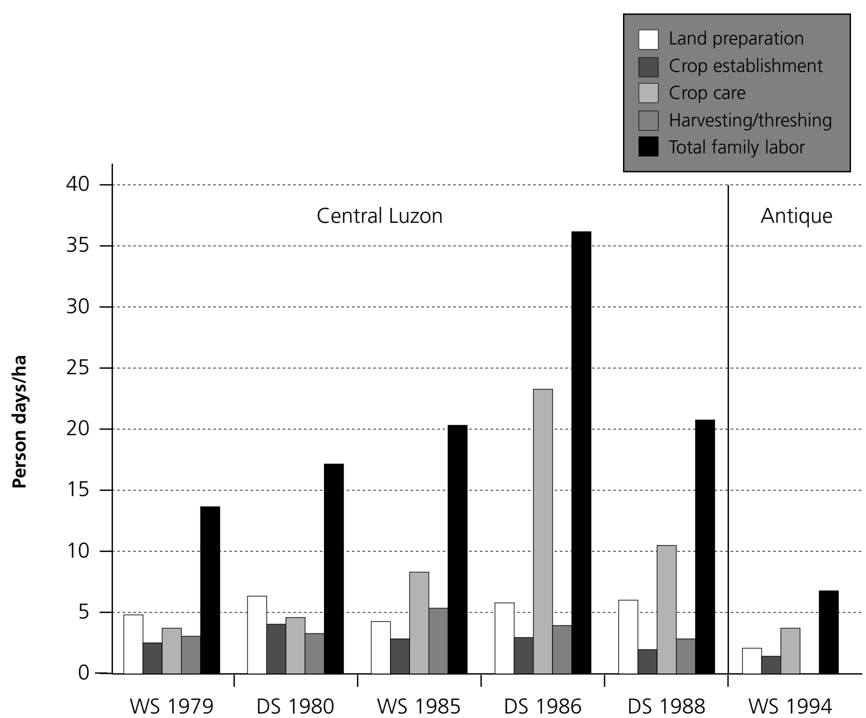


Figure 6.4. Family labor in rice production, Central Luzon 1979-1988, Antique 1994.
Source: IRRI data set for Central Luzon and own survey data for Antique.

activities were derived from the Antique rice labor survey. Family labor was further classified into men, women and children and activities were noted which can only be performed by certain subgroups of family labor. This information, which is summarized in Appendix Table A9.1, serves as the farm labor data base which is utilized in the model development in Chapter 9.

Additional labor requirements for rice-aquaculture and IPM

Both rice-aquaculture and IPM require certain modifications in rice production practices. A central aspect of IPM is the careful monitoring of the field, the crop and the pests and beneficial organisms in the field. On the other hand, pesticide applications in IPM are reduced to a minimum. Since many farmers state that they have always monitored their fields, even before they learnt about IPM, these two effects may be balanced with regard to their effect on labor requirements[74]. However, alternative control methods such as the handpicking of snails require additional labor input.

Rice-aquaculture involves field modifications, the stocking and feeding of fish, monitoring of water level and water quality and finally the fish harvest. It is therefore quite obvious that labor requirements per hectare will increase with the adoption of this technology. A comparison of labor use was conducted among 15 rice farmers and 15 rice-fish farmers from one village in Nueva Ecija, based on data provided by Israel et al. (1994) for the wet season of 1990 and the dry season of 1991. Labor requirements are expressed either in persondays per hectare (pd/ha) or in Pesos per hectare, depending on the dominant contractual arrangement for hired labor[75]. Data for the two groups were first compared for variances to determine the appropriate test statistic for means; they were then compared for means with the help of t-tests, assuming either equal or unequal variances based on the previous results. Apart from additional labor used for the stocking, feeding and harvesting of fish, rice-fish farmers spent significantly more time in the repair of dikes, water management and transplanting/ broadcasting and weeding (Table 6.9). In the dry season of 1991, rice-fish farmers also incurred significantly higher costs for threshing, hauling and drying of rice, which can be explained by the higher average harvest of rice from rice-fish systems than from rice monoculture systems in this season (6.1 t/ha as compared to 4.3 t/ha). In contrast, rice farmers only spent significantly higher amounts of labor on seedbed and seedling management in both seasons. Thus, additional average labor requirements per hectare for rice-fish culture (counting only those activities which were expressed in persondays/ha) amounted to almost 94 days in the wet season of 1990 and 84 days in the dry season of 1991, while additional labor costs per hectare (counting those activities which were expressed in Pesos/ha) came to 885.50 Pesos in the dry season of 1991 (no significant difference for these activities was found in the wet season of 1990). If it is assumed that at least part of this labor is contributed by family members (regular management activities which require only a few minutes every day are not likely to be performed by hired laborers), this time is currently devoted to other

74 Evidence from Indonesia shows that IPM farmers were not found to have a different behavior in visiting the crop from non-IPM farmers. It is not the frequency but the quality of monitoring that is expected to change as a result of the IPM training. Trained farmers are expected to look at natural enemies and consider pest densities rather than pest occurrence, in relation to the development stage of the crop (van de Fliert 1993).

75 Certain activities such as land preparation and harvesting/threshing are normally conducted under a hectare-based contractual arrangement for hired labor, regardless of the time spent on this activity. For other activities such as transplanting and weeding, laborers are hired on a daily basis.

Table 6.9. Average labor requirements for different tasks in rice monoculture and rice-fish culture, Nueva Ecija, 1990/91.

	Wet season 1990		Dry season 1991	
	Rice only	Rice-fish	Rice only	Rice-fish
Seedbed and seedling management (pd/ha)	2.00*	1.73	2.00*	1.73
Land preparation (Pesos/ha)	1 281.67	1 281.67	1 281.67	1 281.67
Repair of dikes (pd/ha)	1.40	8.85**	1.45	7.23*
Water management (pd/ha)	9.40	43.55**	17.00	43.49**
Pulling/bundling of seedlings (Pesos/ha)	269.85	273.09	256.29	304.84
Transplanting/broadcasting and weeding (pd/ha)	18.22	25.00**	16.73	25.25***
Fertilizer and pesticide application (pd/ha)	3.07	3.36	3.7	3.94
Harvesting (Pesos/ha)	900	900	900	900
Threshing (Pesos/ha)	1 403.43	1 656.04	1 442.78	2 048.84**
Hauling (Pesos/ha)	313.27	369.65	322.05	457.33**
Drying (Pesos/ha)	221.37	261.22	227.58	323.18**
Stocking of fish (pd/ha)	0	0.91	0	0.81
Feeding of fish (pd/ha)	0	9.67	0	9.27
Harvesting of fish (pd/ha)	0	34.70	0	33.30
Total persondays/ha	34.08	127.76***	40.88	125.02***
Total Pesos/ha	4 389.59	4 741.67	4 430.37	5 315.86**

Source: Own computations based on data provided by Israel et al. (1994).
* = significantly greater at alpha = 0.05; ** = significantly greater at alpha = 0.01; *** = significantly greater at alpha = 0.001.
No significance tests were conducted for the last three activities which only apply to rice-fish culture.

activities, be they income-generating, household-related or leisure. The discussion of farm-household theory in Chapter 5 has highlighted that the success or failure of alternative farming practices depends ceteris paribus on the returns to labor in different activities and on the individual's preference for leisure or income.

Time allocation of rice farm households in Antique

One of the many potential constraints for the adoption of a new labor-intensive technology by small-scale farmers is the (non-) availability of surplus labor within the farm-household system. Often, it is assumed that enough family labor is available without realizing that the tasks required are performed by other members of the family-household system than previously anticipated. Also, seasonality of labor requirements can interfere with other periods of high labor demand. It is therefore important to understand the time allocation patterns and the division of labor within the household. Another significant aspect of time allocation studies is the actual time allocated to and available for agricultural activities—labor data are often computed based on an assumed working time of 40 hours per week. However, especially in subsistence and semi-subsistence economies, a considerable amount of time is spent on activities other than fieldwork which for the farmers are of equal or even greater importance (maintaining social contacts, performing off-farm or non-farm labor, producing household goods, illness, etc.). Time allocation studies can give an indication of how much time farmers are willing and able to spend in agriculture by taking other activities into account.

For the purpose of this study, time allocation data were collected in two villages of Antique over the course of one year (March 1993 - April 1994). The villages San Antonio and Igpalje (which were also included in the study of farming systems presented above) are located in the municipality of

Barbaza, an irrigated rice-growing area of Antique roughly halfway between the provincial capital San Jose de Buenavista and the northern tip of the province. Twelve households were selected at random from a list of farmers who had participated in an IPM training because they were initially selected for interviews relating to IPM. Five of these households are located in San Antonio, a village between the National Road and the seashore, while seven households belong to Igpalje further inland, approximately two kilometers away from the National Road towards the mountain range. Since a large share of farmers participated in the IPM training[76], the sample can be assumed to reflect a realistic picture of the farming community in the villages.

All households grow rice on irrigated land. Average size of the rice land is 1 hectare; however, especially in the village of Igpalje, farmers cultivate small upland parcels for rootcrops, trees or sugarcane which are usually not clearly demarcated.

Average household size is 5.25; each household has on average three members who were aged between 15 and 65 years (assumed to be the economically active years for which time allocation data were collected). Household members are exclusively family members; sometimes grandparents live together with their grandchildren while the parents live and work outside the province. Originally, the total sample consisted of 37 persons aged 15 years and above; however, three persons were considerably older than 65 years and had to be eliminated from the sample later. The final sample population consisted of 20 adult men and 14 adult women between the age of 15 and 65. Not all of the remaining 34 persons were present for the whole year; so that the sample size varies somewhat between different months.

The method used to collect the data for this study is one of random visits, which was developed and first used by Johnson (1975) to study the Machiguenga of lowland Peru:[77]

> "The researcher selects a sample of households for observation throughout the year and prepares a random schedule of days and hours for visits. When visiting a house, the interviewer records the activities of all members of the household at the moment of the visit. Over the course of the year, a large series of random observations of community members is compiled, and estimates of the proportion of time spent in various activities can be made (Tripp 1982)."

This method is less expensive and requires less interviewer time and skills than intensive time allocation studies in which farmers are visited at frequent intervals (one to three times a week) and all activities since the previous visit are recorded.

[76] The 1990 Census of Population and Housing reports 74 households in San Antonio and 150 households in Igpalje (NSO 1990). By comparing the number of households with the number of farms stated in the 1991 Census of Agriculture (NSO 1994a), it can be concluded that approximately 60% of all households in the municipality of Barbaza are farm households. For San Antonio and Igpalje, this would amount to 44 and 90 farm households, respectively. The IPM training included 25 farmers in each village, representing 57% and 28% of all farm households in San Antonio and Igpalje, respectively.

[77] The method has since been employed in other studies of Amazonian societies, see Gross et al. (1979) and in studies of time allocation patterns among African farmers; see Tripp (1982) and Runge-Metzger (1991).

Data collection in the two villages occurred on different days to spread the workload for the interviewer. For each village, two days were randomly chosen per week. Thus, the total year's schedule for one village consisted of 107 days between March 1993 and April 1994. For each visit, an hour between 6 A.M. and 6 P.M. was randomly assigned for data collection. Thus, on 107 occasions the observer set out at the appointed time to visit the 12 households and record the activities of their members at the instant of his arrival. All households in one village could be visited within the time of an hour.

When household members were absent from the village for longer than a day or when their activity at the time of the visit was not known, the observation was excluded from the sample. The 107 visits to the 20 men in the sample yielded 2 106 observations, but of these, a total of 474 could not be used for the final analysis. Therefore, the number of observations of men is reduced to 1 632. For the women in the sample, 148 observations from a total of 1 496 had to be excluded, leaving 1 348 observations for the analysis. The number of observations for each activity is then expressed as a percentage of total observations[78]. Multiplying this percentage (expressed in decimal form) by 12, the number of hours of observation (from 6 A.M. to 6 P.M.), results in the number of hours spent, a further multiplication by 60 in the average number of minutes per day spent on each activity (Table 6.10).

The activities were sorted according to the average number of minutes per day spent by all respondents, in decreasing order. The aggregation of activities to broader categories follows the classification by Lanzona (1988). In a monitored time period of 12 hours, sleeping and leisure take the first place among all activities. Together with the time spent on eating, schooling, illness, personal hygiene, meetings, and visits to friends, town and church, these 'leisure and consumption' activities account for roughly 4 hours and 26 minutes, leaving around 7.5 hours for other activities. Among these, the income-generating activities (including production of household goods) take up approximately 4 hours and 44 minutes. About two hours and 37 minutes per day are on average spent on domestic activities, the rest of the time (approximately 14 minutes/day) is taken up by community work or times of absence.

The last column in table 6.10 shows the difference between the time spent by men and the time spent by women for every activity. This provides a first indication of the intra-household division of labor, i.e. activities typically performed by men or women. Values for the two groups were compared by means of t-tests and statistically significant differences between men and women are indicated for three levels of statistical significance. The four most time-consuming activities which, taken together, account for more than 7 of the 12 hours monitored, all exhibit high levels of statistical significance, i.e. the amount of time spent on these activities differs considerably between men and women, indicating a gender-specific division of labor. Men spend significantly more time in rice farming and animal husbandry, but they also have more leisure time (almost 1.5 hours/day on average!). Women mainly engage in food preparation, laundrying and housekeeping. They do spend quite a lot of time in rice farming and animal husbandry, but less than men. Other activities which are more often performed

[78] The relevant number of 'total observations' depends on the further classification of the sample. When all observations are included, observations of each activity are expressed as a percentage of 2 980, the total number of useful observations. For a comparison between men and women, the totals are 1 632 and 1 348 observations, respectively. Any further division by villages or month would yield smaller numbers of relevant totals for each subgroup.

Table 6.10. Time allocation of adults in Antique, in average minutes per day[79].

Activity	All respondents	Men	Women	Difference (men-women)
Sleeping/leisure	164.93	200.06	114.73	85.33**
Ricefarm activities	96.26	128.24	50.57	77.67**
Animal husbandry	94.69	134.17	38.29	95.88**
Food preparation	69.25	20.06	139.52	-119.46***
Eating	44.05	44.25	43.77	0.48
Non-farm labor	39.19	31.24	50.55	-19.31
Laundrying	21.27	2.22	48.49	-46.27***
School/training	17.26	7.20	31.64	-24.44
Housekeeping	15.68	3.40	33.22	-29.82***
Other farm activities	12.39	13.48	10.81	2.67
Backyard gardening	12.33	5.89	21.52	-15.63*
Childcare	12.11	3.81	23.96	-20.15
Absent	12.07	10.61	14.16	-3.55
Acquisition of food and daily needs	11.58	6.42	18.95	-12.53*
Ritual/church	11.27	12.40	9.66	2.74
Off-farm labor	11.18	17.54	2.09	15.45*
Illness	10.47	10.65	10.22	0.43
House repair	10.06	13.90	4.58	9.32*
Visits	9.45	6.93	13.04	-6.11
Coconut wine production	8.60	14.22	0.57	13.65
Firewood gathering and processing	7.25	7.80	6.45	1.35
Personal hygiene	5.94	6.87	4.60	2.27
Postharvest activities	4.70	4.40	5.11	0.71
Tailoring/mending	4.56	0.34	10.59	-10.25*
Sickcare	3.61	1.40	6.77	-5.37
Craft	2.48	2.84	1.98	0.86
CIVAC ('civic action', community work)	2.19	3.73	0	3.73**
Fishing	1.71	2.56	0.49	2.07
Finance	1.25	0.35	2.54	2.19*
Town	1.17	1.54	0.64	0.90
Meetings/discussions	1.06	1.46	0.48	0.98
Total	720	720	720	
Total leisure and consumption activities[80]	265.60	291.36	228.78	
Of this:	(= 4 h 26 m)	(= 4 h 51 m)	(= 3 h 49 m)	
'pure leisure'	3 h 20 m	1 h 55 m		
'other leisure'	1 h 31 m	1 h 54 m		
Total income-generating activities	283.53	354.58	181.98	
(incl. production of household goods)[81]	(= 4 h 44 m)	(= 5 h 55 m)	= 3 h 2 m)	
Of this: farmwork	4 h 36 m	1 h 40 m		
off-farm/non-farm work	49 m	53 m		
Total domestic activities[82]	156.62	59.7	295.07	
	(= 2 h 37 m)	(= 1 h)	(= 4 h 55 m)	
Total miscellaneous activities[83]	14.26	14.34	14.16	
Total working time	454.41	428.62	492.21	
	(= 7 h 34 m)	(= 7 h 9 m)	(= 8 h 11 m)	

Source: Own computations.
* = significant at alpha = 0.05; ** = significant at alpha = 0.01; *** = significant at alpha = 0.001.

79 See Appendix 5 for a detailed description of the activity categories.
80 This includes sleeping/leisure, eating, school/training, ritual/church, illness, visits, personal hygiene, town, meetings/discussions.
81 This includes activities on the own ricefarm and other parts of the own farm, animal husbandry, backyard gardening, off-farm and non-farm employment, coconut wine production, post-harvest activities, craft and fishing.
82 This includes food preparation, laundrying, housekeeping, childcare, sickcare, acquisition of food and other daily needs, house repair, firewood gathering and processing, tailoring/mending and finance.
83 This includes times of absence and community work.

by women than by men are backyard farming, food acquisition, tailoring/mending and financial transactions. On the other hand, men more often engage in off-farm labor, house repair and community work. For all other activities, no significant difference between men and women could be detected.

Income-generating, domestic and miscellaneous activities represent the total working time of the household members. The data show that women spend on average one hour more per day on work-related activities than men. Leisure and consumption activities can be divided into 'pure leisure' (i.e., sleeping and doing nothing in particular) and other activities which are required to maintain family, household and social relations. This division further accentuates the stronger occupation of women compared to men.

These data reflect the average time allocation of the monitored persons under their current income possibilities. If a new activity such as rice-aquaculture is introduced in the farm- household system, it will have to compete for labor with those activities currently practiced. In the theoretical framework of farm household theory presented in Chapter 5, only such farming practices will be considered which lead to an upward turn of the income possibility curve, allowing the farmer to reach a higher level of utility. Whether this is achieved with constant, increasing or decreasing total labor input depends entirely on the shape of the farmer's indifference curve for leisure and income. However, in reality there can be certain restrictions to this model which arise from market imperfections, bio-physical relationships or institutional constraints. In the case of rice-aquaculture and IPM, the main restriction lies in the discrete nature of the adoption process. While a continuous process can theoretically be imagined, a real-life farmer faces clearly demarcated paddies which can only be converted as a whole. In the extreme case of a farmer who farms only one paddy and does not engage in other activities, an adoption of these more labor-intensive technologies will automatically require higher labor inputs, some of which are not very likely to be performed by hired labor (routine activities, see above). Thus, leisure time has to be converted to working time which may contradict the person's individual preference for leisure and pose a constraint to adoption. Individual indifference curves for leisure and income are difficult to identify. However, by assuming that there is no systematic difference between men's and women's preference for leisure, a labor-intensive technology is more likely to be adopted if it falls under the responsibility of men. Women have already sacrificed most of their leisure time for work and every additional unit of leisure requires increasingly greater amounts of income to be converted to working time. Considering the gender-specific division of labor discussed above, a backyard fishpond would belong to the domain of women while rice-aquaculture or modified rice production practices such as IPM would demand extra time predominantly of men. From this point of view, the allocation of time leaves some room for the adoption of rice-aquaculture and IPM. Furthermore, a substitution of labor is more likely to happen among similar activities, i.e., a new farming practice might reduce labor input in other farm activities which are dominantly undertaken by men, but not in food preparation or housekeeping. However, seasonality of labor requirements and alternative income possibilities need to be considered simultaneously and may well lead to constraints at certain times during the year. For this purpose, the farm models developed in Chapter 9 are specified on a monthly basis.

Chapter 7

The role of aquatic ricefield organisms in farm household nutrition

It has been proposed in previous chapters that through the culture of aquatic organisms in ricefields, small-scale farmers can improve their nutritional situation. In order to analyze this hypothesis, the following questions have to be asked:

Which aquatic organisms from ricefields are currently utilized by people in the irrigated lowlands of the Philippines? Who are the main users and what are the rules governing their use?

Is there, in fact, an insufficient supply of animal protein in the diet of rice farmers in the Philippines? What role do wild aquatic organisms from ricefields play in the diet of rice farmers today?

What preference do people have for fish species which are commonly cultured in ricefields (carp, tilapia), especially in areas where they have to compete with other (marine) fish species (i.e., in coastal areas)? What are the main determinants for these preferences?

To answer these questions, three different approaches were employed:

- a survey on the presence, use and characteristics of aquatic organisms in ricefields;
- a weekly food consumption monitoring over the course of one year;
- a preference ranking of various fish species.

Utilization pattern of aquatic organisms from ricefields

To obtain an overview of the current utilization of aquatic organisms from ricefields, a survey of 30 rice farmers and 20 landless laborers was conducted in one village in Antique (Catungan IV) between July and August 1994 (subsequently called the 'Antique aquatic ricefield organisms survey', see Appendix 3). In order to include respondents from different socio-economic backgrounds, a wealth ranking was conducted (see Appendix 6) and farmers from each wealth class were selected randomly according to the relative share of their respective class in the total population. Since landless laborers normally belong to the poorer classes of a rural community, they were selected at random without further stratification by wealth class. The survey covered aspects of observation, use, quantity, seasonality of and access rights to aquatic organisms found in the ricefield. The classification between farmers and landless laborers was made to determine whether aquatic organisms are utilized exclusively by the tillers of the land or whether they have to be regarded as an open access or common property resource.

While farmer respondents were asked to list all organisms which they observed in the water of their ricefields, the questionnaire for landless laborers started out by asking which animals are caught or picked from the ricefield. This led to a bias towards useful organisms in the answers of landless laborers which is clearly reflected in Table 7.1. Furthermore, the more general introductory question for farmers caused them to mention a greater number of insects, spiders, bugs and worms than the landless laborers.

Table 7.1. Aquatic organisms in the ricefields - perceptions of farmers and landless laborers.

	Farmers	Landless	Total
Number of respondents	30	20	50
Average number of animals mentioned	4.90	4.55	4.76
of these: useful	2.70	4.15	3.28
of these: insects/spiders etc.	1.50	0.45	1.08

Source: Own computations.

The animals listed in Table 7.2 are those most frequently mentioned (insects and spiders were grouped together). Asked whether and how they utilized these animals, farmers and laborers most frequently stated that they would eat them and sell the surplus in the neighborhood or in the market (Table 7.3). Many respondents made it quite explicit that own consumption came first and that only in case of abundance would they sell some of their catch.

While fish from ricefields are more or less eaten by farmers and laborers alike, all other organisms seem to be more appreciated by laborers than by farmers. The Golden Apple snail is an exception since it is generally not eaten by people but fed to animals (pigs, ducks) if it is utilized at all. When asked whether there is a rule that grants or denies certain people access to the fields and thus to the animals, all farmers and laborers agreed that everybody can catch the aquatic organisms in the ricefields as long as the field and the rice are not damaged. However, most of the organisms are highly seasonal, coming with the onset of rain in May/June and lasting approximately until November (Table 7.4).

During this time, the respondents declared that they caught on average about 28 kilos of fish, 34 kilos of frogs and 58 kilos of crabs[84] (Table 7.5). Taken at face value, this would mean that each respondent has an average daily ration of 77 grams of fish, 93 grams of frogs and 159 grams of crabs from the ricefield, a quantity which is certainly too high. However, if it is taken into account that the average edible portion of fish, crabs and frogs are only 50%, 40% and 30%, respectively (FNRI 1990) and that the catch would have to be divided among a family of 6, each person ends up with a daily portion of 6 grams of fish, 5 grams of frog and 11 grams of crab. When these quantities are converted back into units of organisms[85], this corresponds to eating a ricefield fish every 8 days, a ricefield frog every 6 days and a ricefield crab every 2 days. Allowing for the seasonality of the catch and a certain number of organisms given away, these quantities are then not completely improbable. And even if these numbers might in fact be overestimates due to wrong conversion factors or due to the high aggregation level (respondents might have stated the quantity of a very good catch instead of an average catch), they nonetheless show that despite the intensification of rice production following the Green Revolution it is still a common practice to catch aquatic organisms from the ricefield for food and that these organisms serve as a welcome addition to people's diets.

84 Quantities for other organisms were either given in units which could not be converted to kilos or the number of respondents who provided quantity estimates was too small.

85 Since most respondents stated the number of animals caught, the following conversion factors were used: 1kilo = 10 pieces of fish, or 17.5 frogs, or 20 crabs (own estimates).

Table 7.2. Most frequently mentioned aquatic organisms in ricefields.

	Farmers		Landless laborers		Total	
Fish (various species)	26	(87%)	20	(100%)	46	(92%)
Frogs	17	(57%)	19	(95%)	36	(72%)
Crabs	16	(53%)	20	(100%)	36	(72%)
Golden Apple snail	27	(90%)	8	(40%)	35	(70%)
Edible, pointed snail	7	(23%)	9	(45%)	16	(32%)
Shrimps	2	(7%)	5	(25%)	7	(14%)
Insects, spiders, etc.	22	(73%)	6	(30%)	28	(56%)

Source: Own computations.

Table 7.3. Use of aquatic ricefield organisms by farmers and landless laborers.

	Eat / sell				Others[86]				No use			
	Farmers		Laborers		Farmers		Laborers		Farmers		Laborers	
Fish	26	(87%)	20	(100%)	0		0		0		0	
Frogs	9	(30%)	19	(95%)	4	(13%)	0		4	(13%)	0	
Crabs	16	(53%)	20	(100%)	0		0		0		0	
Golden Apple snail	2	(10%)	2	(33%)	10	(50%)	3	(15%)	15	(15%)	3	(7%)
Edible pointed snail	3	(10%)	9	(45%)	0		0		4		0	(13%)
Shrimps	2	(7%)	4	(20%)	0		0		0		1	(5%)

Source: Own computations.
Values in parentheses are percentage of all farmers or landless laborers interviewed. They do not always add up to 100% because some respondents did not mention the particular organism.

Table 7.4. Main catching season for aquatic organisms from ricefields.

Fish	July–November
Frogs	May
Crabs	May/June–October/November
Golden Apple snail	May/June–July
Edible pointed snail	May/June–November
Shrimps	May–November

Source: Own observations.

The most important outcome of this quantification is that landless laborers consistently reported greater catches than farmers. These results indicate that aquatic ricefield organisms are a cheap open- access source of animal protein which is predominantly used by low-income people regardless of whether they farm the land or not. Access rights to land are not equivalent to access rights to the aquatic organisms in the field, a situation that may well change if fish is deliberately stocked in the ricefields. From the perspective of landless laborers, it will be hard to understand that these fish are different from the wild ones and thus may not be caught by them anymore. What is often perceived as 'poaching' by rice-fish farmers may be regarded as rightful and traditional behavior by landless laborers.

[86] Other uses for frogs: insect control (4 farmers); other uses for Golden Apple snail: animal feed (8 farmers, 3 laborers), sell (1 laborer), weed control (2 farmers).

Table 7.5. Quantities of aquatic organisms caught.

	Fish	Frogs	Crabs
Average frequency of catch per month			
farmers	4.63	6.58	8.25
laborers	9.93	6.11	11.98
Number of animals caught per event			
farmers	11.35	54.68	34.68
laborers	18.75	88.57	113.33
Number of animals caught per month			
farmers	57.73	336.32	516.64
laborers	189.18	682.50	805.17
Average number of catching months			
farmers	2.42	1.31	2.19
laborers	3.35	1.47	3.25
Number of animals caught per year			
farmers	100.54	380.40	634.45
laborers	517.70	751.07	1658.33
Assumed number of pieces per kg	10	17.5	20
Kg of animals caught per year			
all respondents	28.19	34.09	58.43
farmers	10.05	21.74	31.72
laborers	51.77	42.92	82.92
Number of respondents[87]			
farmers	26	10	11
laborers	20	14	12

Source: Own computations.

Food consumption of rice farmers in two Philippine provinces

The food consumption of farm households was monitored over the course of one year (February 1993-March 1994). It was the objective of the study to gain insight into the diet of the monitored persons and to assess the role of aquatic ricefield organisms in the current diet of the rural population. Possible nutritional deficiencies should be identified and the potential of rice-aquaculture for the improvement of people's diets should be assessed.

Among a total of four villages included in the study, two are located in the province of Antique, and two can be found in the province of Nueva Ecija[88]. As stated earlier, one main difference between these two provinces lies in their access to the sea—Antique is characterized by a long coastal strip over the whole length of the province while Nueva Ecija is landlocked to the sea. This locational

87 Only those respondents who stated the number of animals caught were included in the quantification. Respondents who used different units (e.g. volume measures) could not be considered, therefore the number of respondents for frogs and crabs is smaller here than in Table 7.3.

88 These villages were also included in the description of farming systems in Chapter 6. They are: Maragol and Rangayan for Nueva Ecija, and San Antonio and Igpalje for Antique.

difference is expected to influence the consumption of fresh marine fish and the importance of other sources of animal protein in people's diet.

A total of 25 households participated in the study, 12 from Antique and 13 from Nueva Ecija. In Antique, the same households were monitored which were also included in the time allocation study. In Nueva Ecija, the group of households consisted of seven former participants in a rice-fish project and six non-participants. The non-participants were included as a control group to find out whether the former participants had gained a greater appreciation of aquatic ricefield organisms, even though most of them stopped culturing fish some time ago. Because of the small sample size and partly informal selection methods, the samples have to be regarded as case studies and the results can only be generalized to a limited extent. Especially the role of income differences on diet composition cannot be analyzed with these data but was considered through official statistics.

For each family, two persons (husband and wife) were included in the study (except for the six persons in the control group in Nueva Ecija), leading to a sample size of 24 persons for Antique and 21 persons for Nueva Ecija[89]. Since *not the whole family* was monitored, the study cannot make statements concerning the nutritional situation of children or the intra-household distribution of food[90]. The inclusion of two persons per family is due to the fact that at the time of the interviews, not always the same person was available. For the same reason the number of observations per person especially in Antique differs considerably (see Table 7.6).

During the monitoring period (February 1993-March 1994)[91] the selected persons were visited at least once per week and were asked what food items had been consumed during the last 24 hours (24-hour recall). Parameters noted were type of food items consumed, volume of food items consumed in household measures (cup, plate, spoon, etc.) and the meal at which the food item was consumed (breakfast, lunch, dinner). Also, it was explicitly asked if any food had been consumed between meals. Household measures were used instead of weight measures because it was not possible in this study to actually weigh the food and respondents were more confident in stating the consumed amounts in household measures than in the common weight measures.

Table 7.6. Description of the sample for the food consumption study

	Antique		Nueva Ecija		
			Rice-fish farmers		Control group
	Women	Men	Women	Men	Women and men
Number of respondents	12	12	8	7	6
Average number of monitored days	60.33	36	14.87	50.14	32.33
Standard deviation	13.27	10.05	5.28	4.78	0.52
Average number of monitored meals	223	125.42	60.87	183.14	96.83
Average number of food items registered	581	332.50	173.12	532.29	269.50
Average number of meals/day	3.70	3.46	4.10	3.65	2.99
Average number of food items/meal	2.61	2.64	2.80	2.90	2.78

89 In one case, both the wife and the daughter of the farmer were included in the sample because each was absent for about half of the time.

90 There are other studies which cover this topic, for example Garcia and Pinstrup-Andersen (1987).

91 In the case of the six control persons in Nueva Ecija, the study started only in July 1993, roughly five months later than for the other respondents. For the control group, a monitoring period of 32 weeks was completed.

The data collected were first classified into basic food groups (energy foods[92], fish, meat, eggs, pulses, green leafy/yellow vegetables, other vegetables, vitamin C-rich fruit, other fruit). For each of these food groups, age- and sex-specific recommended dietary allowances (RDAs) for Filipinos exist, both in grams and in household measures (de Guzman et al. 1988). However, before these allowances were compared with the amounts actually consumed, a qualitative analysis regarding the average composition of diets was conducted, based on the frequency of consumption of different food items. The percentage of each food group in all food items registered was computed without considering the amounts consumed in weights. This analysis can give an insight into food items consumed frequently and less frequently and can be a first indication for the supply situation of the different food groups and for people's consumption habits. A comparison of the data for the two provinces regarding the main sources of animal protein can also highlight the role of fish and other aquatic organisms in people's diets. Furthermore, an attempt was made to assess the contribution of rice-fish culture to animal protein supply by comparing the average consumption frequency of various food items between the rice-fish farmers and non-rice-fish farmers in the province of Nueva Ecija.

There is a striking correspondence in the consumption frequency of all food groups between the two provinces (Figure 7.1). Rice makes up about 36% in all food items mentioned. With an average of just below three food items per meal, it can be deduced that rice is a part of each meal. The second most important group of food items are the animal protein foods (fish, meat, eggs) which as a whole have a share of roughly 30% of all food items mentioned. This group will be discussed in detail below. Vegetables make almost 18% of all food items mentioned are vegetables. With these three nutritional components (rice, fish/meat/eggs, vegetables) the main elements of a typical Philippine meal have already been identified. All other categories are much less important.

However, such a broad classification of food items can only be of limited use in the detection of differences between the two provinces[93]. It is therefore necessary to further differentiate the food

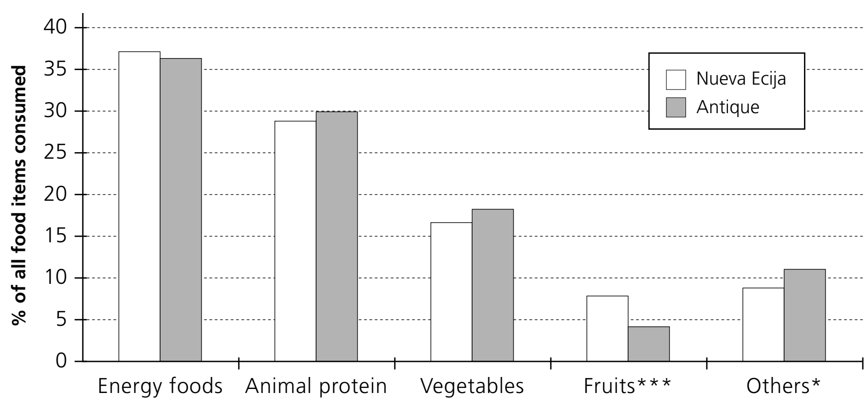


Figure 7.1. Average share of food groups in all food items mentioned, Nueva Ecija and Antique, 1993-94.
Source: Own computations. Nueva Ecija: 6728 observations; Antique: 10962 observations.
* significantly different at alpha = 0.05; *** significantly different at alpha = 0.001.

92 Energy foods include cereals (rice), bread, root crops and noodles. Rice accounts for roughly 90% of all energy foods consumed in both provinces.

93 Significant differences (at alpha = 0.05) between the two provinces could only be found for fruit and miscellaneous food items which did not fit into any other group. These food items taken together only have a share of around 16% in all observations.

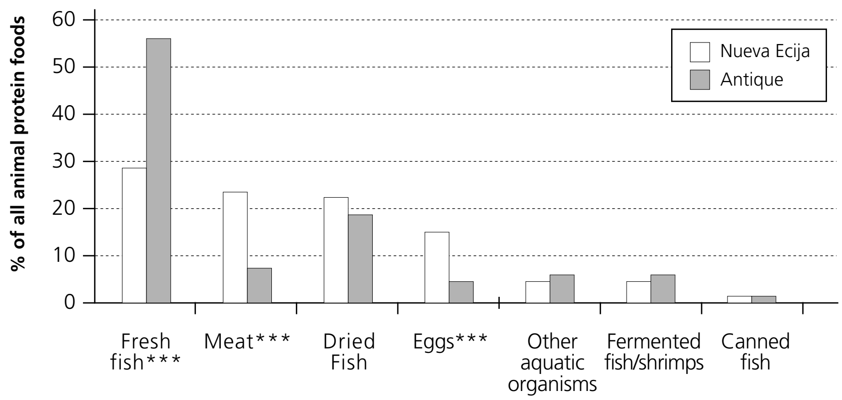


Figure 7.2. Average composition of animal protein foods, Nueva Ecija and Antique, 1993-94.
Source: Own computations. Nueva Ecija:1981 observations; Antique: 3 234 observations.
*** significantly different at alpha = 0.001.

items, especially the animal protein foods (Figure 7.2). Here, some major variance between the two provinces becomes apparent. Highly significant differences (at alpha ≤ 0.001) in consumption frequency were found for fresh fish, meat, and eggs. While fresh fish is consumed predominantly in Antique, meat and eggs dominate in Nueva Ecija. It is interesting to note that significant differences can be detected for the various subgroups of animal protein foods between the provinces, whereas the share of animal protein foods as a whole is roughly the same in both provinces. This indicates a substitution process within the group, based on availability and/or price of the respective food items, so that the level of supply with animal protein foods as a whole (frequency of consumption, not quantity) remains the same.

In both provinces, fresh fish is the animal protein food consumed most often. However, its share in Antique is almost twice as high as in Nueva Ecija. This is an indication for the differential access to the sea coast as mentioned above, which also becomes apparent in the type of fish consumed. While in Antique mostly marine species are eaten, the milkfish (*Chanos chanos*) is the predominant species of fish in Nueva Ecija (roughly 36% of fresh fish meals).

The exceeding importance of fish as a source of animal protein in Antique is further emphasized by the fact that here dried fish is the second most important animal protein food. Including canned fish and bagoong (fermented small fish or shrimps), more than 80% of animal protein foods enumerated in this province is composed of fish. In contrast, meat and poultry have a much higher importance in Nueva Ecija where the consumption frequency of this group almost reaches the level of fresh fish. In addition to the province's geographical location in the center of the Philippine's biggest island, this reflects a difference in the average per capita income level of the two provinces as well as in the income elasticity of demand for meat and fish in the Philippines as a whole (Figure 7.3)[94]. Meat has the highest income elasticity of demand for almost all income classes, showing first a sharp increase

94 Income elasticities of demand were estimated by comparing changes in expenditures for various food groups among different income classes for the year 1991, as provided in official statistics (NSO 1993). While elasticities should ideally be derived from regression analyses of time series data with proper consideration of other important variables (price of the item under study, prices of other relevant products), this was not possible due to lack of data. However, by concentrating on one year, the influence of price changes can be assumed to be eliminated.

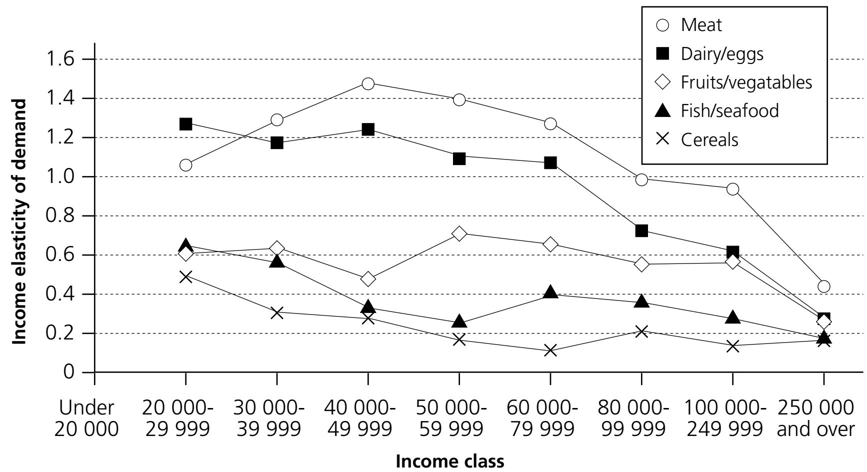


Figure 7.3. Income elasticities of the demand for food, Philippines 1991.
Source: Own computations based on NSO 1993.

and then a gradual decline, but remaining greater than one for all but the highest income class. With increasing income, demand for meat will thus rise over-proportionately. In contrast, income elasticities for fish and seafood range among the lowest of all food groups. They exhibit a decline even for the lowest income classes and are in the range of 0.6 to 0.2, indicating that demand for fish and seafood increases underproportionately with increasing income. Since average incomes in Nueva Ecija are considerably higher than in Antique (NSO 1993), this could be an additional explanation for the higher share of meat in animal protein foods in Nueva Ecija.

From the food consumption data, the share of aquatic organisms other than fish which can potentially be produced in ricefields (snails, frogs, shrimps, crabs, excl. fish) was estimated to be only between 4%and 6% of all animal protein foods. There is no significant difference between the two provinces. This low share indicates that the catch estimates of aquatic organisms reported in the previous section are probably too high. The average protein content of aquatic ricefield organisms is around 18% of the edible portion (FNRI 1990) and the RDA for protein is around 58 grams/day for an average adult in the Philippines (de Guzman et al. 1988). Assuming that this allowance is met and that half of the daily protein intake comes from animal foods, a share of 5% for aquatic organisms would amount to 1.45 grams of protein from aquatic organisms, corresponding to only 8.06 grams edible portion/person/day (catch data excluding fish resulted in a total of 15.26 grams edible portion/person/day). A possible explanation for this divergence is the fact that the food consumption monitoring concentrated on farmers while the previous section showed that more aquatic organisms are consumed by landless laborers.

A comparison of the diet composition of rice-fish farmers in the province of Nueva Ecija with the six members of the control group yielded the following results (Figure 7.4): rice-fish farmers showed a significantly higher share of animal protein foods and fruit in their diet than the control group. In contrast, they consumed significantly less energy foods and vegetables. Among the animal protein foods, rice-fish farmers had a significantly higher share of fresh fish in their diet than the control group, who consumed significantly more dried fish and eggs. Apparently, there is an overlap of two effects: the higher share of fresh fish in the diet of rice-fish farmers is at least partially due to the consumption of fish produced in their own ricefields because tilapia accounts for more than 21% of fresh fish consumed for the rice-fish farmers but only 3.5% for the control group. In addition, based on the

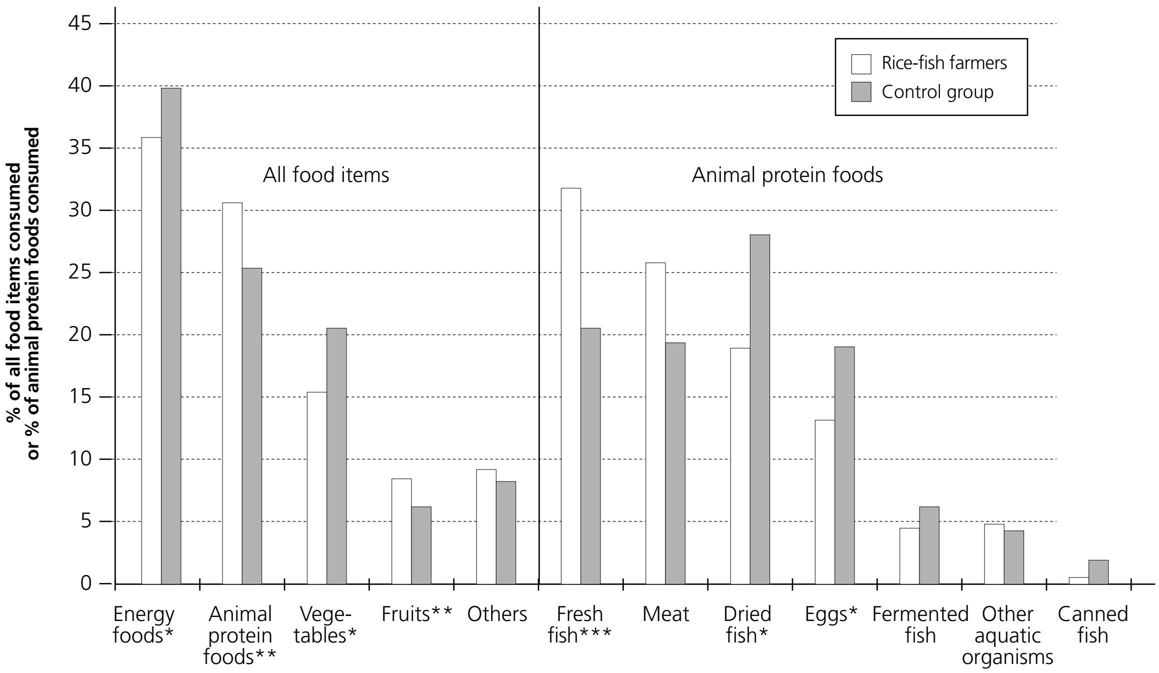


Figure 7.4. Differences in food consumption between rice-fish farmers and control group, Nueva Ecija, 1993-1994. Source: Own computations

income elasticities of demand reported above, the higher share of protein foods and fruit in their diet implies that rice-fish farmers have a higher income than the members of the control group. The question of whether this is a result of the rice-fish culture or whether only those farmers who could shoulder the risk associated with this technology were willing to culture fish i.e., farmers who had more financial resources to begin with, cannot be resolved because of the limited sample size.

An attempt was made to compare the quantities of food items consumed with the RDAs stated in the literature (de Guzman et al. 1988). For this purpose, it was necessary to convert quantities stated in different household measures (e.g. cups of vegetables; pieces of vegetables) to the specific unit used in the literature (cups, servings, pieces). A pragmatic approach was adopted which is based on the assumption that average serving size of comparable food items is the same, regardless of whether it is expressed in cups or in pieces. Thus, conversion factors were found by dividing average serving size in pieces by average serving size in cups. Sex- and age-specific RDAs were identified for each person in the sample and the average RDA for each group of respondents was computed. By comparing RDA and the amount actually consumed, the adequacy of consumption can be expressed in percentage of the RDA (Table 7.7).

Despite all inaccuracies in weight assessment and aggregation, several important conclusions can be drawn from these numbers. First, it becomes apparent that the nutritional situation in Antique is far from adequate—no food group reaches more than 70% of requirements and some only satisfy a small fraction of the RDA (meat, eggs, fruit). In contrast, requirements for energy foods, animal protein foods (fish/meat/poultry, excl. eggs) and other vegetables are almost exactly met in Nueva Ecija, with eggs, green leafy/yellow vegetables and vitamin C-rich fruits still above 50% of the RDA. Only the consumption of dried beans/nuts/seeds falls severely below the requirements. Particularly striking is the very low level of meat consumption in Antique, which to a certain extent is compensated for by a higher consumption of fish, so that the total consumption of fish/meat/poultry is still above that of the non-rice-fish group in Nueva Ecija. As seen in the consumption frequency analysis above, this latter group seems to be at a disadvantage compared to the rice-fish farmers. They eat less fish, meat, eggs and fruit than rice-fish farmers, but more energy foods, with roughly equal intake of vegetables and dried beans/nuts/seeds.

Table 7.7. Consumption, RDA (g/day) and percent adequacy for various food items.

	Antique	Nueva Ecija		
		Rice-fish	Non-rice-fish	Total
Energy foods (rice, bread, etc.)				
cups/day	4.10	6.17	7.64	6.60
RDA	6.22	6.43	7.02	6.60
% adequacy	65.92	95.98	108.88	100
Fish and aquatic organisms				
servings/day	1.16	1.26	0.75	1.12
RDA (fish & meat)	1.88	1.87	1.96	1.89
% adequacy	62.06	67.68	38.35	59.01
Meat				
servings/day	0.13	0.83	0.37	0.70
RDA (fish & meat)	1.88	1.87	1.96	1.89
% adequacy	6.73	44.28	19.09	36.83
Fish/meat/poultry				
servings/day	1.29	2.09	1.12	1.81
RDA	1.88	1.87	1.96	1.89
% adequacy	68.79	111.95	57.43	95.84
Eggs				
pieces/day	0.10	0.53	0.40	0.50
RDA	0.62	0.57	0.57	0.57
% adequacy	16.23	94.32	70.09	87.37
Dried beans/nuts/seeds				
servings/day	0.21	0.10	0.13	0.11
RDA	0.50	0.50	0.50	0.50
% adequacy	42.26	20.93	26.17	22.43
Green leafy/yellow vegetables				
cups/day	0.32	0.45	0.48	0.46
RDA	0.75	0.75	0.75	0.75
% adequacy	43.33	59.86	64.47	61.18
Other vegetables				
cups/day	0.35	0.53	0.41	0.50
RDA	0.50	0.50	0.50	0.50
% adequacy	69.50	105.93	81.75	100
Vitamin C-rich Fruits				
servings/day	0.29	0.77	0.55	0.71
RDA	1	1	1	1
% adequacy	29.20	77.34	54.68	70.87

Source: Own computations.

It can be concluded from this section that there is in fact a need to improve people's diets in remote, low income areas of the Philippines such as Antique province. These diets are deficient in everything, including animal protein. In the light of declining catches of marine fish and the deterioration of open access sources of aquatic organisms, the less than adequate intake of animal protein food in Antique could be amended by increasing the production of aquatic organisms from ricefields. However, it is not only the nutritional aspect which influences people's consumption habits. Preferences for different foods play an important role and many projects aimed at improving nutrition have failed because people did not like the product. The following section examines people's preferences for different types of fish with particular attention given to freshwater fishes that can be cultured in ricefields.

Preferences for different types of fish among women in Antique

The successful introduction of rice-fish culture systems in areas where predominantly marine fish is consumed, such as the province of Antique, requires the cultural acceptance of these freshwater fishes by local people. In order to assess people's preferences for different types of fish, a ranking of fish species was conducted among 39 rural women[95] from four villages[96] in Antique province (subsequently called the 'Antique fish preference ranking', see Appendix 3).

Each respondent was confronted with pictures of 20 fishes (14 marine, 5 freshwater, 1 brackish water) together with their local names (see Table 7.8 for the fish species included and Appendix Table A1.1 for local, English and scientific names of fish species). Only such freshwater fishes were included which could be caught or cultured in ricefields. Marine species were those commonly consumed in the province, as identified in the food consumption study presented above. In addition, the milkfish (*Chanos chanos*) was included because it is a very popular cultured fish in the Philippines.

First, respondents were asked to select all those fishes they were familiar with. These fishes would then be sorted according to the frequency of their consumption. Finally, respondents were asked to sort them according to their subjective preferences. They were also asked to explain what they liked and disliked about each fish species. While the first ranking (consumption frequency) was expected to be influenced mainly by the price and availability of fish species, it was hoped that the second ranking (subjective preferences) would only reflect people's taste. Since an unequivocal ranking of all 20 fishes could not be established, the respondents were asked to sort the fishes into as many classes as they felt necessary. In the analysis, these classes were assumed to represent intervals of the like-dislike continuum and the classification of each respondent was converted into scale values according to the following formula:

$$\text{scale value for class } i = [(100/\text{number of classes}) * i] - [(100/\text{number of classes})/2]$$

95 As Section 6.5 has shown, food acquisition and preparation is predominantly undertaken by women. They are thus expected to know most about different fish species and have the greatest influence on the choice of fish for the family meal.

96 The same villages were included as in the study of farming systems presented in Section 6.2, namely San Antonio, Igpalje and Palma in Barbaza and Catungan IV in Sibalom. The first two villages were also the sites of the time allocation and food consumption studies presented above.

For example, a grouping into five classes would yield 10% for the first class, 30% for the second class, etc. The resulting scale values can be compared across respondents, averages can be computed and a final result for all respondents can be obtained[97].

Analogous to the analyzed food consumption data the ranking procedure revealed that while the five freshwater fishes were known to most of the respondents (with the exception of common carp, *Cyprinus carpio*, which was recognized by only 9 of the 39 respondents), they were consumed least often and received the lowest preference ranks (Table 7.8). In the preference ranking, tilapia and common carp took the last two places. It is an interesting observation that wild fishes occurring in ricefields (cat-

Table 7.8. Ranking of fish species according to consumption frequency and preferences[98].

	Consumption frequency			Preferences		
Position	Fish species[99]	Scale value	N	Fish species	Scale value	N
1	yaito tuna	0.22	39	Spanish mackerel	0.24	36
2	fimbriated sardine	0.29	39	banded cavalla	0.30	35
3	Indian sardine	0.30	37	yellowfin tuna	0.33	39
4	common slipmouth	0.32	39	ribbon-finned nemipterid	0.34	37
5	anchovies	0.34	39	milkfish*	0.37	39
6	yellowfin tuna	0.38	39	yaito tuna*	0.37	39
7	ribbon-finned nemipterid	0.40	38	spotted moonfish	0.40	39
8	spotted moonfish	0.45	39	red snapper	0.47	27
9	short-bodied mackerel	0.47	26	short-bodied mackerel	0.50	26
10	banded cavalla	0.50	35	Indian sardine	0.54	37
11	milkfish	0.52	39	climbing perch*	0.56	37
12	Spanish mackerel	0.54	36	anchovies*	0.56	38
13	red snapper	0.55	27	blue-spotted sting ray	0.57	29
14	blue-spotted sting ray	0.61	29	fimbriated sardine*	0.60	39
15	speckled drepane	0.64	13	common slipmouth*	0.60	38
16	tilapia*	0.65	36	mudfish	0.61	37
17	mudfish*	0.65	37	speckled drepane	0.63	13
18	climbing perch	0.68	37	catfish	0.64	36
19	common carp	0.69	9	tilapia	0.65	36
20	catfish	0.71	36	common carp	0.73	9

Source: Own computations.
* = equal scale values for two consecutive fish species, both take the intermediate position.

97 Maxwell and Bart (1995) point out that ranking data follow an ordinal scale in which the distances between intervals is not known. If a ranking procedure is conducted according to several criteria (e.g., taste, price, availability), an adding-up of ranks to come up with an overall result is therefore not permitted. Instead, they propose to distribute a predefined number of points over the units to be ranked. In this case, however, averages were not computed over different criteria but over the ranking of criteria by different respondents. While this does in fact assume that each respondent created classes of approximately equal size (corresponding to an interval scale), it has been suggested in the literature (Kallmann 1979) that this assumption is valid if the whole range of possible judgments is included (very negative -very positive) and that differences in the actual size of the classes are negligible.

98 Low scale values stand for high consumption frequency and high preference whereas low scale values indicate the opposite. Average scale values were computed over the number of respondents who were familiar with the fish species, leading to varying numbers of respondents among species.

99 Please refer to Appendix Table A1.1 for local, English and scientific names of the fish species.

fish, mudfish, climbing perch) were valued higher than the cultured fishes. In rice-fish culture systems, these wild species would be eliminated as predators of the cultured species. The low rank of common carp both for frequency of consumption and preference is due to the fact that this fish is not very common in the Philippines. This poses a considerable constraint to the options in rice-fish culture (in China and Indonesia, the greatest successes in rice-fish culture have been achieved with common carp).

Discrepancies in the scale positions for consumption frequency and preferences occur under two conditions. On the one hand, a fish species can be consumed quite often without being favored by the respondents (such as in the case of the fimbriated sardine and common slipmouth with positions 2 and 4 on the frequency scale as compared to position 14.5 on the preference scale), or it can be highly valued but rarely consumed (e.g. Spanish mackerel and banded cavalla with positions 12 and 10 on the frequency scale but positions 1 and 2 on the preference scale, respectively). Reasons for these differences can most likely be found in the price and availability of the respective fish species. If the positions on both scales are equal for a fish species (regardless of where on the scale they are), it can be concluded that there is no large discrepancy between the preferred and actual amount consumed. This is the case for all freshwater fishes (except for climbing perch which has position 18 on the frequency scale but position 11.5 on the preference scale). Thus, respondents exhibited no desire to increase their consumption of these fishes.

The most frequently cited positive attributes of fish species relate to their taste, meat quality, (low) price, availability and freshness. In contrast, dominant negative properties concern the (high) price, unpleasant smell, size and number of fish-bones, non-availability and bad taste. A classification into marine and freshwater species showed that unpleasant smell was the most important reason for disliking the freshwater fishes, while it was less significant for marine fishes. In addition, many respondents claimed that freshwater species would eat waste or manure, which would make them less appetizing or even disgusting. Overall, more negative than positive attributes were found for freshwater fishes, while the opposite is true for marine species.

Chapter 8

Exploring complementarities between IPM and ALM

Before dealing with the income aspect of rice-aquaculture and IPM, another hypothesized effect of these technologies shall be discussed, namely the complementary relationship between IPM and ALM with its consequences for the environmental sustainability of rice production systems. This chapter builds on the conceptual framework introduced in Chapter 5. In Figure 5.7, a diagram was presented which can be used to describe the relationship between IPM and ALM based on farmers' proficiencies and skills in these two technologies. In the following sections, an attempt is made to operationalize this framework and to measure the degree of association between IPM and ALM for different groups of farmers. Due to the lack of integrated rice-aquaculture systems in the Philippines, it was decided to investigate only one of the possible relationships, namely the move from 'farmer-driven IPM' to ALM. It is hypothesized that growing skills in IPM lead to a simultaneous advance in ALM. For an empirical test of the impact of IPM-training on ALM-skills, several steps have to be accomplished. First, the axes in the diagram (Figure 5.7) have to be turned into measurable scales. Second, groups of farmers have to be identified who can be expected to differ from the conventional rice farmer with respect to IPM. Third, the position of these farmers on the two scales has to be identified and compared to that of conventional rice farmers. A simultaneous advance on both scales can be interpreted as lending support to the hypothesis, while progress on only one scale (or no significant change compared to conventional rice farmers at all) is equivalent to a rejection of the hypothesis.

Construction of scales for IPM and ALM

For the construction of measurable scales[100] for IPM and ALM, a combination of knowledge, attitude and practices (KAP) with regard to the respective technologies was considered most appropriate. KAP surveys have been used in extension campaigns (Contado 1997) and capture various levels of farmers' awareness and adoption of technologies. The scales thus reflect the three dimensions of farmers' knowledge, attitude and practices with regard to IPM and ALM, measured by different items which are combined to form a single index. The index value reached by each respondent

[100] In the theoretical context of empirical sociology, the difference between an index and a scale is not well defined. A scale can be interpreted as a special case of an index but there is no fundamental distinction. For the construction of a scale (e.g. Likert scale, Guttman scale), criteria exist which determine whether an item should be part of the scale or not. In contrast, an index combines several indicators into a new variable without considering such rules (Schnell et al. 1995). The following procedure thus describes, strictly speaking, the construction of indices for IPM and ALM.

represents its scale value or person score. Items were derived from the literature, from discussions with experts and from the training outline of IPM Farmer Field Schools in Antique province. A brief rationale for each item is provided in Appendix 7. The scoring procedure for each item is based on expert consultations and established research findings (Tables 8.1 and 8.2). The index was constructed without assigning any weights to individual items (a simple additive index, as recommended by Schnell et al. 1995). For each item, respondents could score a maximum of 1 point[101]. Thus, the scale value for one particular respondent should be understood as the sum total of all scores reached by this person.

Data collection

The selected items were converted into a questionnaire which combined the following elements:

- open-ended questions were used to ask for farmers' practices, reason for choosing those practices, farmers' knowledge about the ricefield ecosystem, observed effects of pesticides and farmers' experience with IPM;
- questions were asked in a closed manner only when it was felt that all possible alternatives were known; in that case, the respondent could choose between pre-formulated categories (e.g. sex of respondent; land ownership; source of water; planting methods);
- one set of questions consisted of statements related to pest management to which the farmers could either agree, disagree or not express any opinion. They were then asked to explain their answer;
- in addition, enumerators made their own observations on field characteristics.

The questionnaire was administered to 229 farmers (115 trained, 114 untrained) from 19 villages in Antique province in November 1993. IPM-FFS were conducted in Antique for the first time during the second crop of the crop year 1991/92; since then, there have been FFS in every cropping season. At the time of the survey, the FFS covering the first crop of crop year 1993/94 had just been completed. These latest FFS sites were not included in the survey because it was expected that the trained farmers had not yet implemented what they had learned.

Out of the 29 barangays[102] in which IPM-FFS had been conducted up to the first crop of 1993, 19 barangays were selected according to the following criteria:

- out of each municipality, at least two barangays should be included to account for differences in location factors; this was not possible in Tibiao and San Remigio since there had been only one FFS in these municipalities before the first crop of 1993;
- within each municipality, every season in which IPM-FFS had been conducted should be included in the sample; thus, if FFS had been conducted in more than two seasons in a municipality, there would be more than two barangays from this municipality included in the sample;
- if more than one FFS had been conducted in the same season in the same municipality, one or two of them would be randomly selected and included in the sample; the remaining sites would

101 In the development of a simple additive index, item scores should fall within the same range of values, otherwise weights are assigned indirectly to individual items (Schnell et al. 1995).

102 A barangay is the smallest administrative unit in the Philippines. In rural areas, a barangay is equivalent to a village, while in urban areas, barangays delineate certain districts within a town.

Table 8.1. Scoring procedure in the construction of a scale for IPM.

Indicator	Score
Use of insecticides	yes = 0 points no = + 1 point
Use of herbicides	yes = 0 points no = + 1 point
Use of molluscicides	yes = 0 points no = + 1 point
Application of insecticides during the first 30 days of the cropping cycle	yes = 0 points no = + 1 point
Use of rice straw	burn = 0 points don't burn = + 1 point
Use of organic fertilizer (other than rice straw)	yes = + 1 point no = 0 points
Use of 'old' rice varieties (before IR-60)	0 points
Use of 'new' rice varieties (after and including IR-60)	+ 1 point
Farmer's attitude towards the following statement: 'The use of chemical pesticides will increase rice yields'	disagree = + 1 point depends = + 0.5 points no opinion = 0 points agree = 0 points
Farmer's attitude towards the following statement: 'If the leaves are damaged early in the cropping season it is important to spray'	disagree = + 1 point depends = + 0.5 points no opinion = 0 points agree = 0 points
Farmer's attitude towards the following statement: 'There are enough natural enemies in the field to control the rice pests'	agree = + 1 point depends = + 0.5 points no opinion = 0 points disagree = 0 points
Expected yield loss if no insecticides are used	none = + 1 point little (<10%) = + 0.5 points much (>10%) = 0 points it depends = + 0.5 points
Farmer correctly identifies insects/spiders presented to him/her as harmful or beneficial	+ 0.25 points per pest + 0.33 points per beneficial organism[104]

103 Indicators refer to the first cropping season of the crop year 1993/94.

104 These are in fact two items: identification of pests and identification of beneficial organisms. The sample of insects presented to the farmers consisted of 4 pests (ricebug, leafhopper, stemborer, armyworm) and 3 beneficial organisms (spider, damselfly, ladybeetle). Identifying all pests was deemed equivalent in weight to identifying all beneficial organisms, and the complete solving of each item should score a maximum of one point, thus 0.25 points per pest and 0.33 points per beneficial organism.

Table 8.1, continued

Indicator[103]	Score
Farmer correctly describes the damage symptoms of the identified insect pests	+ 0.25 points per correct of description; -0.25 points if damage symptoms were assigned to beneficial organisms [105]
Farmer states 'resistance to pests' as a reason for choosing a rice variety	yes = 1 point no = 0 points
Farmer knows that pesticide applications are harmful to beneficial organisms in the field	yes = 1 point no = 0 points

Source: Own formulation.

be left out.

In each barangay, 6 trained and 6 untrained farmers were interviewed. Since the selected FFS had on average 26 participants, roughly 25 % of them could be covered which seemed to be a good basis for analysis. With 19 barangays and 12 farmers per barangay, the total sample size amounted to 229 (accidentally, one additional trained farmer was interviewed).

Trained farmers were selected at random from a list of all participants in the FFS. If the selected farmers were not available, others were chosen following the same procedure. Selection of untrained farmers was more difficult. Originally, it was planned that each trained farmer who was interviewed would introduce the enumerator to an untrained farmer whose field would not be adjacent to his field. It was presumed that exchange of agricultural information would take place in the field and that neighboring farmers could influence each other, so that the untrained farmer could not really be called untrained anymore. By having the randomly chosen trained farmers select the untrained ones, the total sample retained its random character.

The interviews were conducted in the farmers' fields. This setting of the interview had several advantages:

- the farmer and the enumerator walked to the field together which helped to create a relaxed atmosphere;
- the interview could focus on the particular field that was visited, therefore sources for misunderstandings were reduced;
- by seeing the enumerator's interest in the field, the farmers responded more willingly.

Fields selected had to be both riceland and irrigated. Farmers normally only had one field that fulfilled these two criteria. If they had more, they were asked if any of the fields was next to a fishpond or whether there was a deep trench in one of the fields. If none of them did, then the field that was

[105] This is the only occasion where respondents could score negative values. In all other cases, scores are in the range between 0 and 1 to avoid implicit weighing of items. However, there had to be a 'punishment' for assigning damage symptoms to beneficial organisms since this contradicts the fundamental principle of IPM. In the previous item, identification of a beneficial organism as harmful did not lead to the subtraction of scores, thus double counting is avoided.

easiest to reach was chosen.

A major part of the interviews dealt with farmers' knowledge about harmful and beneficial insects. It was felt that some visualization was necessary if the purpose was not only to find out how well the farmers had memorized the names of the insects. Therefore, each enumerator had a sample of five of the most common insects (ricebug, spider, ladybeetle, green leafhopper, damselfly) which were stored in little glass vials filled with alcohol. In addition, the pictures of insects which were either not available or were too big to fit into the vials (the adult stemborer and the larva of the armyworm) were obtained from a booklet (IRRI 1983).

The questionnaire was translated into Kinaray-a, the local dialect and administered on a one-to-one basis (one enumerator, one farmer). It was pre-tested in two barangays in the municipality of Sibalom, after which final adjustments were made. Interviews took on average about two hours.

Differences between trained and untrained farmers for individual scale items

As a first step in the analysis, the items selected for the construction of the scales were analyzed for differences between trained and untrained farmers. Data for all of these items are discrete or categorical variables (i.e., they can only assume a limited number of discrete values). The measurement scale for such variables is unrestricted (SAS Institute Inc. 1989a). The data can be represented in two-or multidimensional contingency tables and chi-square values can be computed which test for general association between the selected variable and whether or not the respondent has undergone training. In some cases it was necessary to combine data into broader classes since expected counts for individual cells in the original contingency tables were too small for the chi-square statistic to be reliable. Thus, the number of degrees of freedom differs among items. Several items consist of the number of correct or semi-correct answers given by the respondent. These items were converted to scores by assigning 1 point to correct answers and 0.5 points to semi-correct answers. Whether or not an answer is correct was evaluated with the help of expert judgment and the relevant literature.

Table 8.2. Scoring procedure in the construction of a scale for ALM.

Indicator	Score
Farmer has a pond or trench in his/her field	yes = 1 point no = 0 points
Farmer stocks aquatic organisms in his/her field	yes = 1 point no = 0 points
Farmer feeds aquatic organisms in his/her field	yes = 1 point no = 0 points
Farmer utilizes 6 aquatic key organisms for food, animal feed or as pest control agents	+ 0.167 points for every organism used (max. + 1 point if all organisms are used)
Reasons for non-use of aquatic organisms:	
– not using aquatic organisms for reasons other than pesticide use	0 points
– not using aquatic organisms because of pesticide use	+ 1 point

Table 8.2, continued

Indicator	Score
Farmer names aquatic organisms when asked for organisms living in the ricefield	+ 0.167 points for every organism named (max. 1 point)
Farmer knows that tadpoles are the babies of frogs	yes = 1 point no = 0 points
Farmer correctly describes the habitat of 5 key ricefield organisms:	0.33 points per correct answer (max. 1 point per organism)
Farmer correctly describes the diet of 5 key ricefield organisms:	0.33 points per correct answer (max. 1 point per organism)
Farmer states 'non-use of pesticides' as a way to preserve the aquatic organisms in the field	yes = 1 point no = 0 points

Sourece: Own formulations

Table 8.3. Practice-items of the IPM-scale: difference between trained and untrained farmers.

Item[106]	Dimension/ categories	Trained farmers (n = 115)	Untrained farmers (n = 114)	Difference
Use of insecticides	yes	21	71	***
	no	94	43	X^2 = 46.156
Use of herbicides	yes	70	92	***
	no	45	22	X^2 = 10.879
Use of molluscicides	yes	24	41	*
	no	91	73	X^2 = 6.418
Application of insecticides during the first 30 days of the cropping cycle	yes	6	24	***
	no	109	90	X^2 = 12.610
Utilization of rice straw (not burning)	yes	93	81	not significant
	no	22	33	X^2 = 3.023
Use of organic fertilizer	yes	15	10	not significant
	no	100	104	X^2 = 1.074
Use of 'old' rice varieties (before IR-60)	old	48	66	*
				X^2 = 5.977
Use of 'new' rice varieties (after and including IR-60)	new	67	48	

Source: Own computations.
*significant at alpha = 0.05; ** significant at alpha = 0.01; *** significant at alpha = 0.001.

106All items refer to the last cropping season.

Table 8.4. Attitude-items of the IPM-scale: difference between trained and untrained farmers.

Item	Dimension/ categories	Trained farmers (n = 115)	Untrained farmers (n = 114)	Difference
Farmer's attitude towards the following statement: 'The use of chemical pesticides will increase rice yields'	agree	24	59	
	disagree	59	25	***
	it depends/ no comment	32	30	$X^2 = 28.582$
Farmer's attitude towards the following statement: 'If the leaves are damaged early in the cropping season, it is important to spray'	agree	17	74	
	disagree	77	25	***
	it depends/ no comment	21	15	$X^2 = 63.210$
Farmer's attitude towards the following statement: 'There are enough natural enemies in the field to control the rice pests'	agree	107	80	
	disagree			***
	it depends/ no comment	8	34	$X^2 = 19.99$
Expected yield loss if no insecticides are used	none	80	34	
	little	8	15	***
	much	14	50	$X^2 = 41.081$
	it depends/ no comment	13	15	

Source: Own computations.
*significant at alpha = 0.05; ** significant at alpha = 0.01; *** significant at alpha = 0.001.

Table 8.5. Knowledge-items of the IPM-scale: difference between trained and untrained farmers.

Item	Dimension/ categories	Trained farmers (n = 115)	Untrained farmers (n = 114)	Difference
Farmer correctly identifies insects/spiders presented to him/her as harmful	1 or 2 points	7	10	not significant
	3 points	22	29	($X^2 = 2.237$)
	4 points	86	75	
Farmer correctly identifies insects/spiders presented to him/her as beneficial	0 points	2	17	***
	1 points	6	7	($X^2 = 26.760$)
	2 points	47	63	
	3 points	60	27	
Farmer correctly describes the damage symptoms of the identified insect pests[107]	≤ 0 points	7	18	not significant
	0.5 points	16	27	($X^2 = 12.429$)
	1 points	22	16	
	1.5points	26	18	
	2 points	24	17	
	2.5 points	10	12	
	≥ 3 points	10	6	
Farmer states 'resistance to pests' as a reason for choosing a rice variety	yes	27	10	**
	no	88	104	($X^2 = 9.140$)
Farmer knows that pesticide applications are harmful to beneficial organisms in the rice field	yes	92	84	not significant
	no	23	30	($X^2 = 1.284$)

Source: Own computations
* significant at alpha = 0.05, ** significant at alpha = 0.01, *** significant at alpha = 0.001.

107 Non-integer values because of semi-correct answers. Answers were judged to be partly correct if the respondent combined correct symptoms with wrong ones, or if symptoms of diseases were mentioned which are transmitted by the pest.

Table 8.6. Practice-items of the ALM-scale: difference between trained and untrained famers.

Item	Dimension/ categories	Trained farmers (n = 115)	Untrained farmers (n = 114)	Difference
Farmer has a pond or trench in his/her field	yes	5	5	not significant
	no	110	109	(X^2 = 0.000)
Farmer stocks aquatic organisms in his/her field	yes	5	1	not significant
	no	110	113	(X^2 = 2.703)
Farmer feeds the aquatic organisms in his/her field	yes	2	1	not significant
	no	113	113	X^2 = 0.329)
Farmer utilizes aquatic organisms for food, animal feed or as pest control agents				
fish	yes	105	108	not significant
	no	10	6	(X^2 = 1.038)
frog	yes	81	69	not significant
	no	34	45	(X^2 = 2.487)
edible snail	yes	112	105	not significant
	no	3	9	(X^2 = 3.22)
Golden Apple snail	yes	68	56	not significant
	no	47	58	(X^2 = 2.309)
crab	yes	112	111	not significant
	no	3	3	(X^2 = 0.000)
shrimp	yes	110	107	not significant
	no	5	7	(X^2 = 0.370)

Source: Own computations.
* significant at alpha 0.05; ** significant at alpha 0.01; *** significant at alpha 0.001.

Table 8.7. Attitude and knowledge-items of the ALM-scale: difference between trained and untrained famers.

Item	Dimension/categories	Trained farmers (n = 115)	Untrained farmers (n = 114)	Difference
Reasons for non-use of aquatic organisms	reasons other than pesticide use	102	103	not significant
	because of pesticide use	13	11	(X^2 = 0.167)
Farmers name aquatic organisms when asked for organisms living in the ricefield	0 named	31	27	not significant
	1 named	41	47	(X^2 = 0.813)
	2 named	23	22	
	3 named	12	11	
	≥ 4 named	8	7	
Farmer knows that tadpoles are the babies of frogs	yes	67	68	not significant
	no	48	46	(X^2 = 0.046)

Table 8.7, continued

Item	Dimension/categories	Trained farmers (n = 115)	Untrained farmers (n = 114)	Difference
Correct description of the habitat of 5 key organisms in the ricefield				
Frog	0-0.5 points	90	91	not significant
	1-1.5 points	25	23	(X^2 = 0.084)
Edible snail	0 points	22	27	
	0.5 points	31	24	
	1 point	53	54	not significant
	1.5-2 points	9	9	(X^2 = 1.406)
Golden Apple snail	0-0.5 points	27	34	
	1 point	54	57	not significant
	1.5-2 points	34	23	(X^2 = 3.003)
Crab	0-0.5 points	69	58	
	1 point	32	48	not significant
	1.5 points	14	8	(X^2 = 5.785)
Shrimp	0-0.5 points	25	19	
	1 point	78	75	not significant
	1.5-2 points	12	20	(X^2 = 5.952)
Correct description of the diet of 5 key organisms inthe ricefield				
Frog	0 points	20	27	not significant
	1-2 points	95	87	(X^2 = 1.390)
Edible snail	0-0.5 points	40	49	
	1 point	70	58	not significant
	2 points	5	7	(X^2 = 2.364)
Golden Apple snail	0-1 points	76	88	not significant
	2 points	39	26	(X^2 = 3.474)
Crab	0-0.5 points	28	28	
	1 point	68	72	not significant
	1.5-2 points	19	14	(X^2 = 0.868)
Shrimp	0-0.5 points	27	34	
	1 point	67	67	not significant
	1.5-2 points	21	13	(X^2 = 2.681)
Farmer states 'non-use of pesticides' as a way to preserve the aquatic organisms in the field	yes	96	85	not significant
	no	19	29	(X^2 = 2.748)

Source: Own computations.
* significant at alpha = 0.05; ** significant at alpha = 0.01; *** significant at alpha = 0.001.

This comparison of trained and untrained farmers gives a first indication of the impact of IPM-training on various aspects of crop and ecosystem management. It is quite apparent that the impact is most pronounced for issues relating to pest management, i.e. items included in the IPM-scale. Trained farmers use significantly less pesticides than untrained farmers. They avoid early-season spraying and oppose any notion of benefits from pesticide application. They do not expect to suffer great yield losses if no insecticides are used and believe in the regulating power of beneficial organisms in the ricefield, which they can identify much better than untrained farmers. Trained farmers know about varietal resistance against pests and select more modern varieties. However, they do not show any significant difference with regard to the use of rice straw or organic fertilizer. Harmful insects can be identified equally well by trained and untrained farmers.

On the other hand, there is a striking correspondence between trained and untrained farmers with regard to items included in the ALM-scale. No significant difference could be found for any of these items, in fact, the values are almost identical. Knowledge of the habitat and diet of aquatic ricefield organisms is equally prevalent among trained and untrained farmers. Items relating to the practice of ALM show that most respondents utilize aquatic organisms in ricefields but do not take any further steps for their culture or preservation. Only few farmers see pesticide use as a deterrent for their use of aquatic organisms, even though most respondents believe that one would have to discontinue the use of pesticides in order to preserve the aquatic organisms in the field.

Thus, while there is a general awareness of the negative impact of pesticides on aquatic ricefield organisms, this does not seem to be influenced by the IPM-training. It rather seems that the impact of IPM-training is limited to the management of rice pests[108]. However, this first step in the analysis only looked at differences for individual items between the groups of trained and untrained farmers as a whole. In contrast, the main research question relates to the association between IPM and ALM, two complex concepts for which a different analytical approach is required.

Analysis of the scales

IPM and ALM represent two very intricate systems of practices, attitudes and knowledge which cannot be adequately described or measured by a single indicator. In fact, there is still considerable debate regarding the definition and scope of IPM, and hardly any attempt has been made to define ALM prior to this study. The items discussed above and in Appendix 8 were selected to represent certain fractions of the overall concept of IPM or ALM as introduced in earlier chapters. To come up with an overall index which captures the essence of either IPM or ALM, the separate items have to be combined. For this purpose, the scale values for each individual farmer were determined following the scoring procedure described in Tables 8.1 and 8.2. By assigning scores to the selected items and adding them up, interval scale level is assumed[109].

---

108 It could also be argued that the negative impact of pesticides on aquatic ricefield organisms is so obvious that no special ecological knowledge is required to detect the relationship.

109 Various authors have pointed out the problems associated with this assumption (e.g. Mayntz et al. 1978; Diekmann 1996). However, the scoring procedure for the two scales can be interpreted as a 'solving' of items in the sense of the scale, similar to the solving of problems in a test (see Borg and Staufenbiel 1989). Scores are assigned according to the number of 'correct' answers. This interpretation not only justifies the assumption of interval scale level, it can even be interpreted as ratio scale level.

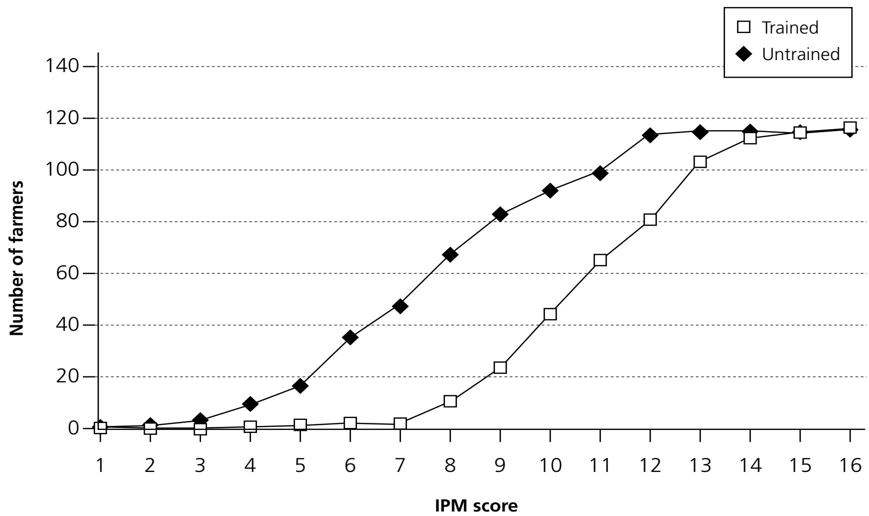


Figure 8.1. Cumulative frequency distribution of IPM-scores for trained and untrained farmers. Source: Own computations.

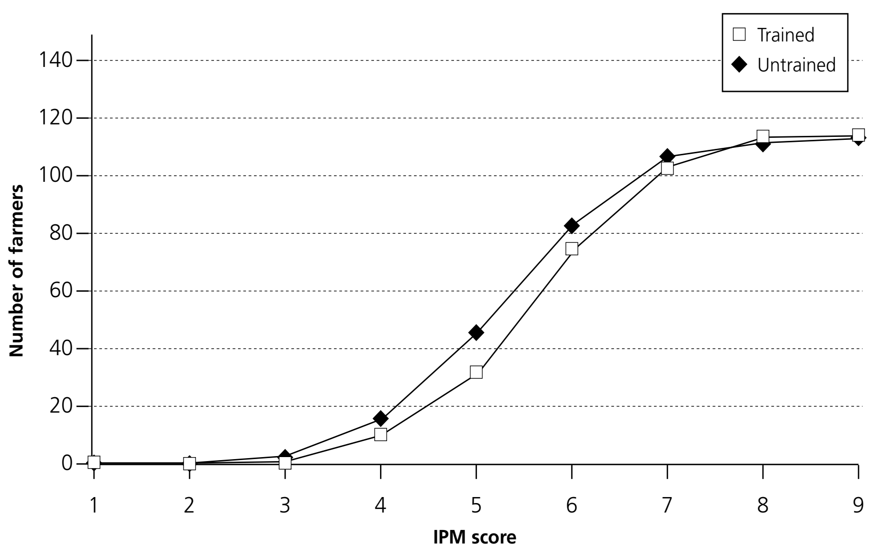


Figure 8.2. Cumulative frequency distribution of ALM-scores for trained and untrained farmers. Source: Own computations.

By graphing the cumulative frequency distribution of IPM-and ALM-scores for trained and untrained farmers (Figures 8.1 and 8.2) it becomes clear that while there is a considerable difference in IPM-scores for the two groups of farmers, no difference exists for ALM-scores. In order to test for the difference between means of IPM and ALM scores for trained and untrained farmers, a distribution-free test (the Wilcoxon rank sum test) was employed because the data set of IPM-scores is not normally distributed for untrained farmers[110]. While a clearly significant difference (alpha = 0.001) could be detected between trained and untrained farmers for values of the IPM-scale, no significant difference was found for the ALM-scale.

Up to this point, the analysis has shown that IPM training had no impact on ALM, neither for individual items of the ALM-scale nor for the ALM-index as a whole. However, there might still be an association between IPM and ALM within each group of farmers which is masked if scores for IPM and ALM are compared separately. Appendix 8 shows the scatterplot of IPM-and ALM-scores for trained and untrained farmers. In order to analyze this relationship, the correlation coefficient between IPM-scores and ALM-scores was determined for the two groups of farmers. As has been pointed out before, the subset of IPM-scores for untrained farmers is not normally distributed, thus the Spearman rank correlation was utilized. The analysis yielded an unexpected result: While no correlation between IPM and ALM was found for trained farmers (r = 0), the subset of untrained farmers produced a correlation coefficient of r = 0.30 at alpha = 0.0013. An interpretation of this finding is difficult within the conceptual framework employed in this study. It was hypothesized that IPM-training has a positive influence on ALM, but no causal effect was identified which explains the positive relationship among untrained farmers. One possible explanation suggests that there are always farmers who know more about the ricefield ecosystem than others. This is reflected in the positive correlation between IPM-and ALM-scores for untrained farmers. In the course of an IPM training, farmers increase their knowledge and skills in IPM but remain at the same level of ALM as before the training, which was high for some and low for others. Thus, an association can no longer be detected.

---

110 A test for normality was conducted by using the PROC UNIVARIATE feature of the SAS System (SAS Institute Inc. 1988) which led to a rejection of the normality hypothesis for untrained farmers at alpha = 0.06.

Chapter 9

Economic assessment of rice-aquaculture and IPM

At the farm-household level, income is probably the most critical factor for the choice of technology and enterprises, subject to other considerations such as those discussed in previous chapters. In this chapter, the income effect of rice-aquaculture is first analyzed by a simple comparison with rice monoculture. In the second part of the chapter, the effects of aquaculture integration and IPM on income, nutrition and other aspects of the whole farm-household system are simulated in the context of a linear programming model.

Partial analyses

Secondary data from various sources were compiled to come up with a preliminary assessment of the profitability of aquaculture in rice-based farming systems in several Asian countries. While many studies have analyzed the biophysical aspects of rice-aquaculture, only few studies have included economic indicators to assess the profitability of rice-aquaculture systems. Of these, the majority consists of a pairwise comparison of the situation with and without fish. The following studies are listed in chronological order. Their main results have been summarized in Table 9.1.

Campos (1985), in his review of Philippine rice-fish culture, reports a 47% increase in net returns of rice-fish culture compared to rice monoculture under experimental conditions (on-station experiments). Additional expenses for rice-fish culture are caused by the need for fingerlings and extra labor. On the returns side, rice-fish culture yielded an additional 250 kg of rice compared to rice monoculture (a yield increase of 7%), plus the returns from fish which here amount to 15% of total returns. However, additional capital costs for the construction and maintenance of dikes and trenches as well as for other initial outlays necessary for rice-fish culture are not considered in these computations[111].

[111] Campos reports that additional capital costs for the initial outlay of the rice-fish operation amount to US$ 68 (at 1984 prices). Assuming a useful life of 10 years and an interest rate of 12% (following Alsagoff et al. 1990 and Israel et al. 1994), this reduces the increase in net returns to a still impressive 44% compared to rice monoculture. However, this still does not include repair and maintenance costs of pond and trenches, which can be considerable.

Table 9.1. Profitability indicators of rice aquaculture systems, partial analyses.

Source/Author	Country/Environment	Indicator	Rice mono-culture	Rice-fish culture			% change [112]
				Wet season	Dry season	Total	
Campos (1985), own computations	Philippines irrigated, research station	Net returns (US$/ha) at 1984 prices	446			655	+47
Tagarino (1985), own computations	Philippines irrigated, farmers' fields	Net returns (US$/ha) at 1982 prices		554	649		
		Profits[113] (US$/ha) at 1982 prices		393	580		
Sollows and Thongpan (1986), own computations	Thailand, irrigated, farmers' fields	Net returns (US$/ha) at 1984/85 prices	160	-41	133	121	-24
Amaritsut et al. (1988), own computations	Thailand, rainfed a) farmers' fields b) research station	Net returns (US$/ha) at 1988 prices	a) 219 b) 128			a) 259 b) 173	a) +18 b) +35
Mang-umphan and Arce (1988), own computations	Philippines, irrigated, research station	Net returns (US$/ha) at 1986 prices				370-432	
Nie et al. (1992)	China, irrigated, farmers' fields	Revenues (US$/ha)					
		early crop	128			198	+54
		median crop	241			332	+38
		late crop	291			471	+62
Syamsiah et al. (1992), own computations	Indonesia, irrigated research station (*minapadi* system)	Rice yield equivalent[114] (kg/ha)	6619 115			7704	+16
Sevilleja (1992)	Philippines, irrigated, farmers' fields	Net returns (US$/ha) at 1987 prices	213			294	+27
Bimbao et al. (1992), own computations	Philippines, irrigated farmers' fields	Net returns (US$/ha) at 1977-79 prices	234			345	+47

112 Difference between rice monoculture and total rice-fish culture.
113 Total returns–total costs–opportunity costs of land and unpaid operator and family labor and management inputs.
114 Fish yield in rice yield equivalent = fish yield (kg) * fish price/rice price.

Tagarino (1985) studied simultaneous rice-fish culture production systems in parts of Luzon, Philippines, based on farmers' recalled input-output data. A total of 53 farmers in six provinces[115] were interviewed and data for the wet and dry seasons of crop year 1981-1982 were obtained. Even after deducting opportunity costs of land and unpaid operator and family labor and management inputs, profits per hectare from rice-fish culture amounted to US$393 and US$580 in the wet season and dry season, respectively. The harvested fish stock accounted for 26% and 30% of the gross returns in the wet and dry season, respectively. It is an interesting observation of this study that about 80% of the harvested fish were consumed by the operator's family, while the remaining portion was either given away or retained for farm use. Apparently, no fish were sold in the market.

Sollows and Thongpan (1986) investigated the economics of rice-fish culture and rice monoculture by field studies of six farms in the Lam Dom Noi irrigated area of Ubon, Thailand. On each farm, inputs and outputs of fields stocked with fish and unstocked fields were monitored by weekly visits to the participating farmers between June 1984 and June 1985. They report that all operations had reached the break-even point in rice-fish culture after one year. However, only in the dry season were net returns per hectare and per personday of rice-fish culture higher than those of rice monoculture. Overall profitability of rice-fish culture remained below that of rice monoculture, presumably because of the high initial investments in rice-fish culture (actual development costs are not reported).

Amaritsut et al. (1988), also in the northeast of Thailand, arrive at different results. They report an increase in net returns of 18% and 35% in farmers' fields and research stations, respectively, due to the presence of fish. Net returns in farmers' fields were generally higher than in research stations. However, they did not consider initial investment costs.

Mang-umphan and Arce (1988) describe an on-station experiment of fertilizer impact on rice-fish culture in the Philippines. Different fertilizer treatments (organic and inorganic) were applied to the fields stocked with Nile tilapia. No statistically significant differences with regard to fish growth, recovery and estimated total production were found among the treatments. Fish seem to be able to cope with lower nutrient input in the form of fertilizer, although it is often stated that nutrients are essential for sufficient primary production in the water (Diana et al. 1988). Net returns for the different treatments are in the range of US$370 to US$432/ha (at 1986 prices).

Nie et al. (1992) compared revenues from ricefields with and without stocked grasscarp (*Ctenopharyngodon idella*) under experimental conditions in farmers' fields in China. In three cropping seasons (early, median and late crop), revenues increased by 54%, 38%, and 62%, respectively, due to the presence of fish. However, since no data on costs are stated, these results cannot be directly compared to changes in net returns cited in other studies.

Syamsiah et al. (1992) summarize the results of experiments on rice-fish culture conducted at the Sukamandi Experiment Station in Indonesia. Only the results on minapadi (concurrent rice-fish culture) are reported here. According to their study, rice yield equivalent increased by 20% due to the presence of fish.

---

115 The originally intended sample size of 200 farmers in the Central Luzon area could not be achieved since most of the rice-fish farmers listed in a National Food and Agriculture Council (NFAC) report had long discontinued practicing rice-fish culture; the sample size for Central Luzon is, therefore, near complete enumeration of rice-fish culture in the area during the year of the study (Tagarino 1985).

Sevilleja (1992) reports a 27% increase in net returns from rice fish culture as compared to rice monoculture from on-farm data in the Philippines[116]. Although expenses are higher in rice-fish culture due to increased labor expenses and fingerling costs, this is more than compensated for by the additional income from fish.

The empirical foundation for integrated rice-aquaculture systems in the Philippines is weak, indicated by the small total area under such systems and the decline of cooperators in the national rice-fish program as described in Chapter 3. The most recent data on rice-fish culture in the Philippines are reported by Israel et al. (1994) who monitored 15 rice farmers and 15 rice-fish farmers in Nueva Ecija during the wet season of 1990 and the dry season of 1991[117]. They provide detailed tables on costs and returns which were used in this study to arrive at the basic economic parameters presented in Table 9.2.

Table 9.2. Economic parameters for rice monoculture and rice-fish culture, Nueva Ecija, Philippines, 1990-91 (in Pesos/ha)[118].

	Rice monoculture (n= 15)	Rice-fish culture (n= 15)	Difference[119]
1. Wet season 1990			
Variable costs of production[120]			
Rice	5 251.90	4 946.43	Not significant
Fish	-	2 451.82	
Total	5 251.90	7 398.24	**
Interest [121]	315.11	443.89	**
Labor costs (hired and family labor)	6 021.26	11 896.96	***
Fixed costs[122]	3 666	4 867.40	
Total costs	15 254.27	24 606.49	***
Gross returns			
Rice	21 343.81	25 185.58	Not significant
Fish	-	14 569.54	
Total	21 343.81	39 755.12	***

116 Data collected under the 1986 National Rice-Fish Culture Program. No information on sample size or study area available.

117 This dataset has already been employed for the description of labor requirements in rice and rice-fish culture in Chapter 6. In the Philippines, the farmers who are known to practice rice-fish culture are concentrated in the vicinity of the Freshwater Aquaculture Center of Central Luzon University (FAC/CLSU) in Nueva Ecija. These farmers have been studied repeatedly by various researchers. It was therefore decided to utilize the data collected by Israel et al. (1994) for the partial analyses instead of re-visiting the same farmers for own data collections.

118 PhP1 = US$ 0.038 in 1990/91 (FAO 1994).

119 * = significant at alpha = 0.05; ** = significant at alpha = 0.01; *** = significant at alpha = 0.001. No statistical tests were conducted for fixed costs because values are uniform across farms within seasons and for those cost and returns items which only apply to rice-fish culture

120 Labor costs are listed separately because no data are available on hired vs. family labor. For the purpose of these computations, it was assumed that all labor is provided by family members.

121 Opportunity costs for capital computed by multiplying the total costs of variable inputs (excluding labor) with the existing time deposit interest rate (12% per annum or 6% for a period of 6 months = one cropping season). Problems associated with using the formal interest rate are discussed further below.

122 Opportunity costs of land, pond repair and maintenance, pond depreciation.

Table 9.2, continued

	Rice monoculture (n= 15)	Rice-fish culture (n= 15)	Difference[119]
Gross Margin[123]	15 776.80	31 912.99	**
Net return[124]	12 110.80	27 045.59	**
Returns to labor[125]	2.62	2.68	Not significant
Returns to capital[126]	2.75	3.55	Not significant
2. Dry season 1991			
Variable costs of production			
Rice	6 493.90	6 895.98	Not significant
Fish	-	2 407.31	
Total	6 493.90	9 303.29	**
Interest	389.63	558.20	**
Labor costs (hired and family labor)	6 417.56	12 266	***
Fixed costs	3 738	5 368.65	
Total costs	17 039.09	27 496.14	***
Gross returns			
Rice	2 2457.54	31 891.19	*
Fish	-	15 358.11	
Total	22 457.54	47 249.30	***
Gross Margin	15 574.01	37 387.81	***
Net return	11 836.01	32 019.16	***
Returns to labor	2.43	3.05	Not significant
Returns to capital	2.33	3.55	*

In both seasons, rice-fish farmers exhibit significantly higher total costs but also higher returns than rice monoculture farmers. While variable costs for rice production are approximately equal for both groups of farmers, the most striking difference in cost components is evident for labor costs: rice-fish farmers use about twice as much labor (expressed in monetary terms) as rice monoculture farmers. They also incur higher fixed costs due to pond depreciation and pond repair/maintenance. Higher returns from rice (significant only for the dry season) and additional returns from fish lead to significantly higher gross margins and net returns for rice-fish farmers. However, by relating the returns to individual factors of production it becomes clear that only in the dry season is there a significant difference in the returns to capital. No significant difference could be found with regard to returns to labor. Thus, this study implies that especially labor in particular is not used more productively in rice-fish culture than in rice monoculture.

With the exception of Sollows and Thongpan (1986), all of the studies reviewed above conclude that based on a pairwise comparison of rice production with and without fish, rice-fish culture is a profitable operation. However, some cautionary remarks are called for. First, four of the ten studies

123 Gross margin = gross returns - (variable costs + interest). For the computation of gross margins it was assumed that all labor is provided by family members, thus labor costs were not included in variable costs.
124 Net return = gross returns - total costs (excluding imputed costs for family labor).
125 Returns to labor = [Gross returns - variable costs (excl. labor and interest)] / total labor costs
126 Returns to capital = (Gross returns - labor costs) / variable costs (excl. labor and interest)

are based on experiments conducted in research stations (Campos 1985; Mang-umphan and Arce 1988; Nie et al. 1992; Syamsiah et al. 1992) which can hardly be as a basis for conclusions arrived at for farmers' fields. Research stations operate under completely different constraints than farmers and will probably implement the recommended technology package, whereas dela Cruz and Montalvo (1993) found that among 15 farmers who practiced rice-fish culture in the Philippines, each had developed his or her own particular system. These systems are based on the availability of resources in the farm-household and reflect constraints and preferences of each individual farmer. Second, among the studies conducted in farmers' fields, at least two fall under the 'researcher-designed/farmer-managed' category (Amaritsut et al. 1988; Nie et al. 1992) where the technology package and inputs are provided by the researcher, often at no or low costs to the farmer. Subsidized inputs can induce farmers to change their farm plan for the duration of the project and thus lead to biased results. Third, the work with farmer cooperators often implies that the sample sizes of such studies are small (Sollows and Thongpan 1986; Israel et al. 1994) and results are not representative. Fourth, studies based on recall data (e.g. Tagarino 1985) do not produce very reliable data, especially if the recall period covers several months. Fifth, none of the studies can provide time series data, thus results cannot be generalized across years. Sixth, initial capital costs for rice-aquaculture systems are discussed separately in many studies (e.g. Campos 1985; Tagarino 1985) but are not considered in the computations of net returns. Other studies (Amaritsut et al. 1988; Nie et al. 1992; Sevilleja 1992) do not consider initial capital costs at all. Seventh, partial analyses exclude all interactions with other components of the farm-household system, such as competition for scarce factors of production during certain periods of the year, resulting in changes in the allocation of resources to other enterprises and/or activities, changes in cropping pattern and possibly changes in household food consumption.

In summary, these results have to be judged against the low adoption rates of rice-aquaculture systems in many of the countries where the studies were conducted (see Chapter 3). If a partial analysis of costs and returns concludes that rice-aquaculture is profitable, there must be other constraints which prevent farmers from adopting this technology. These constraints can only be detected in a whole-farm context which also accounts for the household as a unit of production and consumption.

Whole-farm analyses

Evidence from the literature

While most economic analyses of rice-aquaculture systems have been restricted to a pairwise comparison of rice with and without fish, there have been some attempts to model the integration of fish into rice-based farming systems.

Alsagoff et al. (1990) used a mixed-integer programming approach for an integrated poultry, multi-species aquaculture-rice system in Malaysia. A 2 ha rice farm was developed from Malaysian farm and agriculture data to study the feasibility of multi-species aquaculture and poultry integration. A new feature of this model is the introduction of ecological aspects in the form of food niche balances, prey predator ratios and species survival rates. However, rice production technology is not made explicit and only the 0.1 ha area that can potentially be converted to a pond is modeled. Therefore, linkages between pond and ricefield or other parts of the farming system are neglected.

Initially, the optimal integer solution yielded a negative income value. When the model was changed to assume that the pond would be built by the government free of charge, a positive income value was reached. The same was true for a situation in which interest-free loans were provided. This led to the conclusion that without government interventions, integrated agriculture-aquaculture as specified in the model is not very lucrative. However, a pond area of 1 000 m^2 is rather large compared to rice-fish systems described by other authors (dela Cruz et al. 1992) and construction costs may indeed be prohibitive. The model does not allow for smaller ponds which could be a viable alternative for small-scale farmers. In addition, a very intricate system of fish and shrimp species with high management requirements was chosen for the model formulation. Such a system is not applicable to the situation of small-scale farmers in most rural areas of Asia due to the lack of fingerlings and juvenile shrimps in most locations. Poultry housing units were designed for up to 100 grown birds or layers which is beyond the financial capacity of most rice farmers. The model results suggest that integrated agriculture-aquaculture at this level of technical refinement and complexity is no viable option for small-scale rice farmers.

Ahmed et al. (1992) used the linear programming (LP) technique to simulate the impact of rice-fish culture on a mixed farm in Central Luzon, Philippines. The model describes a 2.3 ha irrigated land which can be allocated to rice monoculture, fish monoculture or rice-fish culture with or without intercrops (mungbean, watermelon and cowpea). It accounts for subsistence requirements of the farm family by introducing minimum consumption values for rice, fish, mungbeans and cowpeas which can either be met from own farm production or purchase. The model was divided into wet season (July-December), interseason and dry season (January-June) to coincide with existing cropping seasons and to account for cash flow from one period to the next. Starting from a base model of rice monoculture with intercrops of mungbean, watermelon and cowpea, and rice-fish models initially with 1.5 ha farm area under rice-fish, several LP models were developed. The optimal farm plan derived from this initial rice-fish model chose the entire 1.5 ha available for rice-fish culture in the wet and dry season. As a result of this 1.5-ha rice-fish production, farm gross margin increased by 67% while farm requirements for cash and labor increased by 22% and 17%, respectively. In subsequent models, the maximum area available for rice-fish culture was varied to examine effects on farm gross margin, cropping patterns, resource allocation and production portfolio. Since no upper limits on labor and capital availability were incorporated in the model[127], optimal farm plans would always allocate the maximum feasible area to rice-fish culture. The maximum farm gross margin of US$ 3 406/year was realized when the entire 2.3 ha farm was devoted to rice-fish.

A typical problem in the interpretation of LP models is the lack of information on how activities and constraints in the model were defined. For example, Ahmed et al. (1992) do not specify why family labor availability changes over the course of the year. They also do not include alternative uses of family labor like off-farm or non-farm employment. Technical coefficients for crop activities are not specified so that no information is available on production technology and intensity. In their model, organic fertilizer use increases up to 10/ha with the expansion of rice-fish culture to the entire 2.3 ha farm, a rather extreme amount. On the other hand, rice output remains the same regardless of area under rice-fish culture. Linkages between farm enterprises are not made explicit apart from their competition for labor, land and capital. These shortcomings make it difficult to reach a final conclusion as regards the profitability of rice-fish culture in a whole-farm context.

---

[127] Informal credit and hired labor were assumed to be available in unlimited amounts at 20% interest rate and US$2 per person-day, respectively.

Israel et al. (1994) adopted a risk programming approach to assess the effects of output risk[128] on farm income and technology adoption. Fifteen farmers practicing rice monoculture on irrigated farms in Nueva Ecija, Philippines and 15 rice-fish farmers were monitored during the wet season of 1990 and dry season of 1991[129] and data were entered in a target MOTAD risk programming model of rice-fish culture on a 3 ha farm in Nueva Ecija. In this model, which falls under the category of ´safety-first´ models[130], a target income is specified and deviations from the target are measured and collected. A parameter is introduced which describes the level of compliance with the target income. This parameter can be interpreted as the degree of risk aversion of the decision maker. By varying this parameter, a set of efficient farm plans is obtained which, for any given level of compliance with the target income, have the maximum possible value of expected income (Hazell and Norton 1986).

In this particular case, net returns from rice monoculture and rice-fish culture of the 30 farmers were used to build the risk programming matrix. Since all costs (including opportunity costs of land and costs for family labor) had already been deducted from gross returns, the target was specified as net returns being equal to or greater than zero (thus realizing a profit). Risk, which in this model is the deviation from the target value, was measured in monetary terms. It was allowed to vary from 0 to 5 000 Pesos, at equal intervals of 500 Pesos. A deviation limit of 0 reflects a situation where the farmer is completely risk averse, i.e., he or she will only accept farm plans where the expected income does not deviate from the specified target value. The higher the deviation limit is set, the less risk averse is the farmer who chooses the resulting farm plans.

There are four production alternatives open to the farmer: leave the land idle, practice rice monoculture, practice rice-fish culture or adopt both rice monoculture and rice-fish culture. However, while there is a complete specification of the risk programming matrix, only the land resource is constrained in the model. Labor is assumed to be abundant and access to capital is unconstrained at the given interest rate. These assumptions (and others) were made necessary due to lack of data. But they are the reasons why the model does not capture the complex reality of small-scale rice farmers in the Philippines. In addition, there might be some computational errors in the model of Israel et al. (1994). Using the raw data provided leads to different results for net returns and, consequently, for the model.

The differences in the data sets render these results somewhat inconclusive. All that can be said is that rice-fish culture in the wet season is a more risky enterprise than rice monoculture but that, with decreasing risk aversion of the farmers, the incorporation of rice-fish culture in the farm plan results in higher expected net incomes. The overall higher relative profitability of rice-fish culture in the dry season, as indicated by the dry season farm plans, is regardless of data set used. However, mean net returns computed from the raw data indicate that production is generally lower in the dry than in the

---

128 Output risk was defined as the variability in the net income (which depends on rice and fish output) across the 30 farms used in the actual model.

129 This dataset has been used for the description of labor requirements of rice-fish culture in Chapter 6 and for a partial comparison of rice monoculture and rice-fish culture in the first part of this chapter.

130 Safety-first models' are designed to help a farmer insure that he attains a minimum income necessary to meet his fixed costs (including credit repayment), and to meet his family's living costs each year' (Hazell and Norton 1986). The maximization procedure is different from the profit maximization of standard LP models in that the output variability from certain activities is explicitly considered. Optimum farm plans can be computed for different levels of risk aversion. Risk aversion is measured as the accepted deviation from the target value (the minimum income that has been specified). For a more detailed description of safety-first models, see Hazell and Norton (1986).

wet season. This points to the problem of adequate water supply which might constrain rice-fish culture in many parts of the Philippines during that time of the year.

Each of the models presented above contributes an important part to the understanding of rice-aquaculture economics. While Alsagoff et al. (1990) concentrate on ecological processes in a polyculture environment, Ahmed et al. (1992) present the first attempt at incorporating household consumption requirements in the model formulation. Israel et al. (1994) have ventured to analyze risk in the context of rice-aquaculture systems. However, the economic investigation of these systems is far from complete. For the purpose of modeling, the farm household system is the level of choice because it is at this level that production decisions are made. Farm-household models such as those presented above need to be refined and adjusted to farmers' reality in different environments and situations. In particular, the nutritional aspects of rice-aquaculture and the linkages with other segments of the farm need to be considered, leading to the specification of a more comprehensive farm-household model. An attempt at such a model is made in the remainder of the chapter.

Own computations

The Linear Programming (LP) technique was chosen for the simulation of farm-household decision making with regard to the allocation of land, labor and capital under different technology options. The purpose of the LP model is to describe a typical rice-based farm-household in the irrigated lowlands of the Philippines and to demonstrate the impact of rice-aquaculture and/or IPM on farm-household income, resource allocation and on the nutritional situation of the household.

Mathematical structure

For a given farm situation the LP model requires specification of:

- the alternative farm and household activities, their unit of measurement, their resource requirements and any specific constraints on their production;
- the fixed resource constraints in the farm-household system;
- the forecast activity returns net of variable costs, hereafter called gross margins (Hazell and Norton 1986). It is also possible to single out the various components of the gross margin and to let buying activities (e.g., buying of seeds, fertilizer, pesticides, etc.) enter the objective function with the unit-price of the particular input bought. Correspondingly, sales activities (e.g., rice sales) can be expressed through the price received per unit of the particular output sold. This formulation leads to the maximization of total sales minus total purchases which has also been called the maximization of the annual farm gross margin (see Ahmed et al. 1992). Because of its greater flexibility, the latter formulation was employed for this particular study.

The general structure of a simple linear programming model is as follows:

$$\max z = \sum_{j=1}^{n} c_j X_j$$

such that

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i, \text{ all } i = 1 \text{ to } m$$

and

$$X_j \geq 0, \text{ all } j = 1 \text{ to } n$$

where

Xj = the level of the j^{th} farm activity, such as the acreage of rice grown. Let n denote the number of possible activities, then j = 1 to n.
c_j = the forecast gross margin of a unit of the j^{th} activity (e.g., dollars per hectare). Alternatively, cj can express the variable costs of production (which will enter the objective function as a negative value) or the returns per unit of output sold.
a_{ij} = the quantity of the ith resource (e.g., hectares of land or days of labor) required to produce one unit of the jth activity. Let m denote the number of resources; then i = 1 to m.
b_i = the amount of the i^{th} resource available (e.g., hectares of land or days of labor).

Contextual structure
The model depicts four technology options: (a) rice monoculture with conventional pest management; (b) rice-aquaculture with conventional pest management; (c) rice monoculture with IPM; and (d) rice-aquaculture with IPM. It is the objective of the farmer to maximize annual household income[131], subject to a number of constraints which can be classified into land, labor and capital constraints, plus a number of special constraints for individual activities which are explained in detail below. Activities and constraints are either formulated on a monthly basis or for one of two cropping seasons plus a fallow period (see below).

Based on the discussion of farming systems in Chapter 6, two different production environments were identified which can be regarded as typical cases of irrigated rice production in the Philippines. On the one hand, there is a relatively remote, more subsistence-oriented rural environment, represented by farms in the province of Antique. On the other hand, a relatively more market-oriented environment is represented by farms in the province of Nueva Ecija. These two environments have been found to differ with respect to the size of farms (larger in Nueva Ecija) and households (larger in Antique), the number of rice crops per year (two to three in Antique, two in Nueva Ecija), the prices for external inputs (higher in Antique) and for outputs (higher in Nueva Ecija)[132], prices for food commodities purchased in the market (higher in Nueva Ecija), and off-farm employment opportunities and wages (higher in Nueva Ecija). In the model formulation, the situation in Antique is taken as the starting point to analyze the role of rice-aquaculture in integrated farming systems[133]. In order to simulate the move towards greater market integration, the situation in Nueva Ecija is approximated in subsequent runs by modification of the relevant parameters, as explained below. Production

131 The objective function value in this model is defined as household gross margin (= farm gross margin plus income from off-farm activities) net of food expenses and pond annuity, see further below.
132 Because of its proximity to Manila, Nueva Ecija supplies most of the rice requirements of the metropolis. Farm gate prices of rice are higher than in the other regions of the country and input prices are relatively lower. Thus, it is more profitable to produce rice in commercial quantities in Central Luzon than in any other region of the country (Rola and Pingali 1993).
133 All prices for inputs and outputs pertain to the crop year of 1993/94.

technology for rice and rice-aquaculture is assumed to be equal in both environments[134]. Even though a difference in seasonality of cropping seasons was found among the two provinces (see Chapter 6), they were made uniform in the model to avoid confusion. While some farmers in Antique can grow three crops of rice per year, this is not typical for the Philippines as a whole. The most common cropping pattern in the Philippines is rice-rice with a fallow period in the dry season (David et al. 1994), which was the cropping pattern selected for the model formulation. The cropping seasons have been defined as follows:

- first crop: June -September;
- second crop: October -January;
- fallow period: February -May.

While potentially a number of other crops can be grown in the second and third cropping (mungbeans, peanuts, onions, watermelon, etc.), these options are not considered in the model since they do not directly relate to the main research question. It is assumed that apart from the backyard garden, all land is grown with rice or left fallow.

The model farm was a fully irrigated 1.7 ha riceland. Originally, the model contained an option for renting additional land on a seasonal basis. However, this option was later excluded since discussions with farmers revealed that land rent is usually not possible on a short notice due to the growing scarcity of land. If land is rented, the contract is made well in advance. Therefore, the area of land available to each farmer has to be seen as fixed for the one year period the model is designed for.

Household size was defined to be six persons, consisting of husband and wife (both in their mid-forties), two daughters aged 10 and 14 and two sons aged 12 and 16[135]. All household members contributed to the total amount of family labor available for farm and household production; however, certain activities could only be performed by men and others were predominantly performed by women (see Chapter 6). Children can helped with routine activities and during labor peaks (weeding, replanting). They are assumed to be less efficient than adults, thus the effective working time of one hour of child labor input was estimated to be only 0.5 hours. The requirements for particular types of family labor were specified in the respective activities (see Appendix Table A9.1).

The time allocation study presented in Chapter 6 has shown that adult men spend an average of six hours per day on income-generating activities. This was defined to be the average working time that adult men are willing to supply. However, to allow for seasonal differences in the work load, a maximum of seven hours per day per adult man (husband and eldest son) was assumed to be available. In contrast, the wife could only devote three hours per day to income-generating activities since the rest of her time was already taken up by household chores which were not made explicit in the model. While the time allocation data were collected for all days of the week and thus make no

---

134 Equal production technology stands for equal steps of production, equal type and amount of inputs used and equal yield (= equal input-output relationship). With respect to the formulation of production technology, the model is a hybrid of the two provinces, based on data availability.

135 The specification of sex and age of the household members is important for the formulation of food and nutrient requirements as well as for the assessment of available family labor. The age of husband and wife was estimated based on the average age of farmers observed in the Antique IPM/ALM survey; the age of the children was spread over the child-bearing age of the wife (older children are assumed to have left the household already).

difference between weekdays and weekends, the model allowed for a free Saturday afternoon and Sunday by reducing the maximum number of working days to 24.5 per month[136]. The three youngest children were assumed to go to school and only available for farmwork during weekends and holidays (approximately four days per month each).

For certain activities, hired labor can be employed at the prevalent wage rate in unlimited amounts. The only limiting factor is the amount of capital available to the farm family. As long as the opportunity costs of family labor are below or equal to the farm labor wage rate, the model will first exhaust all family labor resources before employing hired labor. Hired labor is assumed to be less efficient than family labor due to transaction costs associated with the employment process. This is expressed by a smaller-than-one technical coefficient for hired labor input (i.e., the effective working time for one unit of hired labor is only 0.9 units, implying a loss of 10% due to transaction costs). Certain activities such as plowing and leveling are assumed to be always conducted by hired labor because they involve the use of a handtractor or a carabao, both of which the model farmer did not own. These activities require some family labor for organization and supervision purposes.

In every month, family members could earn off-farm or non-farm income to a certain extent; if this option was realized, it took away some of the time available for farmwork. Because of the great variation in the off-farm income realized and in the opportunities of individual farmers to earn off-farm income, this will only be dealt with on the side. Based on the results of the time allocation study, adult men (i.e., husband and eldest son) spent on average 2.5 days per month in off-farm or non-farm activities each, while women could find 2.7 days of gainful employment[137]. Since off-farm or non-farm employment opportunities are scarce in rural areas, these values defined the maximum time that can be allocated to off-farm or non-farm activities. The off-farm or non-farm income earned in any particular month added to the cash balance of the following month (see below).

Capital was available from own funds or credit. Own funds available at the beginning of the model period were estimated to be PhP10 000. Farmers in Antique had frequently claimed to possess around PhP4 500/ha at the beginning of the first cropping. This value, however, which would come to PhP6 800 for 1.7 ha, was only meant to cover farming expenses. Since this model included consumption requirements which had to be met at least in part from food purchases, an allowance had to be made for these additional expenses. Furthermore, the higher value for own funds accounted for income derived from sources not considered in the model during the fallow period.

Credit could be obtained through formal or informal sources at different interest rates[138]. There were limits as to how much credit a farmer could get. It was assumed that farmers have access to

136 If one working day is defined as having eight hours, husband and eldest son can contribute 21.4 working days per month each; the wife can contribute 9.2 working days per month. No difference was made between months.

137 Seasonality of non-farm or off-farm employment is not considered due to lack of data. The wage rate for both men and women was equated with the prevalent wage rate for hired farm laborers, i.e. PhP50/day.

138 Information on credit was obtained through key informant interviews in one village in Antique. While there are certainly differences in the credit conditions among villages and provinces, the general features—limited formal credit at low interest rates, high interest rates on informal credit —can be assumed to be the same everywhere in the Philippines.

formal credit through a farmers' association during the first and second cropping[139]. They could obtain a maximum of PhP4 500 per hectare, which had to be repaid after six months (at the latest). In the model it was assumed that they repay the credit plus interest at the end of the cropping season (after four months), as is common practice in Antique. The whole amount was only available at the beginning of the cropping season. Interest rates were 1.25%[140] per month. Informal credit is available from neighbors, relatives, businessmen and other sources at 10% interest per month[141]. The credit limit was set at PhP4 000. PhP3 100 was available at the beginning of the cropping season and PhP300 for each of the following three months[142].

Cash balance rows described the use of the farmer's funds at the beginning of each month as well as for each of the two cropping seasons and the fallow period. Money was taken out of the cash balance rows through buying activities or the payment of hired labor; money entered the cash balance rows through sales, off-farm income or credit. Any surplus of cash could be transferred to the next period. The sales in each period originated from crops produced in the previous period. In addition, an own fund maintenance row was introduced to make sure that at the end of the year, all credit including interest was repaid and the farmer had at least as much money left over as he or she had at the beginning of the three periods.

Monthly balance rows were introduced for cash and labor as well as for all crops and animals produced in the farm. While cash and labor balances ensured that requirements did not exceed the available resources, crop balance rows were responsible for the balance between production, purchase and initial stocks on the one hand and consumption, sales and final stocks on the other hand. Any surplus of rice and/or cash at the end of the month was transferred to the next month. The storage of rice was connected with losses, thus 10% of the rice was lost during a transfer activity. In the first month of the model period, the family was assumed to have enough rice to cover their own consumption requirements (plus a small amount for contingencies) until the next harvest, amounting to 500 kg or around

---

139 No formal credit is available during the fallow period due to scarcity of funds.

140 While this seems to be a relatively high interest rate for formal credit, it corresponds to the practice of farmers' associations to charge some additional interest from their members for the accumulation of own capital.

141 Interest rates for informal credit vary widely. In Antique, borrowing money from friends, neighbors, businessmen or relatives at 10% interest per month is the most common and cheapest source of informal credit. In addition, there is an informal credit arrangement called 'alili' which requires that for every PhP100 borrowed, one cavan of rice (42 kg) or PhP220 has to be repaid after the harvest (i.e., after a period of three months). This implies an interest rate of 40% per month. The most expensive source of informal credit encountered in Antique is based on a scheme called 'five/six'. It demands that for PhP500 borrowed, PhP600 have to be paid back after 1 week, thus raising the interest rate to an impressive 20% per week. In some parts of the Philippines (e.g. Manila, Baguio City), 'five/six' is even implemented on a daily basis. This source of informal credit is predominantly used by traders who borrow money for their daily transactions and repay the amount plus interest at the end of the day, when all market transactions have been completed. These more expensive sources of informal credit have been excluded from the model because preliminary runs have shown that even the cheapest source of informal credit is hardly ever utilized.

142 While there is no strict limit to the amount of informal credit a farmer can get, it is unrealistic to assume that it is available in unlimited amounts. If a farmer has already taken up informal credit to a certain extent, people will become more and more reluctant to lend him or her additional money. The informal credit limit used in the model was declared to be realistic by key informants in Antique. In the fallow period, only PhP300 of informal credit is available per month since there is no harvest with which to repay greater amounts.

twelve sacks of rough rice[143]. Thus, at the end of the model period, the same amount of rice was retained for the next cropping season through a year-end rice balance.

In addition to the riceland, the model farm consisted of a small backyard garden. Backyard gardening was defined as the production of fruit and vegetables for own consumption. Since most farmers were not able to provide detailed production data for the individual production processes involved, backyard gardening has been aggregated to form one single activity. The backyard garden activity was based on an average homestead size of 600 m^2 as reported in Chapter 6. Only labor requirements were considered because capital inputs are assumed to be negligible. The average time spent in the backyard garden was derived from the time allocation data presented in Chapter 6. The time spent by men in the backyard garden was multiplied by two to account for two adult men as defined in the model family. A total labor input of 33 minutes per day over 24.5 working days lead to an average labor input of 1.7 days per month (seasonality was neglected). Because of the wide variety of crops grown in the backyard, the model was based on the assumption that the family produces an amount of fruit and vegetables equivalent to that reported in the food consumption study (see Chapter 6)[144].

The farm family was assumed to own one pig and raise up to nine chickens for meat and eggs (see average livestock numbers in Chapter 6). A piglet was bought at the beginning of the model period and sold after six months; a new piglet was bought immediately afterwards and sold at the end of the model period. In the first month of the model period, the farmer was assumed to own nine chickens which he or she could either keep for eggs, sell or consume. A chicken was assumed to lay three eggs per week and weigh 1 kg when sold. Eggs could be consumed or sold; additional chickens could be purchased to replace those that were consumed or sold, but not more than nine chicken could be kept at the same time[145]. Both animal husbandry activities required family labor as their main input. However, since no other livestock was included in the model formulation, the labor input as reported in the time allocation study was certainly too high. As a rule of thumb, it was estimated that one chicken requires five minutes of labor input per day while a pig requires at least 20 minutes for feeding, cleaning and other care activities. The animals were fed with rice bran which was either purchased or produced on-farm. A chicken was assumed to consume on average 50 grams of rice bran per day while the rice bran consumption of the pig was adjusted to correspond to approximately 5% body weight per day (computed on a monthly basis, reaching a total body weight of 100 kg after six months).

---

143 Minimum consumption requirement for a family of six, as specified above, is 71.68 kg of milled rice (see also below). For a period of four months, this amounts to 286.72 kg of milled rice or 422 kg of rough rice at a milling recovery rate of 68%. About two sacks of rough rice (42 kg per sack) are kept for contingencies.

144 The amount of fruit and vegetables produced in the backyard garden was estimated based on the percentage adequacy of the recommended dietary allowance identified for fruit and vegetables in the food consumption study. By computing the RDA for the whole family and taking the reported percentage adequacy, the quantity of fruit and vegetables produced or exchanged from neighbors for own produce was determined.

145 This limitation was made necessary by the simplified formulation of the chicken enterprise. Preliminary runs with unrestricted numbers of chickens resulted in flocks of 180 and more birds, with all family labor engaged in fowl raising, since only few cost components are considered in the model. It was therefore decided to set an upper limit to this very extensive poultry enterprise corresponding to the average number of chickens kept by farmers in Antique (see Chapter 6).

Taken together, these activities and constraints formed the skeleton of the model. They described the general framework in which small-scale rice farmers in the Philippines operate. In addition, the model consisted of four contextual blocks, all were interrelated. While each block will be described in detail in the following sections, a brief overview is given here.

The first block contained the basic features of rice production by small-scale farmers in irrigated areas in the Philippines. An additional block described the nutritional situation of the household. It was based on minimum and maximum consumption requirements for certain foodstuffs and nutrients which could be satisfied through own production or through purchase of food in the market, the latter option leading to competition for scarce cash resources[146].

In order to depict the different technology options (with aquaculture, with IPM, with both aquaculture and IPM), the model contained two blocks with special activities for aquaculture and IPM, respectively. These blocks consisted of activities which only became relevant if the particular technology was practiced. Both technologies have an influence on the way rice is produced; therefore, the coefficients in the basic rice model have to be adjusted accordingly.

Table 9.3 presents an overview of the four blocks and their main components, all of which will be discussed in the following sections.

Table 9.3. Activity blocks of farm-household model with rice-aquaculture and IPM.

1. Basic rice	2. Nutritional component production component	3. Special rice-aquaculture	4. Special IPM component
Breakdown of rice production in individual tasks	Definition of a typical diet	Pond construction, field modification and maintenance	Changes in rice production technology (elimination of pesticide use)
Specification of material and labor requirements	Nutrient composition of items included in the diet	Buying of fingerlings (for snails)	Use of certified input seeds
Allocation of family labor and hired laborers for particular tasks	Minimum and maximum consumption limits for nutrients and groups of food items included in the diet, based on the model household composition	Stocking, feeding, catching of fish	Use of alternative control methods
Purchase of inputs	Purchase or own production of various foodstuffs[148]	Changes in rice production technology (water management, pest management).	Reduced health costs
Use of own inputs (seeds)	Consumption of various foodstuffs	Sale or consumption of fish[149]	Greater availability of aquatic organisms in the field.
Consumption or[147] sale of output			

146 This formulation necessitates a change in the interpretation of the objective function value. While it has previously been described as household gross margin, it now has to be called household gross margin net of food expenses. Thus, the amount of money left over at the end of the year can be used for other purposes and does not have to take food expenses into account.
147 Consumption of rice is part of the nutritional component of the model.
148 Production of foodstuffs is part of the basic farm household activities (backyard gardening, pig and poultry raising), of the rice production activities or of the special rice aquaculture activities.
149 Consumption of fish is part of the household health and consumption component.

Basic rice production component

Rice production enters the objective function as a single activity. The objective function coefficient for the rice production activity is zero. However, this activity is linked to other activities with non-zero coefficients in the objective function[150] by breaking it down into the various steps of production, i.e., land preparation, crop establishment, fertilizer application, pesticide application, weeding, field observation, harvesting and threshing. Each step of production requires certain amounts of labor (see Appendix Table A9.1) and material inputs (seeds, fertilizer, pesticides, labor, animal days, machinery etc.). Inputs are either bought at local prices which were prevalent in 1993/94 (see Appendix Table A9.2) or they can be produced on-farm (seeds).

Rice seeds can be bought or they can be taken from last period's harvest. Bought seeds are assumed to be certified seeds which command a higher price than rough rice for consumption. If own seeds are used, they are taken out of the rice stocks which are available at the beginning of the period. The use of own seeds has an objective function coefficient of zero; it only has an indirect influence on household gross margin by reducing the amount of rice available for sale (as well as by reducing the need to buy rice seeds). Even though the model allows for both sources of seeds, the formulation implies that conventional rice farmers predominantly use their own seeds[151]. The use of purchased seeds is discussed in the IPM-component below. The seeding rate is defined to be 150 kg/ha in both cropping seasons, based on data provided by Israel et al. (1994), Quintana et al. (1991a) and own observations.

Fertilizer is applied in mineral form at the following rates per hectare: 80 kg N, 20 kg P_2O_5 and 10 kg K_2O in the first cropping season, and 95 kg N, 30 kg P_2O_5 and 12 kg K_2O in the second cropping season (based on Israel et al. 1994 and IRRI data set). Fertilizer applications are higher in the second crop than in the first crop because too much fertilizer increases the danger of lodging in the wet season. To satisfy these nutrient requirements, five mineral fertilizers with different nutrient composition are available, namely urea (46% N), ammonium sulphate (21% N), ammonium phosphate (16% N, 20% P_2O_5), muriate of potash (62% P_2O) and a compound fertilizer (14% N, 14% P_2O_5, 14% K_2O). Local prices for these fertilizers are presented in Appendix Table A9.2. Fertilizer is applied in two doses, one in the second and one in the third month of each cropping season.

Under conventional rice production technology, the farmer is assumed to apply molluscicides and herbicides once and insecticides twice per cropping season. From the Antique IPM/ALM survey it was found that endosulfan (brand name Thiodan) was the pesticide most frequently used for snail control, even though it is registered as an insecticide. The most common herbicide was pretilachlor (Sofit), while for insecticides endosulfan (Thiodan) and methyl-parathion (Fosferno) were mentioned most often. Local prices for these pesticides are presented in Appendix Table A9.2. The application rate was assumed to be 1 liter/ha for all chemicals, as is common practice in the Philippines (own computations based on Rola and Pingali (1993 and ADB 1987).

---

150 Buying inputs, hiring labor: negative coefficient, cost of buying this input. Selling output: positive coefficient, price received.

151 Results of informal interviews with a number of farmers in the Philippines have shown that conventional rice farmers only occasionally purchase certified seeds. If farmers want to try a new variety which they haven't grown before, they will often turn to other farmers for seeds (which for the model is equivalent to using own seeds since the price of seeds from other farmers is equal to the sales price of rice). In addition, small amounts of new seeds are sometimes distributed by the Department of Agriculture for free.

Rice yields were defined to be 3 600 kg per hectare in both the wet season and the dry season, corresponding to own observations as well as to average values for irrigated farms in Antique as reported by David et al. (1994) and Arano et al. (1992) with the use of modern rice varieties.

While there is no seasonal variation in the prices for agricultural inputs, prices for rice differ between seasons. They are usually higher in the dry season because of the lower moisture content of the rice. In addition, during the fallow period and before the harvest of the first crop, most rice stocks have been exhausted which again drives the prices up (see Appendix Table A9.3 for the monthly price development of rough and milled rice in Antique between 1992 and 1994). This price development was considered in the model by adjusting the price coefficients for rice accordingly. Since the price development for wet and dry rough rice is almost identical, the average of both prices was chosen in the model formulation to allow for variations in the moisture content.

Nutritional component

In most models of farms and agricultural systems, only the production side of the farm-household complex is considered. However, in this study it was hypothesized that rice-aquaculture has a positive impact on household nutrition, both through its income effect as well as through the increased availability of fresh fish. In order to simulate these effects, the model was augmented by a nutritional component based on recommended dietary allowances (RDAs), maximum and minimum consumption requirements for different groups of food items (rice, meat/fish, eggs, vegetables, fruits, etc.) and nutrients (energy, protein, calcium, iron, vitamin A, vitamin C) reflecting the composition of the household (see Appendix Table A9.5 and A9.6).

Minimum and maximum consumption levels were defined as nutritional constraints in the model, representing the idea of a balanced diet which is allowed to vary within tolerable limits. Both food item groups and nutrients were considered in the formulation of requirements to arrive at a certain degree of variety in the diet and to comply with other nutritional criteria which cannot be captured by nutrient supply alone (de Guzman et al. 1988).

To meet these requirements, 30 food items were selected which are part of a typical diet in both provinces, as became evident in the food consumption study discussed in Chapter 7. For each of these food items, the nutrient composition is listed in Appendix Table A9.7. With the help of this information, a combination of food items can be identified which fulfills all nutritional requirements at minimum costs[152].

The necessary food items can be bought in the market and some of them can be produced in the own farm or backyard garden. Backyard garden productivity was estimated from food consumption data, based on the assumption that the amount of beans, nuts, root crops, fruit and vegetables actually

152 This, of course, is a rather simplified approach to food consumption. It neglects all aspects of preferences for different types of food, cultural or traditional significance of certain food items, as well as inequalities in intra-household food consumption. Seasonality is only considered to a limited extent. The resulting diet is likely to exclude important food items, especially more expensive ones which are nonetheless consumed on special occasions. Furthermore, the food consumption study discussed in Chapter 7 has shown that the diet of farmers is hardly ever balanced but exhibits some important deficits. Thus, the diet composition determined by the model is not very likely to be accepted by household members. However, with regard to the main research question, these simplifications seem warranted. The model identifies minimum monthly food expenditures needed for a balanced diet as well as the change in food expenditures if rice- aquaculture is introduced.

consumed in the households was produced in own garden or exchanged from neighbors for own produce (see Appendix Table A9.9). Some of the selected fruit and vegetables exhibited a marked seasonality which limited their production in the backyard garden to certain months (see Appendix Table A9.8). Thus, the model reflects a change in the diet over the course of the year and it helps to identify lean months characterized by low production in the farm and/or backyard and the need to purchase large amounts of food in the market, resulting in high overall food expenses for the respective months. However, with the exception of rice, prices for food items were not adjusted to reflect seasonal scarcity, partly due to lack of data and partly because the reasons for price fluctuations could not clearly be identified. Thus, for all food items other than rice, average prices for the whole model period were used (see Appendix Table A9.4).

Under the IPM-technology option, wild aquatic organisms can be gathered from ricefields at certain times of the year (see Chapter 7). This requires labor input from family members and adds to the food item and nutrient balances in the respective months. For the purpose of this model, only a limited number of aquatic organisms were considered, namely the mudfish (taken as a representative for all wild fishes in the ricefield), crabs, edible snails and edible frogs. While frogs were assumed to be only caught and consumed during the month of May, fish, crabs and snails are available from June until November (during the wet season). The maximum available quantities of fish, frogs and crabs per hectare were derived from the catch data reported in Chapter 7 (see Table 7.5), adjusted for the area from which this catch was obtained and spread over the catching season. Thus, maximum available quantities per month were defined to be 1.2 kg of fish, 4.36 kg of crabs and 1 kg of snails for the period between June and November. In the month of May, a maximum of 16 kg of frogs could be obtained from the ricefields. Due to lack of data, it was assumed that the labor effort is equal for all aquatic organisms and that one hour of labor input is needed to obtain 1 kg of these organisms.

Rice-aquaculture component

This component introduces the option to allocate all or part of the land that was previously under rice monoculture to a rice-aquaculture enterprise. For the purpose of this study, rice-fish culture was selected as the most common and widespread type of rice-aquaculture[153]. Only the monoculture of tilapia was considered since carp, the other major species used in rice-aquaculture, is not available in most parts of the Philippines. It is assumed that all of the 1.7 ha of irrigated riceland is potentially suitable for rice-fish culture[154]. Fish may only be kept during the two rice cropping seasons, since even the ponds are reported to be dry in Antique during the fallow period (Corre 1985). The aquaculture

---

153 Only concurrent rice-fish systems have been considered in this model, because, unlike in Indonesia, rotational rice-fish systems are not common in the Philippines and have not been promoted during the National Rice-Fish Programme. One farmer in Nueva Ecija practiced rotational rice-fish culture and converted parts of his ricefields to ponds for the period between two rice crops. However, this farmer could be regarded as an exception because his farm acted as a model farm for the nearby Freshwater Aquaculture Center of Central Luzon State University.

154 This postulation points to a very common assumption in the formulation of LP models, namely the assumption of linear relationships between inputs and outputs (constant returns to scale). The discussion of farming systems in Chapter 6 has shown that farmers cultivate different types of riceland which may not all be equally well-suited to rice-fish culture (different topography, soil quality, sources of irrgation water, etc.). Thus, strictly speaking, one activity would have to be formulated for each plot. However, these conditions vary widely among farmers and it is impossible to come up with an average estimate of the number, size and quality of plots per farm.

component builds on the basic rice production activities described above, but some important activities and constraints have been added.

The first step in the establishment of a rice-fish enterprise is the initial modification of the field, including raised dikes and some type of refuge for the fish during times of water stress. Since the pond refuge has been found to be superior to the trench refuge (see Chapter 3), it is the type of refuge considered in the model. A pond refuge takes away 10% of the ricefield area and is about one meter deep (dela Cruz 1990). One advantage of the pond refuge compared to the trench refuge is the fact that it needs to be constructed only once at the beginning of the rice-fish operation and requires only minor upkeep and maintenance efforts the following years. This, however, poses a methodological problem in the formulation of the model which was designed to describe an 'average' year in the rice-fish production cycle. While it is obvious that initial construction costs may not be neglected, they have no influence on the cash flow during all other years of the rice-fish operation[155]. This problem was solved by introducing an activity for the initial modification of the field, which is linked with the rice-fish culture activity for the model year but with none of the cash balances. If the rice-fish culture activity is part of the optimum solution (i.e., a certain portion of the land is allocated to rice-fish culture), the field modification activity is automatically part of the solution as well and enters the objective function with the (negative) annuity of the initial field modification costs[156]. The pond size needed in the optimum solution is determined by computing 10% of the rice-fish area. Field modification costs were estimated from data provided in the literature (ICLARM 1981; Tagarino 1985) as well as from key informant surveys in Antique. Pond excavation costs cited in the literature vary widely. While ICLARM (1981) reports costs of US\$1.30/m^3 excavated soil, Tagarino (1985) claims that total development costs (including water control devices, wire screens and fencing materials) amount to only US\$0.02/m^2 of rice-fish area. However, Tagarino's data are averages of 53 farmers with different culture systems who all use the trench refuge, thus costs for the construction of pond refuges might be higher. Farmers in Antique stated values between US\$0.17/m^3 and US\$2.60/m^3, depending on soil type, family labor involvement (which was normally not included in cost calculations) and contractual arrangement. For the purpose of this study, the value reported by ICLARM (1981) was perceived to be most realistic because it was based on the exclusive employment of hired labor and deal explicitly with the excavation of ponds. A service life of the pond of 10 years is normally assumed in the literature (Alsagoff et al. 1990; Israel et al. 1994)[157]. The interest rate for formal credit used in the model (1.25%/month or 15%/year) was employed to compute the annuity of pond construction costs, which amounts to US\$ 0.26/m^3/year (PhP26.97 = US\$ 1.00 in 1993).

Upkeep of the refuge is estimated to require two persondays per hectare of rice-fish culture per cropping season. In addition, the comparison of labor requirements for rice monoculture and rice-fish

155 The only situation in which construction costs do have an influence on the cash flow of following years is when credit is taken to finance the initial field modifications. In this case, repayment of the credit plus interest would have to be deducted from the cash balances of the respective years. However, in this model it is assumed that all initial costs were covered by own funds.

156 Because rice-fish culture is possible in two seasons, only half of the annuity is deducted in each particular season.

157 Other authors estimated the service life of pond systems at 20 years or longer (e.g. Broussard and Reyes 1985). However, while these estimates were derived for a large-scale operation at a research station, the shorter service life employed in this model reflects the danger of natural disasters (especially typhoons) which is realistic under farmers' conditions in the Philippines.

culture presented in Chapter 6 resulted in significantly higher labor input for the maintenance of the raised dikes in rice-fish culture. This activity is supposed to require an additional five persondays per hectare of rice-fish area per cropping season.

Tilapia fingerlings can be bought from local hatcheries at PhP0.24/piece (1994 prices). In the second cropping season, they can also be taken from own production, in quantities depending on the stocking density selected by the model for the first cropping season (based on evidence from the literature (Fermin 1985), fingerling number at the end of the growth period is assumed to equal 150% of initial number of fish stocked). Four different stocking densities of fish were included, namely 5 000, 10 000, 15 000 and 20 000 fish/ha. These stocking densities are defined as a special ordered set, since only one of them can be selected per cropping season. The fingerlings are stocked in the pond after land preparation activities in the field have been completed (during the first month of each cropping season)[158]. Stocking requires approximately one personday/ha, regardless of stocking density (Israel et al. 1994). Fish are assumed to be stocked at an initial length of 3 cm. An empirical model for the growth of tilapia in tropical ponds in the Philippines, developed by Prein (1993) was employed to estimate the growth of fish over a production cycle of 90 days[159]. Survival rates were set at 50%, in line with the data reported by various authors for rice-fish culture under farmers' conditions (Dewan 1992; Sastradiwirja 1992). By estimating fish growth at different times during the growth cycle, requirements for supplemental feeding could be adjusted to correspond to 5% of the respective fish body weight, the recommended average feeding rate for fish (PCARRD 1985; Vincke and Micha 1985; see Appendix Tables A9.10 and A9.11 for fish weight and feeding rates in kg/month/ha). Only rice bran was used as supplemental feed. Compared to feeding rates cited by other authors (e.g. Israel et al. 1994), the computed feeding rates were rather high. Furthermore, Singh et al. (1980) state that the quantity of supplemental feed in a rice-fish enterprise will be less than for pond culture because of primary production in the ricefield. Therefore, only 50% of the computed feeding rates were used in the model formulation. Additional nutrients were probably added to the rice-fish field from other sources such as animal manure or kitchen waste which may compensate for the difference.

Rice bran could be bought from local rice mills or it is produced through the milling of own rice by traveling rice mills. Supply of own rice bran is adjusted to the farmer's particular situation by linking it with the amount of own rice consumed in the household. One kg of rough rice produces approximately 100 grams of rice bran and 680 grams of milled rice and the rest is waste. Thus, for each kilogram of own rice consumed, 1.47 kg of rough rice are taken from the farmer's stocks and 0.147 kg of rice bran are added to the 'own rice bran' balance row. Own rice bran can be transferred from one month to the next. Since storage losses can be expected, it is assumed that 10% of rice bran will be lost in the transfer activities (transfer coefficient = 0.9).

---

158 Fish are assumed to stay in the pond until the rice is big enough to tolerate higher water levels (15-20 cm). Only then will the dikes be opened and the fish allowed to forage in the field.

159 The growth model was estimated for an average pond size of 200 m^2. This corresponds to a rice-fish area of 2 000 m^2, 10% of which is taken up by the pond. Two conceptual problems are related to this specification: on the one hand, the ricefield area is not included in the fish growth computations because the growth model cannot account for the environmental conditions in the field which differ significantly from those in the pond. On the other hand the LP-model can result in a much larger area being devoted to rice-fish culture, thus total pond size will also be bigger. However, bigger ponds lead to higher tilapia growth (Prein 1993). Therefore, the bias against fish culture introduced through the postulation of small ponds can only lend additional support to the decision of the model to grow fish.

Feeding the fish takes about 35 minutes/ha/day, regardless of stocking density (Israel et al. 1994). In the first and last month of each cropping season, only two weeks of feeding time have been calculated since feeding starts in the middle of the first month and ends at the time of fish harvest, in the middle of the last month. Feeding is only done by family labor.

Rice agronomy remains more or less the same under rice-fish culture. The same amount of seeds is used in both rice and rice-fish area, even though some farmers report a reduced seeding rate in the rice-fish field to provide the fish with more space to move[160]. Molluscicide and herbicide use is also the same in rice and rice-fish area under conventional pest management, since these chemicals are applied before the fish are released into the field. However, the type of insecticide used in the rice-fish area had to be changed, since endosulfan is highly toxic to fish (Cagauan and Arce 1992). Instead, methyl parathion was assumed to be the only insecticide used in the rice-fish area. Methyl parathion is moderately toxic to fish but very toxic to humans (Cagauan and Arce 1992). The price for endosulfan (brand name Thiodan) and methyl parathion (brand name Fosferno) is approximately equal, thus the change of insecticides has no influence on the model result.

Fertilizer use in the rice-fish area is assumed to be the same as under rice monoculture, due to conflicting evidence on this issue. While Singh et al. (1980) recommend increased fertilization rates (especially phosphorus) for rice-fish culture to stimulate primary production, other authors (e.g. Nie et al. 1992) believe that fish feces fertilize the field and thus reduce the need for commercial fertilizer.

General crop care activities (field visits, pest monitoring, weeding, snail picking) are assumed to be the same for rice monoculture and rice-fish culture; thus, labor requirements for rice monoculture were replicated for rice-fish culture. In addition, the pond refuge has increased water requirements vis-à-vis rice monoculture of about 26.3% (Sevilleja et al. 1992). While it is assumed that the water is provided by gravity irrigation at fixed rates per crop (no extra expenses for water in rice-fish culture), the continuous adjustment of water level in the case of rice-fish culture is assumed to require additional labor input corresponding to 30 days per crop, divided equally among the four months of each cropping season (see Chapter 6, Table 6.9)[161]. Water control is only performed by adult men.

Fish harvest is conducted on different occasions, starting in the third month of each cropping season. About one-fourth of the fish has reached the marketable size of 55-60 grams by that time and is taken from the field for own consumption or sale (see Appendix Table A9.10). This is done with the help of small nets or hook and line. Since rice-fish farmers in Nueva Ecija regard this occasional catching of fish as a means of relaxation rather than farm work, the time needed for this activity is not accounted for in the model.

---

160 In fact, some farmers in Nueva Ecija were observed to transplant the rice into their rice-fish fields while all other fields were direct seeded. This was done to be able to increase the water level earlier than with direct seeded rice and to provide more space for the fish to move.

161 The data presented in Table 6.9 show that while labor requirements for water management in different seasons remain roughly the same in the case of rice-fish culture, rice monoculture has higher requirements in the dry season than in the wet season. Presumably, this is due to the fact that some farmers irrigate their fields by water pump in the dry season. In the case of rice-fish culture, no such seasonal difference is apparent. Water management in the wet season is crucial to prevent flooding, while in the dry season it is needed to provide adequate water supply.

The main fish harvest takes place just before the rice is harvested. The field is drained, the fish gather in the refuge and are then harvested. Israel et al. (1994) report that an average of 34 person-days/ha are needed for the harvest of fish. Since harvesting has to be completed in one day, 34 persons have to be present at the same time. This requires that hired laborers are employed to help the adult men in the family with the fish harvest. The fish can either be consumed or sold at a farm-gate price of PhP30/kilo (retail prices for tilapia are set at PhP34/kilo, see Appendix A9.4).

The harvest of fish fingerlings is conducted simultaneously with the harvest of big fish, thus no additional labor is needed. Again, one-fourth is ready for harvest after three months, while the remaining three-fourths will be harvested just before the rice harvest. Fingerlings can either be sold or transferred between months (in practice, this means that they are left in the field or pond if they cannot be sold); in the model, this is done through the usual transfer activities. However, the efficiency of transferring fingerlings is not very high since some might grow too old to still be called fingerlings and others might escape or die. Thus, the transfer coefficient for fingerlings is estimated at 0.75. Fingerlings from the own field will be of different sizes and the farmer is assumed to sell them to neighbors at a cheaper price than fingerlings from local hatcheries, therefore the sales price is set at PhP0.20/piece.

Modeling IPM

While IPM is much more than just non-use of pesticides, other features of IPM such as human capital formation or improved decision-making are difficult to quantify and to incorporate in a model such as this. Changes in general farming practices (e.g. method of land preparation or use of fertilizers), in addition to showing a large degree of variation, cannot clearly be attributed to IPM. Therefore, the main feature of the IPM-component as formulated in the model is the renunciation of pesticide use. Results of the Antique IPM/ALM survey have shown that the majority of farmers trained in IPM have stopped using insecticides. Thus, insecticide applications on rice are eliminated under IPM. Evidence from the literature suggests that in a 'normal' year (i.e. provided that there is no pest outbreak), untreated plots produce the same yield as plots treated with insecticides (Rola and Pingali 1993). Experience from many IPM programs shows that yields may increase or at least are not expected to decrease under IPM (van de Fliert 1993). Therefore, yields in the model are defined to be the same under IPM and conventional pest management. The monitoring time required for adequate pest control decisions under IPM is assumed to be included in regular crop care activities. Under IPM, it is not so much the additional time spent in the field but the additional knowledge acquired by the farmers which leads to better pest management decisions (van de Fliert 1993).

The use of molluscicides is also eliminated, since several alternative methods for snail control are taught in IPM. However, these methods are more labor-intensive than the use of molluscicides which needs to be accounted for in the model. Due to lack of data it was assumed that a thorough picking of snails is necessary twice a week during the vegetative stage of the rice crop (i.e., during the first and second month of each cropping season). For one hectare, about two hours are needed per round, thus two additional days of crop care activities were added for the first two months of each cropping season.

Even though weed control is an important topic in IPM, the Antique IPM/ALM survey has shown that many trained farmers continue to use herbicides. Effective weed management in IPM requires careful land preparation and water control as well as the use of weed-free seeds. Therefore, the use of certified seeds was introduced as a condition under which farmers stop using herbicides. Certified seeds are more expensive than own seeds, but they are guaranteed weed-free to a certain extent. In the IPM component of the model, farmers are assumed to purchase certified seeds and cease to use herbicides. The estimated time for manual weeding remains the same under IPM as under conventional weed management.

This very reduced conception of IPM was used for the computations of technology options in the base model. In subsequent runs, two modifications were introduced. The first refers to the health costs caused by the use of pesticides (primarily insecticides and molluscicides). Rola and Pingali (1993) have estimated the health costs associated with each application of insecticides among Filipino rice farmers. Under farmers' practice, each dose of insecticides caused mean health costs of US$ 22.43 in the wet season and US$ 25.92 in the dry season of 1991. These values were added to the objective function of the model in the expanded version of the IPM-component. Health costs are defined as treatment costs (including medication and physicians' fees) plus the opportunity cost of farmers' time lost in recuperation (Rola and Pingali 1993). However, due to the lack of more detailed data, it was not possible to identify the individual cost components, i.e. additional cash and/or additional time available to the farmers under IPM. Furthermore, it is doubtful whether health costs can be associated with individual pesticide applications. Health costs may occur with a considerable time lag in relation to pesticide use, therefore no attempt was made to incorporate them into the cash and/or time balances of the model.

The second modification refers to the positive impact of IPM on the aquatic fauna of the ricefield. Due to the lack of empirical data on aquatic organism populations with and without IPM, it is assumed that no aquatic organisms are available under conventional pest management. If IPM is practiced, aquatic organisms are expected to return to the field in the quantities reported in Chapter 7[162]. They can be caught or gathered by family members as described under the nutritional component above.

Results

In its final version, the model contained 1 095 activities (not counting the slack and surplus activities which amounted to 720 and 169, respectively) and 935 constraints, plus the objective function. The model was solved separately for each of the four technology options introduced above, namely rice monoculture under conventional pest management, rice monoculture under IPM, rice-fish culture under conventional pest management and rice-fish culture under IPM[163]. The matrix of activities and constraints is the same for each technology option so that only one matrix is needed; however, some of the technical and right hand side coefficients vary among options (e.g., the maximum land available for rice-fish culture is set equal to zero in scenarios which only look at rice monoculture).

---

162 This representation is a very simplified approach to reality. On the one hand, even under conventional pest management there are still aquatic organisms to be found in the ricefields. It had to be assumed that these organisms are not fit for human consumption as long as pesticides are used in the ricefield. On the other hand, if one farmer decides to practice IPM, there is no guarantee that aquatic organisms will return to the field as long as other farmers in the same irrigation system continue to use pesticides. It had to be assumed that IPM is practiced at the village level.

163 These technology options will subsequently be called 'conventional rice monoculture', 'rice-IPM', 'conventional rice-fish culture' and 'rice-fish-IPM'.

A simplified version of the matrix is presented in Appendix 10, the whole model is available from the author upon request. The model was solved by using the LP-routine in the SAS/OR®, package (SAS Institute Inc. 1989b). In addition to the base model described above, a price sensitivity analysis was conducted and different scenarios were analyzed in subsequent runs.

It should be noted that in the context of this study, the main purpose of the model is to describe the change in different parameters of the farm-household system under various technology options and scenarios. Thus, this model is more descriptive than normative in nature. First, it was impossible to include all potential income-generating activities open to the farmers, ranging from animal husbandry to crop diversification to off-farm and non-farm employment. These options are different for each individual farmer so that no important information would be gained by including them in the model. Second, the model does not leave much room for the allocation of resources. The main decisions made with the help of the model are the land area devoted to rice and/or rice-fish culture, and whether or not to employ hired laborers, to take up credit and to engage in off-farm activities. In addition, the optimum diet is determined which meets all nutritional requirements at minimum costs. The formulation of the model does not allow the allocation of land to crops other than rice and/or fish and to increase animal husbandry, backyard gardening and off-farm activities beyond the limits defined in the previous sections. These constraints might seem too strict compared to the reality faced by many farmers. However, they are necessary to avoid too much variation in model parameters and to concentrate on the main research question, namely the impact of rice-aquaculture and IPM on the farm-household system.

It has earlier been indicated that the objective value should be interpreted as household gross margin net of food expenses and, in the case of rice-fish culture, net of pond annuity. While this value is important in determining the optimum farm plan and diet composition, it is nonetheless difficult to interpret since pond annuity does not necessarily influence the cash situation of the household in a 'normal' year. Therefore, additional household gross margin balances were introduced for the whole model period as well as for each individual month to arrive at an estimate of the money available at the end of the year to cover fixed costs and to remunerate family labor. The relationship between objective value and household gross margin can be described as:

household gross margin = objective value + food expenses + pond annuity -PhP10 000,

where PhP10 000 is the amount of own funds assumed to be available at the beginning of the model period.

Base model

In Figure 9.1, the objective values reached by the four technology options in the base model are contrasted with the respective household gross margins as well as with farm cash expenses incurred and credit taken up during the model period. Under conventional rice monoculture and rice-IPM, all land is allocated to rice production in both cropping seasons. In contrast, as soon as rice-fish culture is introduced as an alternative option to the farmer, all land is allocated to this technology (1.55 ha of rice-fish fields and 0.15 ha of pond area). From the objective values and household gross margins it can be deduced that rice-fish culture is clearly dominant over rice monoculture, regardless of the pest management strategy employed. The objective value of conventional rice-fish culture is 174% higher than that of conventional rice monoculture while the objective value of rice-fish-IPM is 141% higher than that of rice-IPM. A similar relation emerges for household gross margin, which is 154% higher for conventional rice-fish culture and 146% higher for rice-fish-IPM. The total amount of fish produced in the pond and rice-fish fields comes to 1 619.18 kilos over the whole year (equivalent to 476 kg/ha/cropping season), an impressive yield made possible by the highest stocking density of 20 000 fingerlings/ha selected in the optimum solution. In addition, 63 750 fingerlings are sold, so that the annual gross income from fish alone amounts to PhP61 325.40/farm or PhP36 073.77/ha. However, a first drawback to this stunning result arises when looking at the sum of all farm cash expenses incurred over the course of the year. Cash requirements for conventional rice-fish culture are 146% higher than for conventional rice monoculture and cash expenses for rice-fish-IPM exceed those of rice-IPM by 149%. This is also reflected in the amount of credit taken up under the different technology options. While under conventional rice monoculture a formal credit of PhP4 638 is taken up at the beginning of the model period (June), this credit volume increases by 77% under conventional rice-fish culture. The formal credit limit is completely exhausted in June and additional informal credit of PhP570.00 is needed in June and July to finance the high production costs of rice-fish culture. If IPM is practiced, the need for credit declines compared to conventional pest management. Rice-IPM requires only PhP2 773 of formal credit, the lowest among all technology options. However, under rice-fish-IPM the credit volume increases by 76%.

The impact of IPM on all parameters discussed so far is less pronounced. The objective values of rice monoculture and rice-fish culture increase by 22% and 8%, and household gross margin by 8% and 4%, respectively, if IPM is the pest management strategy employed. Farm cash requirements and credit volume under IPM decline by 3% and 40% for rice monoculture and by 2% and 7% for rice-fish culture, respectively. Thus, IPM has an overall positive effect on the profitability of rice production.

The productivity parameters presented in Table 9.4 reveal a positive impact of rice-fish culture which is strongest for land and smallest for cash. Interestingly, returns to cash are higher under rice monoculture with IPM than under conventional rice-fish culture.

A look at the monthly distribution of household gross margin and farm cash requirements further clarifies the situation (Figure 9.2 and Figure 9.3). Farm cash requirements comprise all purchases of material inputs such as seeds, fertilizer and pesticides as well as expenses for hired labor. For all technology options, they are highest in the beginning of each cropping season when all inputs are purchased[164]. Under rice-fish culture, the amount of cash needed in the beginning of the cropping season

Table 9.4. Productivity parameters for different technology options.

	Rice	Rice-fish		Rice-IPM	Rice-fish-IPM	
Returns to labor (Pesos/person day)	68.38	112.76	(+64.90)	75.36	117.09	(+55.37)
Returns to land (Pesos/ha)	14 330.49	36 439.87	(+154.28)	15 413.76	37 862.88	(+145.64)
Returns to cash (Pesos/Peso operating capital)	1.33	1.37	(+3.26)	1.47	1.45	(-1.44)

Source: Own computations.
Figures in parentheses are % change as compared to rice monoculture (with and without IPM).

164 It has to be noted that payments for rice harvest and threshing are not included in the farm cash requirements. In the Philippines, laborers employed for rice harvesting and threshing are normally paid in kind, i.e., they receive a certain share (16.67%) of the gross rice yield. This reduces the amount of rice available for consumption and sale, but has no impact on the amount of cash needed during harvest time. Had this amount of rice been converted to cash, cash requirements would have increased by PhP5 866 in September and PhP5 611 in January for all technology options.

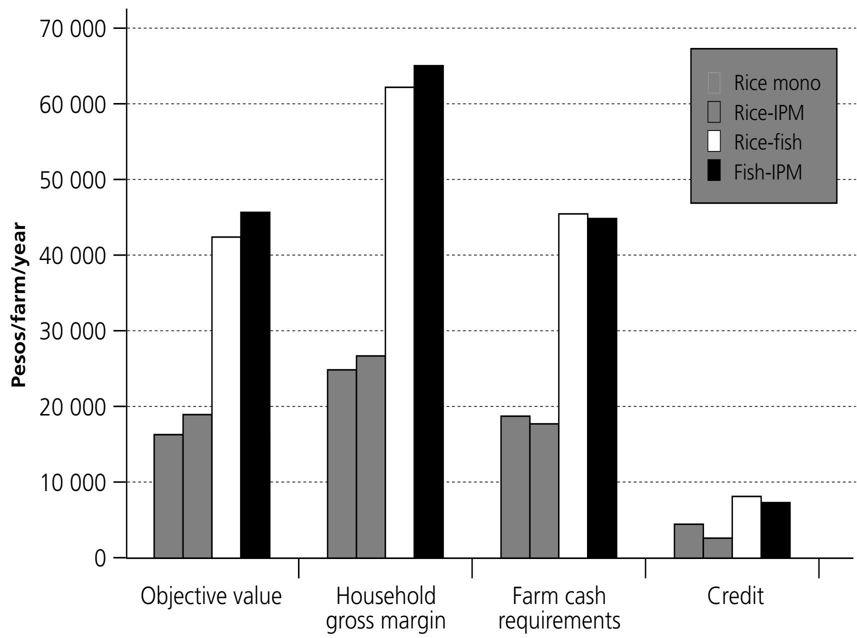


Figure 9.1. Key parameters under different technology options. Source: Own computations.

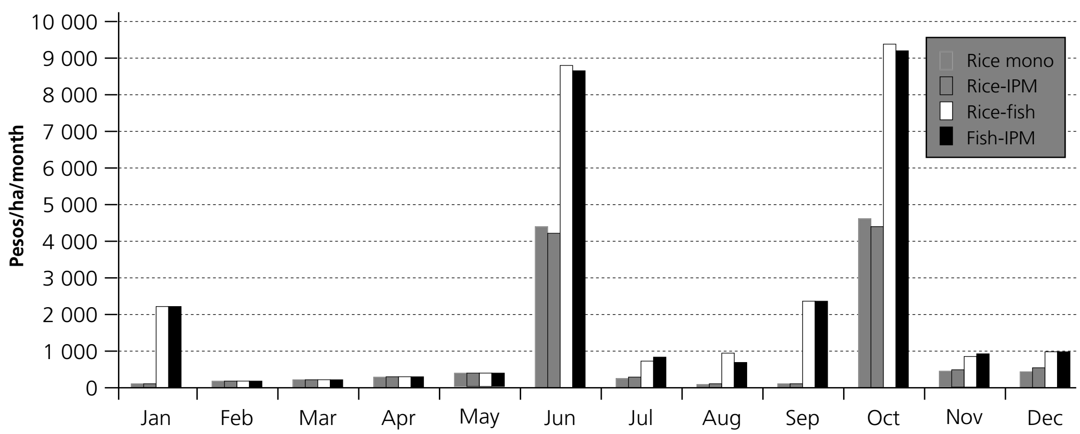


Figure 9.2. Monthly cash requirements under different technology options. Source: Own computations.

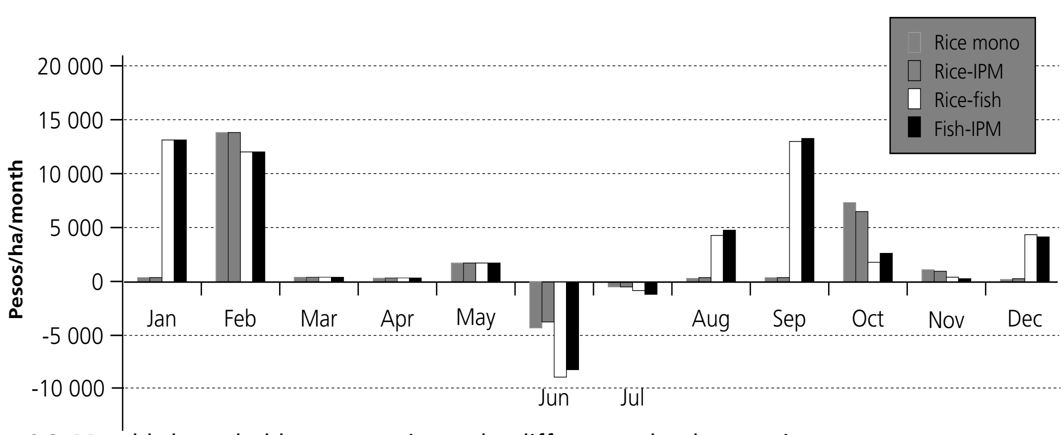


Figure 9.3. Monthly household gross margins under different technology options.
Source: Own computations.

is roughly twice as high as for rice monoculture, regardless of pest management strategy. Furthermore, additional cash is needed in the following months, primarily to buy fish feed and to pay hired laborers employed for the harvest of fish.

The high expenses at the beginning of each cropping season lead to a negative household gross margin in June, which marks the end of the fallow period and the beginning of a new crop year (Figure 9.3). The months up to the harvest of the first crop are generally characterized as the 'lean months' since own funds from the last harvest have been exhausted and expenses have been incurred in the preparation and establishment of the first crop[165]. Additional cash requirements during this time of the year are difficult to meet. This situation is less pronounced at the beginning of the second cropping season when most of the yield of the first crop is sold. However, rice-fish culture puts extra stress on farmers' scarce cash resources during times of high expenses. Thus, in addition to high capital requirements for the initial modification of the field (which have been assumed to be covered by own funds in a previous year), availability of operating capital at the beginning of the crop year may act as a constraint to the adoption of rice-fish culture by farmers who have no or limited access to credit or who have less own funds than is assumed in the model.

Another constraint becomes apparent when monthly farm labor requirements are compared among technology options (Figure 9.4). For this purpose, family labor inputs in farm activities were converted to monetary values by multiplying them with the wage rate for hired labor (PhP50/day)[166]. Furthermore, the monetary equivalent of hired labor employed for rice harvesting and threshing was added to the labor balances. Rice-fish culture increases total farm labor input in all months apart from the fallow period. Particularly striking is the additional labor required for fish harvest in the last month of each cropping season (September and January). These months are the most labor-intensive months of the year due to rice harvesting and post-harvest activities. Any additional labor requirements are difficult to meet. On the one hand, family labor is occupied in organizing and conducting the rice harvest, including the hiring and supervising of laborers. On the other hand, fish harvest is primarily undertaken by hired laborers (Figure 9.5) who are paid in cash. Since fish is harvested

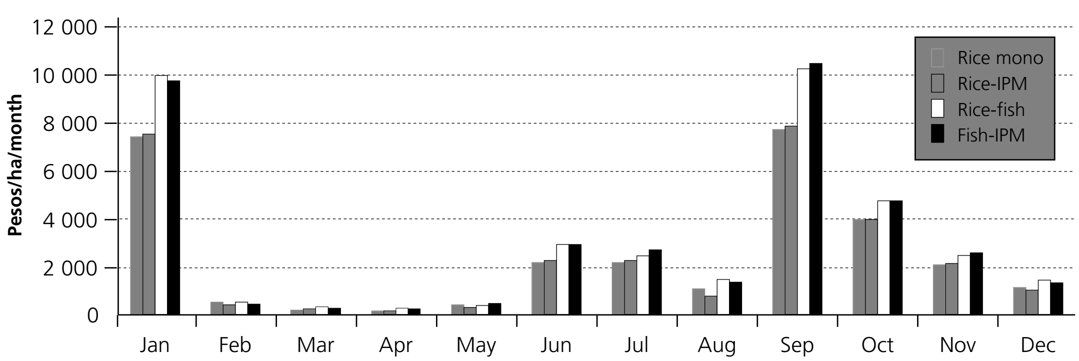


Figure 9.4. Monthly farm labor costs (hired and family labor) under different technology options. Source: Own computations.

165 The exact timing of cropping seasons and fallow period is not significant in this respect. The important point here is that concurrent rice-fish culture incurs high cash expenses during the lean months of the year, when many farmers are glad if they can cover their expenses in rice production.

166 Monetary values are needed because of contractual arrangements for some hired labor tasks which could not be converted into days.

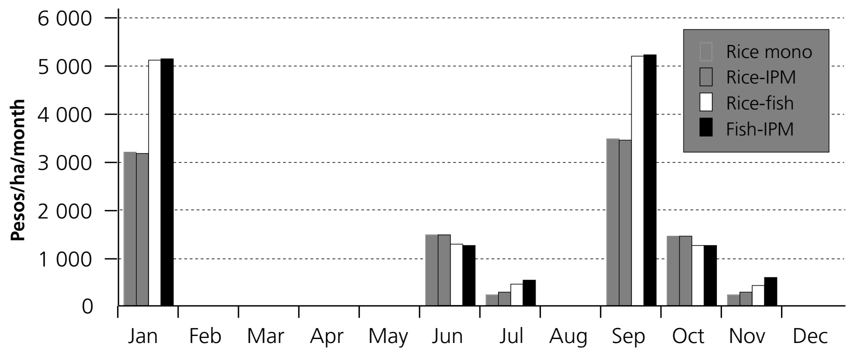


Figure 9.5. Monthly hired labor costs under different technology options. Source: Own computations.

before the rice crop, which is the main source of funds throughout the year, availability of cash at harvest time may prove to be another constraint to the adoption of rice-fish culture[167].

The impact of rice-fish culture on family labor deserves a closer look (Figure 9.6). July and November are the busiest months, due to crop care activities which are mainly undertaken by family members. All family labor resources are exhausted in these months and some hired labor is employed, but the difference among technology options is small. In all other months (apart from the fallow period), rice-fish culture leads to increased family labor input. Under the assumption of limited off-farm employment opportunities (which are fully realized in the optimal solution, except for the months of July and November), this result implies a reduction in family labor surplus compared to rice monoculture (Figure 9.7). In the case of rice-fish culture, the labor supply is more fully utilized during slack months, particularly for adult men who undertake most of the tasks in rice-fish culture (Figure 9.8)[168]. In the light of otherwise highly seasonal labor demand alternating with under-or unemployment in rural areas, this has to be regarded as a positive effect.

The impact of rice-fish culture and/or IPM on nutrition is negligible in most months. Monthly food expenses hardly differ among technology options (Figure 9.9). They fall in the range between PhP1 200 and PhP2 200/month, which is more than most farm families would spend on food[169]. These high values are caused by the nutritional constraints in the model so that a balanced diet is achieved at all times. Particularly high food expenses are apparent for the months of May, August and September (except for rice-IPM and rice-fish-IPM in August and rice-IPM in September). This is due to the fact that rice stocks have been exhausted and the family needs to buy all the rice needed for consumption. Because the model period starts in the month of June, with a certain amount of cash and rice assumed to be available for the months up to the next harvest, the fact is concealed that if no rice stocks are available in May, then all rice for consumption will have to be bought in June and July as well. If this is taken into account, it becomes clear that the months between May and September are truly 'lean months' with no produce to sell nor to consume. Food expenses in August and September are

167 To avoid these difficulties, fish harvesters could be paid in kind or payment could be postponed until the fish has been sold.

168 The impact of rice-fish culture on women and children labor is difficult to isolate. Many activities included in the model can be performed by women and children alike, so that more than one optimal solution can be imagined for the distribution of labor.

169 Own computations based on the 1991 Family Income and Expenditures Survey revealed that average food expenses in Antique came to roughly PhP1 250/family/month in 1991 (NSO 1994b).

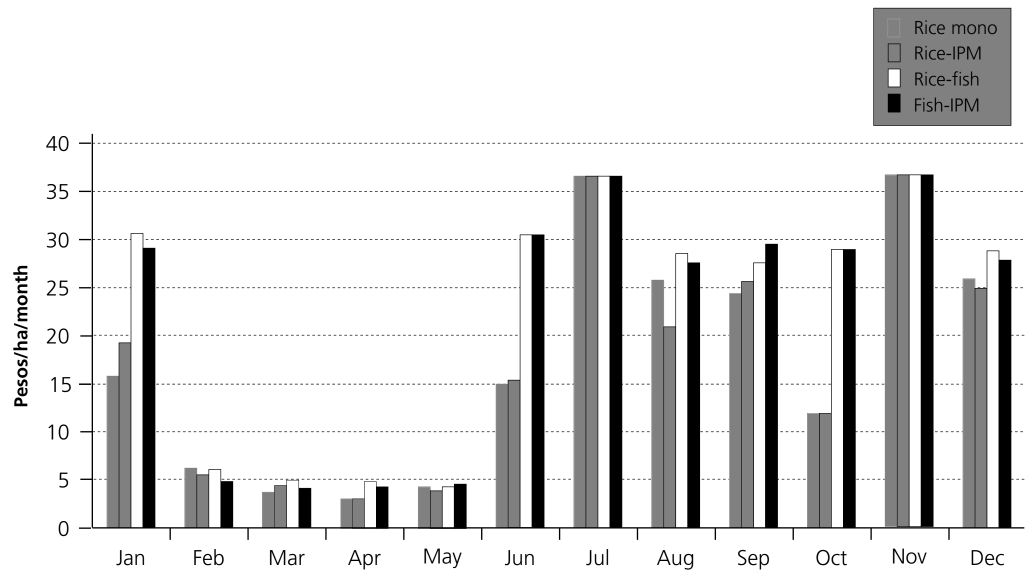


Figure 9.6. Monthly family labor input under different technology options. Source: Own computations.

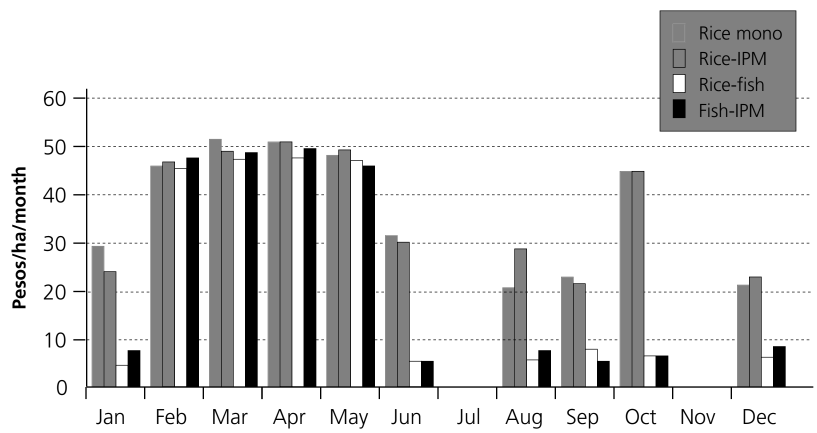


Figure 9.7. Monthly surplus of family labor, all family members. Source: Own computations.

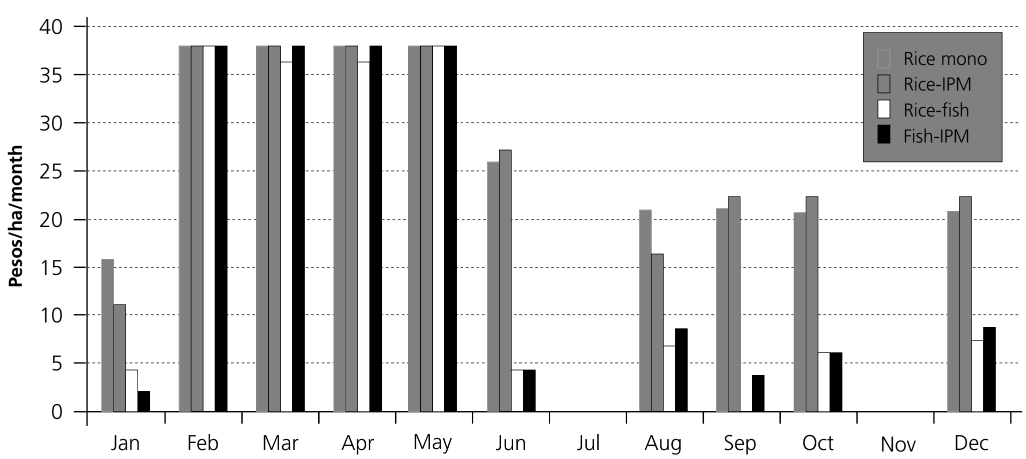


Figure 9.8. Monthly surplus of family labor, adult men only. Source: Own computations.

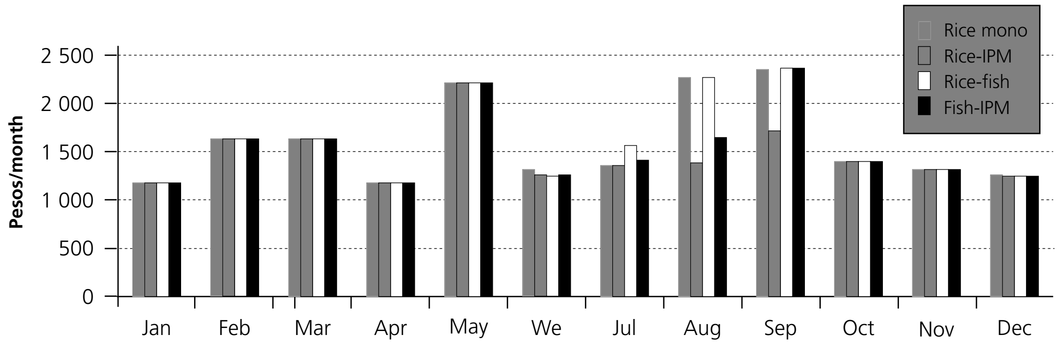


Figure 9.9. Monthly food expenses under different technology options. Source: Own computations.

lower under rice-IPM than under any other technology option because rice seeds are assumed to be bought (certified seeds) and all rice can be used for consumption, thus rice stocks last longer. The same should apply to rice-fish-IPM; however, due to high cash requirements at the beginning of the cropping season, the family sells part of their rice stocks so that by the end of August they have to buy their rice for consumption.

The monthly composition of the minimum cost diet which meets all nutritional requirements of the model family is presented in Appendix Table A9.12. Among the potential food items included in the model formulation, only beef, pork, chicken, milkfish and sardines are never part of the diet. Apart from sardines, these are the more expensive animal protein foods which are only eaten on certain occasions. The diet is at the minimum level for energy, calcium and vitamin A, while it reaches the maximum levels of protein and vitamin C. Iron uptake is close to its maximum level. This shows that it is possible to achieve a balanced diet with the food items available to the farmers, without having to resort to expensive animal protein foods. A significant contribution to nutrition is made by the production of fruits and vegetables in the own backyard garden. The shadow price of the backyard garden constraint, which limits this activity to one unit of 600 m^2, amounts to approximately PhP3 400 per year or PhP283 per month for the different technology options. This value would have to be added to monthly food expenses if backyard gardening was made impossible. Conversely, the shadow price of the backyard garden constraint can serve as an estimate for the marginal value product of additional land available for vegetable production in the case of rice-fish culture. Raised dikes are often used as vegetable beds. A rice-fish plot of 1 000 m^2 adds approximately 140 m^2 of dike area (depending on the shape of the field) which could be valued at PhP793, thus further increasing the profitability of rice-fish culture.

Price sensitivity analysis

Even though it was assumed in the model that the farmer can sell the tilapia produced in the own field or pond at a lower price than he or she would have to pay for tilapia in the market (due to imperfect marketing channels, small size of fish and special prices made for friends, neighbors and relatives), all fish is sold and none is consumed in the household[170]. The consumption of own tilapia has

170 This is based on the assumption that all of the surviving fish reach marketable size (55-60 grams) and are caught on two occasions only. In reality, the family will consume those fish which are too small to sell and will frequently catch fish for own consumption.

an average reduced cost value of -1.31, indicating that there are cheaper sources of animal protein available to the family. In the light of low preferences expressed for tilapia (see Chapter 7), this might seem contradictory at a first glance. The fact that tilapia commands a relatively high market price but is not highly valued by many people points to a small specialized market or to a regional market differentiation[171]. Tilapia prices faced by producers can indeed be much lower than assumed in the model if they are located in an unfavorable region. In order to determine the minimum price at which investment in tilapia production is still profitable, a price sensitivity analysis was conducted. Because standard range analysis as provided in the SAS/OR®, package (SAS Institute Inc. 1989b) cannot be performed on problems containing special ordered sets, price sensitivity was analyzed by successively reducing the price of tilapia and tilapia fingerlings (both farm gate and retail), while leaving all other parameters constant.

Allocating all land to rice-fish culture remains the optimal solution until the price of tilapia (grown fish and fingerlings, farm gate and retail price) has been reduced by 45% (Figure 9.10 and Figure 9.11). Further price decreases lead to the gradual replacement of rice-fish culture by rice monoculture. Only at price reductions of 70% is rice-fish culture no longer practiced both under conventional pest management and under IPM. This means that rice-fish culture remains profitable even under very pessimistic price scenarios, when the retail and farm gate price for tilapia falls below the prices for all other animal protein foods. For both IPM and conventional pest management, rice-fish culture is first reduced in the first cropping season, thus further supporting the finding that high cash requirements at the beginning of the crop year present a drawback to the adoption of rice-fish culture.

The key parameters introduced in the previous section, namely objective value, household gross margin, farm cash requirements and household food expenses, are influenced to varying degrees by a change in tilapia prices (Figure 9.12 and Figure 9.13, see also Appendix Tables A9.13 and A9.14 for the underlying values). They all show a declining trend up to the point where land allocation changes.

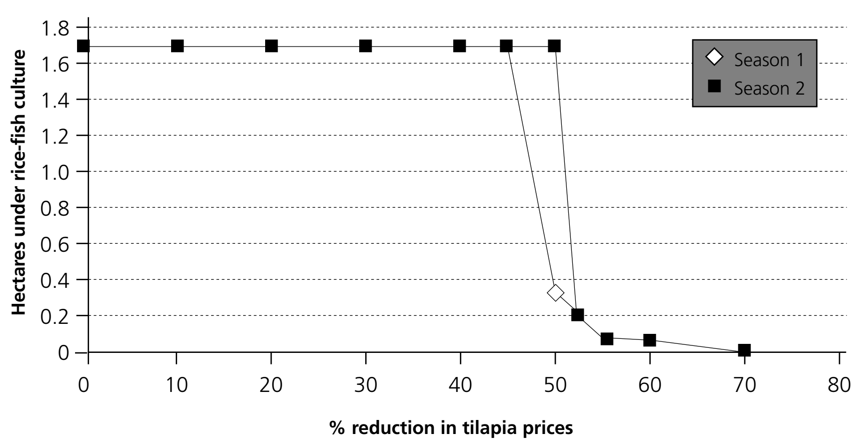


Figure 9.10. Area allocated to rice-fish culture under different price scenarios for tilapia (conventional pest management). Source: Own computations.

171 Several authors have pointed out that geographical location within the Philippines, associated with regional diversity in culture and eating habits among regions and differential access to the sea, is an important determinant for the tilapia market (e.g. Gonzales 1985, Corre 1985; Guerrero 1985).

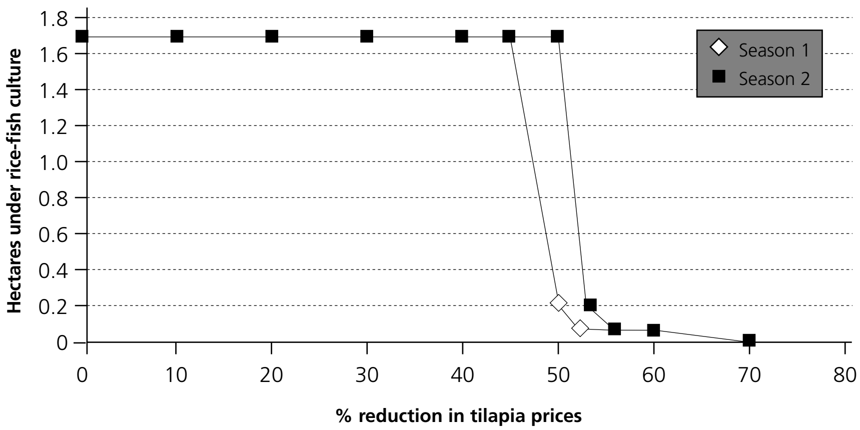


Figure 9.11. Area allocated to rice-fish culture under different price scenarios for tilapia (IPM).
Source: Own computations.

The decline is strongest for household gross margin and the objective value, less pronounced for farm cash requirements and smallest for food expenses. When tilapia prices are reduced to such a degree that some land is allocated to rice monoculture rather than to rice-fish culture (45% price reduction), the behavior of the key parameters changes quite radically. Farm cash requirements decline most strongly, reflecting the high cash requirements of rice-fish culture. Household gross margin also decreases considerably but remains at a higher level. At 55% price reduction, around 95% of the land is allocated to rice monoculture (see Figure 9.10 and Figure 9.11). While farm cash expenses and household gross margin remain more or less stagnant from this point onwards, the objective value exhibits a minor increase. This can be explained by declining food expenses due to the decrease in the price of tilapia (see next section). In the range from 55% to 70% price reduction, the objective value increases while the farmer continues to produce tilapia. This can be explained as follows: the drastic decrease in rice-fish area has increased the availability of family labor and reduced the need to employ hired seasonal laborers for fish production, thus lowering average production costs. The farmer continues to produce tilapia for own consumption (all produced tilapia are consumed in the household at price reductions of 55% and more) as long as marginal production costs of tilapia are below the price of alternative sources of animal protein, which is the case at 70% price reduction.

The development of food expenses under different price scenarios for tilapia is influenced to a large degree by the consumption of own tilapia or the purchase of tilapia in the market (Figure 9.14). At the original price level some tilapia are purchased for consumption in the months of February and March, but none of the own-produced fish is consumed due to high farm gate prices. However, a reduction in prices by 10% already leads to the consumption of 64 kg of own fish per year. With further price decreases this quantity increases continuously until it reaches a maximum of 96 kg/year between 40% and 52.5% price reduction. Interestingly, except for the case of 10% price reduction, purchase of tilapia in the market always remains above the consumption of own fish, even though the retail price is 13% above the farm gate price. This shows that returns from own tilapia production must be higher than the difference between farm gate and retail price. At 55% price reduction (52.5% in the case of IPM), consumption of own fish starts to decline, due to the decrease in rice-fish area (see Figures 9.10 and 9.11). In contrast, purchase of tilapia continues to increase over the whole range until it reaches a maximum at 416 kg/family/year. This is the limit set by the nutritional constraints in the model—the maximum amount of meat, fish and poultry as well as of protein is consumed under this

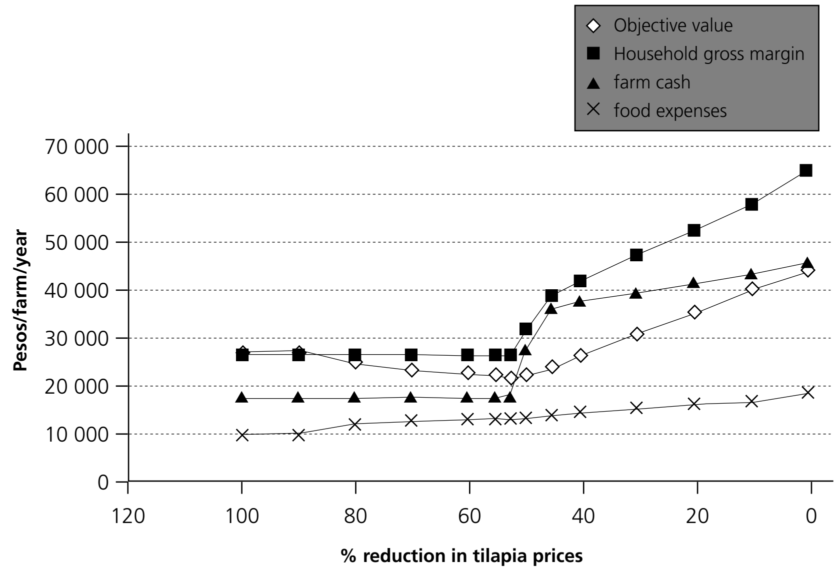


Figure 9.12. Key parameters under different price scenarios for tilapia (conventional pest management). Source: Own computations.

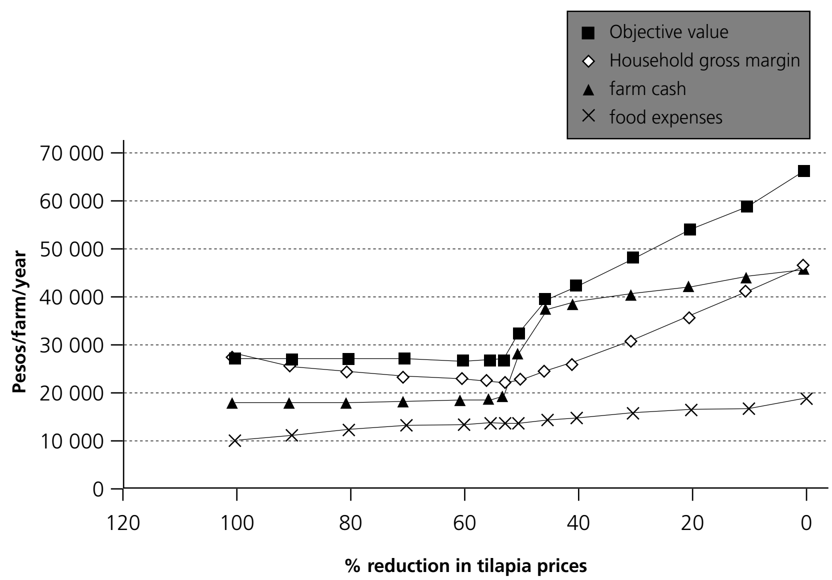


Figure 9.13. Key parameters under different price scenarios for tilapia (IPM). Source: Own computations.

scenario. The small dent in the food expenses curve at 52.2% price reduction is due to the fact that consumption of own and purchased tilapia remains the same as under 50% price reduction but prices decline.

Reduced fish yields

Since the base model has resulted in a complete adoption of rice-fish culture, there is no need to analyze scenarios which would further improve the profitability of this technology, such as an increase in rice yields due to the positive effect of fish. In contrast, it is more interesting to look at scenarios which reduce the profitability of rice-fish culture. In the Philippines, there is a considerable danger of

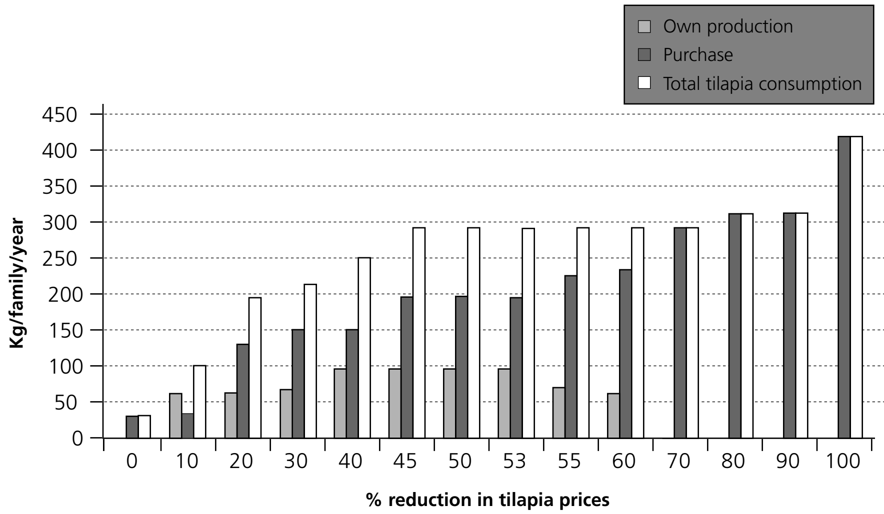


Figure 9.14. Consumption of tilapia (own and purchased) under different price scenarios for tilapia (conventional pest management and IPM). Source: Own computations.

losing part of the fish yield to natural disasters such as typhoons or to poaching, pesticide poisoning or mismanagement. Even though survival rates of fish were assumed to be relatively low in the model, further reductions in fish yield were simulated to identify the minimum yield at which this technology is still profitable. The main difference between this scenario and the price sensitivity analysis for tilapia presented in the previous section can be found on the consumption side of the model—price decreases pertain to both the farm gate and retail price of tilapia and thus have an impact on household food expenses while yield reductions only affect the production side of the model. Consequently, land allocation in the optimum solution is more sensitive to yield reductions than to price changes. The change in land allocation under different yield scenarios is almost identical under conventional pest management and IPM (Figure 9.15). Initially, all land is allocated to rice-fish culture. At 30% yield reduction (corresponding to a total fish survival rate of 35%), a small part of the land is converted to rice monoculture in the first cropping season and at 50% yield reduction (25% fish survival rate) all of the land is taken out of rice-fish culture and grown with rice monoculture in both seasons. As in the price sensitivity analysis, a change in land allocation in the second cropping season takes place at higher yield reductions than in the first season, showing that conditions for rice-fish culture are more favorable at this time of the year. However, for both cropping seasons there is quite a margin over which fish yields can vary before the optimum farm plan changes. In the case of natural calamities (flood, drought), loss of fish can be close to 100%, so that these findings provide no consolation. But in the case of poaching or mismanagement, losses up to 30% can be tolerated and still leave rice-fish culture more profitable than rice monoculture.

Reduced own funds

In previous sections it was frequently mentioned that high cash requirements at the beginning of the crop year can act as a constraint to the adoption of rice-fish culture. Cash is available from own funds or through credit. The following analysis was conducted to identify the impact that reduced own funds have on the optimum farm plan. Initially, the family is assumed to have PhP10 000 at the beginning of the crop year to cover their farming expenses and to purchase food. This quantity was reduced by successively greater amounts until own funds were completely eliminated and all

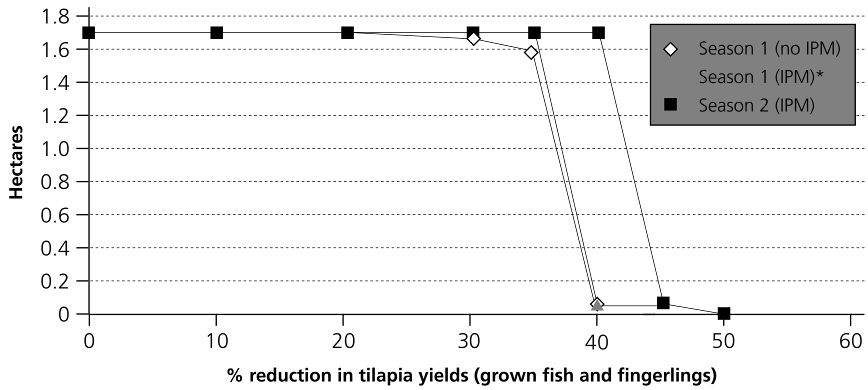


Figure 9.15. Area allocated to rice-fish culture under different yield scenarios for tilapia (conventional pest management and IPM). Source: Own computations. *Season 2 (no IPM) is identical to season 1 (IPM).

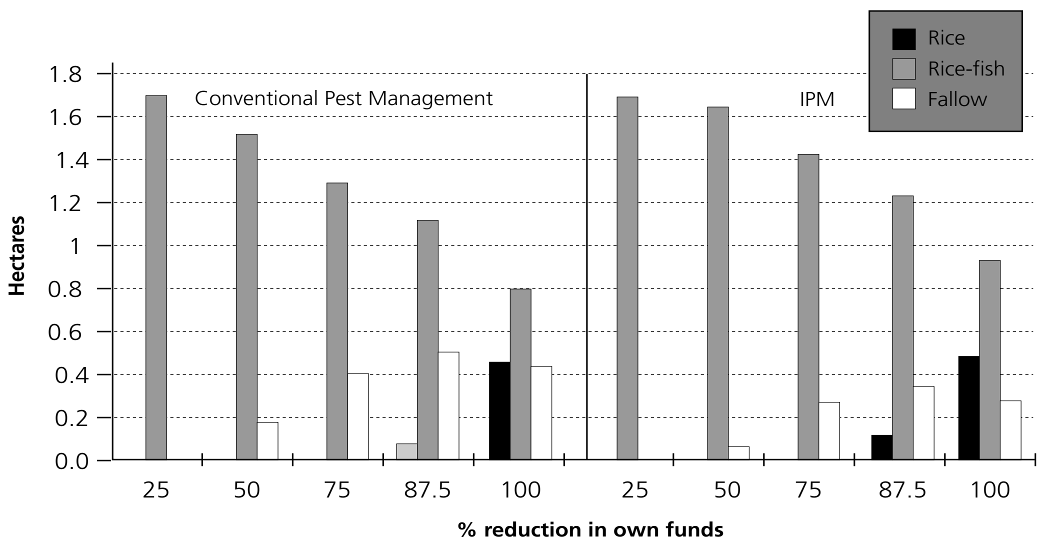


Figure 9.16. Changes in land allocation with a reduction in own funds, first cropping season only. Source: Own computations.

transactions had to be financed through credit. Only land allocation in the first cropping season is affected by these changes since in the second cropping season, enough funds have been generated through the sale of the first season crop to practice rice-fish culture over the whole area. Interestingly, a reduction in own funds does not immediately lead to a substitution of rice monoculture for rice-fish culture, but rather to a continuous reduction in the total area farmed (Figure 9.16). Only at 87.5% reduction of own funds does rice monoculture enter the optimum farm plan. Even when all own funds have been eliminated the farm is still operational and rice-fish culture is practiced on a large part of the area (0.79 ha under conventional pest management, 0.93 ha under IPM). If IPM is practiced, the reduction of rice-fish area is smaller and less land is left fallow than under conventional pest management. This is due to the fact that IPM helps to save cash resources, thus a reduction of own funds under IPM has less impact than under conventional pest management.

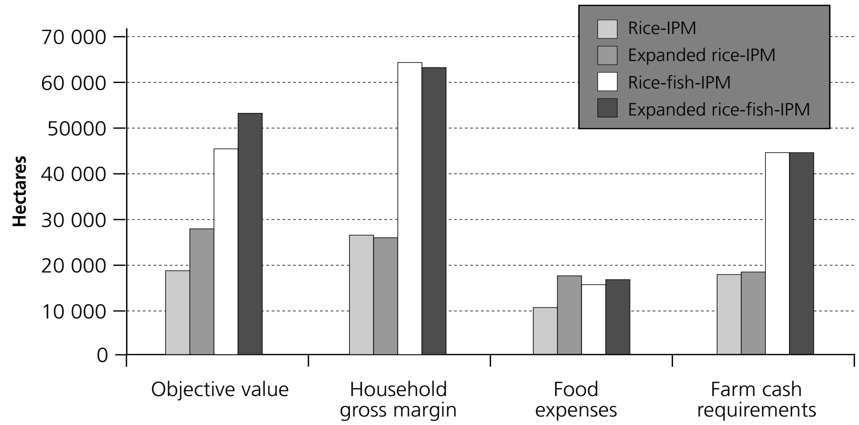


Figure 9.17. Key parameters under reduced and expanded concepts of IPM. Source: Own computations.

Expanding the concept of IPM (including health costs and environmental benefits)

It has earlier been said that through the reduction of pesticide use, IPM has a favorable impact on farmers' health and on the ricefield ecosystem. Health costs of pesticide use have been estimated by Rola and Pingali (1993) for the Philippines. While these costs have no direct influence on farmers' decision making in most cases (due to time lags, lack of knowledge about the cause of the disease and compounding factors such as smoking and drinking), they can be an important incentive for policy makers to support IPM-training. Therefore, the health costs of each pesticide application forgone under IPM (insecticide and molluscicide only) was added to the objective function as an additional benefit of IPM. This change has no influence on the optimum farm plan but increases the objective value of the scenarios with IPM vis-à-vis those with conventional pest management (Figure 9.17). In addition, the environmental benefits of IPM were exemplified by the return of aquatic organisms to the ricefields, as described above. The main impact of these changes is a reduction in food expenses by about 10% in the case of rice monoculture and 13% in the case of rice-fish culture. Under the expanded concept of IPM, the farm family consumes 6 kg of snails, 26.16 kg of crabs, 7.2 kg of mudfish and 16 kg of frogs, spread over the time when these animals occur in the ricefields. Family members spend a total of 6.92 adult working days in collecting and gathering these organisms. Their implicit value or shadow price can be derived from the reduced cost of the slack activity corresponding to the maximum consumption constraint. Increasing this constraint, which limits the consumption of wild aquatic organisms to the levels identified in Chapter 7 by one unit would increase household gross margin on average by PhP41.46 in the case of snails, by PhP22.87 in the case of mudfish, by PhP21.89 in the case of crabs and by PhP24.36 in the case of frogs. Thus, the use of these organisms can present a considerable benefit to the farm family which can be obtained at a low cost. However, especially in the case of wild aquatic organisms, preferences and eating habits play a prominent role, as has been pointed out in Chapter 7. If for such reasons aquatic organisms are only utilized by landless laborers who have no influence on the farmers' decision of whether or not to use pesticides, this ecological benefit will not provide an incentive to the farmer to practice IPM.

Approximating the situation in Nueva Ecija

The description of farming systems in Chapter 6 has led to the conclusion that two types of farming environments can be distinguished which are both typical for the Philippines, namely a relatively central, more market-oriented environment, exemplified by farms in the province of Nueva Ecija and a more remote, subsistence-oriented environment such as in Antique. These environments differ with respect to various parameters such as farm size, household size and off-farm employment opportunities. Up to this point, the potential for rice-aquaculture has been analyzed for the subsistence-oriented environment which is characterized by small farms, big households and limited off-farm employment opportunities leading to an abundance of family labor available for farm work. In the course of economic development, it can be expected that off-farm employment opportunities increase (leading to higher opportunity costs for family labor) and family or household sizes decrease. An increase in farm size is likely if urbanization continues to proceed and young people leave the rural areas in search for better jobs. Thus, in order to describe the situation in Nueva Ecija and to anticipate future developments in remote provinces, the model was re-formulated in the following manner:

- farm size was increased to 2.3 ha (see Chapter 6);
- family size was reduced to five persons (the eldest son of the model family is assumed to have left the household for better work). This has an impact on family labor availability as well as on food requirements. In addition, children are assumed to spend less time on the farm, due to higher schooling requirements (max. 6 days/month for all children).
- off-farm employment opportunities were doubled (i.e., 5.4 days/month for the wife and 5 days/month for the husband).

The main effect of these changes is a growing scarcity of family labor available for farm work. Correspondingly, more hired labor is employed in this farming environment, as can be seen in the costs of hired labor per hectare (Figure 9.18). Another effect of these changes lies in a considerable reduction of returns to land, especially for scenarios which include rice-fish culture (Figure 9.18). In contrast to results obtained for the Antique situation, not all land is converted to rice-fish culture if this option is introduced to the model. In the first cropping season, which has been described as problematic above, less than half of the area is stocked with fish and a small part of the land (0.12 ha) is even left fallow if conventional pest management is practiced.

The stronger dependence on hired labor which can be observed in the scenarios for Nueva Ecija raises the problem of increasing farm wage rates, which can be expected in the case of growing off-

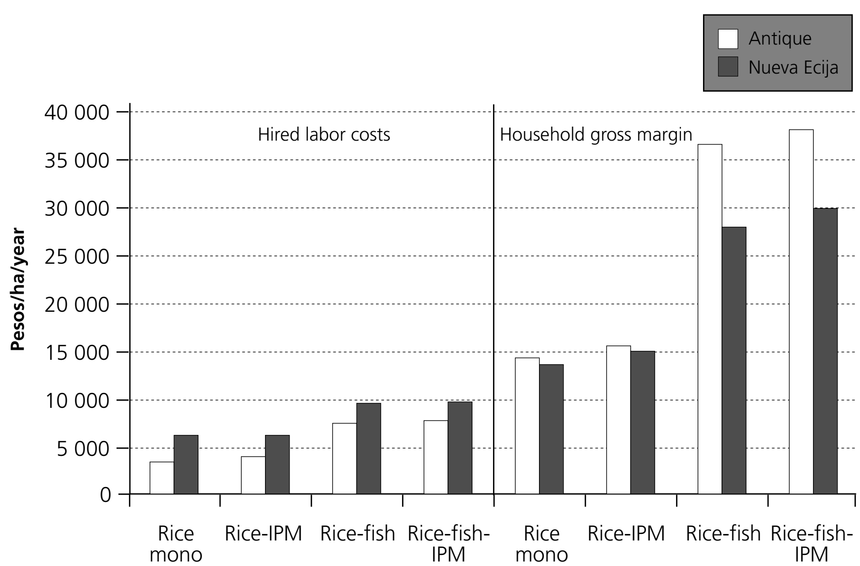


Figure 9.18. Annual hired labor costs and household gross margin for different technology options in two farming environments. Source: Own computations.

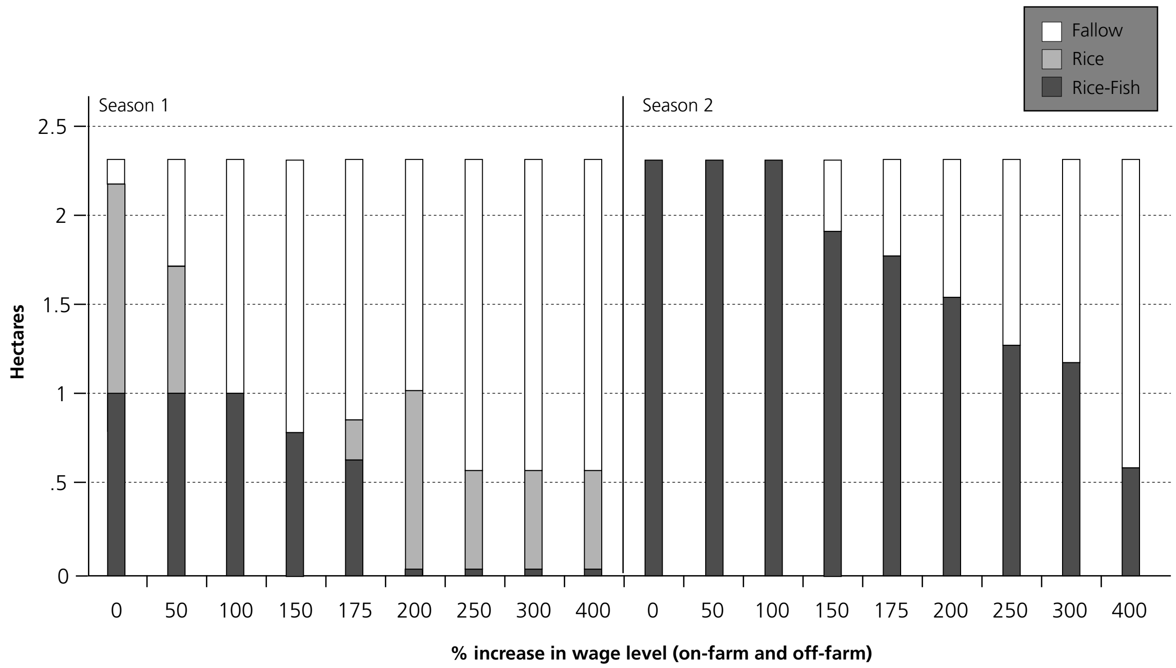


Figure 9.19. Changes in land allocation under different wage levels, Nueva Ecija, conventional pest control only. Source: Own computations

farm employment opportunities. Returns to labor are higher under rice-fish culture than under rice monoculture (see Figure 9.6). Therefore, increasing wage rates initially lead to a reduction in the area under rice monoculture while leaving the area under rice-fish culture constant (Figure 9.19; see also Appendix Table A9.15). Instead, increasingly more land is taken out of production, predominantly in the first cropping season. Only if the wage level is increased by more than 100% is there a decrease in the area under rice-fish culture, both in the first and second cropping. It is an interesting observation that in the first cropping season, rice monoculture returns to the optimum farm plan at high wage increases (175% and more), with a small part of the area still under rice-fish culture. This solution is stable even at 400% of the original wage level. What these results imply is that even though rice-fish culture is more labor-intensive than rice-monoculture, the returns to labor under the former technology are so much higher that the wage level has to increase by more than 175% before rice-monoculture becomes dominant. Thus, growing opportunity costs of labor present no constraint to the adoption of rice-fish culture in the medium run. The results also show, once again, that the second cropping season seems to be more favorable for rice-fish culture than the first season, due to the cash constraints at the beginning of the crop year, as discussed above.

Excursus: Interactive assessment of the potential rice-aquaculture in small-scale rice-based farming systems

A model can only process the information that has been included in its formulation and many aspects will be missed if there is no confrontation between the model results and reality. To avoid this pitfall and to gain further insight into the potential of rice-aquaculture in small-scale rice-based farming systems in the Philippines, an interactive process was initiated between the researcher and a group of farmers in the village of Catungan IV, Sibalom, Antique. This should help to verify the model results and to identify additional constraints in the adoption of rice-fish culture for these particular farmers.

Box 9.1

RAPID APPRAISAL OF CONDITIONS FOR RICE-AQUACULTURE IN THE VILLAGE OF CATUNGAN IV, SIBALOM, ANTIQUE

CATUNGAN IV IS A POTENTIAL SITE for rice-aquaculture in Antique Province because of its flat terrain, abundant water supply and far from the sea[172]. It is located about 7.5 km inland from the provincial capital San José de Buenavista and 4 km from the market town of Sibalom. In 1994, it had a population of 151 households. The municipality of Sibalom is considered the 'rice bowl' of Antique. In Catungan IV, all rice land was irrigated, partly from a larger irrigation system (river diversion) and partly from wells that spring from the ground at various places in the village. A Farmer Field School for IPM was conducted in Catungan IV during the first cropping season of the crop year 1992/93. The village was first visited during the Antique IPM/ALM survey in November 1993. At that time, it was noted that one of the respondents had a fishpond next to his field and that other farmers expressed an interest in this technology. It was therefore decided to conduct a case study on the potential of rice-aquaculture in this village. The first meeting, which was arranged by the president of the People's Organization of Catungan IV, was attended by more than 20 farmers who all participated in the group discussion. The main outcome of this session was a seasonal calendar which brings together aspects of climate, farm activities, fish supply and labor requirements which were all deemed important determinants for a rice-aquaculture enterprise (see Appendix Table A4.2). From this calendar, the conflicting conditions for rice-aquaculture can be derived. In the months of June to November, fish supply from the sea is scarce, thus fish produced in the own field could fetch a good price. However, at the same time the danger of flooding is greatest, making rice-aquaculture a very risky enterprise. The months of February to May is the time when vegetables are grown. Water supply is often not sufficient for a third rice crop, much less so for an aquaculture operation. The supply of marine fish alternates with supply of wild aquatic organisms from own field—the dry season is peak fishing time, whereas during the wet season, aquatic organisms can be gathered from the field. The calendar also shows labor peaks during the year, which occur during land preparation and harvest time. For the establishment of a rice-aquaculture operation, participants in the discussion suggested the following time plan: make the necessary field modifications (pond refuge, raised dikes) during the dry season, after the harvest of the second rice crop (but before the soil becomes too hard). When the rain comes, the pond can be filled with water, but stocking should not take place before September, when the danger of typhoons is less. Fish could enter the rice fields during the second cropping season and would be ready for harvest before the ponds fall dry (February/March). With the help of the seasonal calendar, it was thus possible to design a rice-aquaculture system which fits the specific conditions in this village.

Five farmers were included in the process. They had all expressed an interest in rice-fish culture and had attended the group discussions which were initiated during the first visits to the site (see Box 9.1).

The model, which was formulated to represent a 'typical' farmer in the irrigated lowlands of the Philippines, was adapted to the specific situation of the five farmers by including information on farm size, household composition and size, as well as on other employment opportunities and income

172 In Antique, most of the villages with irrigated riceland are located along the coast and thus obtain their fish directly from the sea. Sibalom is one of the two municipalities in Antique which have no direct access to the sea and has to rely on travelling fish vendors from other places.

sources. The farmers had been interviewed on several occasions and every refinement of the model required another visit to fill in data gaps. In this sense, an interactive process between researcher and farmers was already initiated at the stage of model formulation. While farmers were not directly confronted with the results of the model at this point, inconsistencies and misunderstandings could be clarified by talking about specific aspects of the model that proved to be difficult (e.g., credit conditions, labor availability, own funds).

The model was then solved separately for each individual farmer, both with and without fish. The model results showed that all farmers could improve their income by investing in a rice-aquaculture enterprise. However, there might be other options for diversification out of rice and the model specification might not have been complete. In order to find an entry point for discussion, the Philippines economic development program called 'Philippines 2000', which was discussed widely during the time of the study, was changed into 'Catungan 2000-what will your farm look like in the year 2000?' For visualization purposes, the bioresource flow models prepared by the farmers for their respective farms (see Chapter 6) were copied onto one half of a piece of paper while the other half was left empty, to be filled with the farmer's plans for the year 2000. The five farmers were confronted with the household gross margin of their current operation as the main model result. All farmers stated that they wanted to improve their economic situation by the year 2000 and some already had definite plans. However, only two farmers considered aquaculture as a possible enterprise. These farmers already possessed small fishponds in which they cultured tilapia and mudfish. While they had pondered the option of stocking fish in their ricefields, they were more interested in growing catfish in concrete tanks. They pointed out that catfish has a higher value than tilapia and that the fish could be better protected in tanks close to the respondents' houses. Catfish culture requires considerable management skills. However, these farmers were already discussing techniques of induced spawning and were planning to obtain the necessary chemicals from the BFAR station in Iloilo.

All farmers agreed that there are three major location factors which determine the success of an aquaculture operation: a reliable water supply, the area must be free from flooding and the site must be close to the house. The lack of such sites was the main reason why the other three farmers did not consider rice-aquaculture a viable alternative to their current production system. Catungan IV is located along a creek which frequently overflows during the rainy season and it is impossible to protect a pond refuge in a field which is prone to flooding. In fact, the two fishpond owners reported that a large part of their fish had escaped during the rainy season. Distance of the field from the house is regarded as equally important by the farmers because the fish need to be protected against poaching. The existing fishponds in the village of Catungan IV can all be found on the homesteads of the respective farmers.

Chapter 10

Discussion and conclusions

In the previous chapters, the role of rice-aquaculture and IPM has been analyzed with respect to the three problem areas of income, nutrition and environmental sustainability of rice production. While income and nutrition are closely related aspects which were both considered in the model analysis in Chapter 9, environmental sustainability takes a special place because of the dynamic nature of the problem and the fact that the farmer might not be aware of the benefits of sustainable practice. Therefore, this aspect was analyzed separately in Chapter 8 and will be discussed first.

IPM, rice-aquaculture and environmental sustainability of rice production

Sustainability of farming practices was not actually measured but it was assumed that certain technologies are more likely to be sustainable than others. In this context, IPM takes a prominent role. As was shown in the problem analysis, pesticide use poses a major threat to the ricefield ecosystem. The practice of IPM is a promising alternative to conventional pest management and is regarded as a step towards environmental sustainability of rice production. For aquaculture, an equivalent concept was developed which was called ALM.

It was hypothesized that farmers trained in IPM would extend their knowledge about ecosystem processes to the aquatic organisms in the ricefield and start practicing rice-aquaculture in an environmentally friendly way. The aquatic organisms would act as an incentive not to use pesticides and increase farmers' motivation to practice IPM. The combination of IPM and ALM was thus seen as a way to generate sustainable farming practices. However, the analysis of the relationship between IPM and ALM revealed that the hypothesis of complementarity between IPM and ALM in the perceptions and actions of farmers cannot be supported. While IPM-training has a significant positive effect on farmers' proficiencies and skills with regard to IPM, no such effect could be found for ALM. Furthermore, there is no significant association between scores for IPM and for ALM among the group of trained farmers.

There are two possible explanations for this finding. First, it can be concluded that topics relating to ALM are not covered by the IPM-training. The training outline is focused on rice and the related pest/predator complex. Even though fish and frogs have been found to control rice pests to a certain extent (e.g. Halwart 1992, 1994b), their perceived relative importance compared to beneficial insects and spiders is so low that they are not explicitly considered in the training. It has been pointed out that the main role of aquatic organisms in IPM is not the control of pests but rather the increase in the economic threshold level (Waibel 1992). Potential income from fish is considered as an opportunity cost due to the use of insecticides. This aspect could be incorporated into IPM training outlines to increase the attractiveness of IPM for farmers. However, as the Antique IPM/ALM survey has shown, farmers are already well aware of the detrimental effect of pesticides on aquatic organisms, regardless of whether they have been trained or not. The fact that despite this knowledge untrained farmers continue to use pesticides indicates a certain helplessness with regard to pesticide use. Untrained farmers do not seem to see any other way of controlling rice pests, even if chemical control leads to a decline in the population of aquatic organisms in the field. From this point of view, IPM training can play a very important long term role.

Second, the observation that trained farmers do not extend their improved understanding of ecosystem processes to the aquatic component of the ricefield ecosystem indicates that there is a lack of interest in ALM by farmers which is not related to pesticide use. This is further confirmed by the finding that most farmers claim to utilize wild aquatic organisms from their fields but do not take any steps towards their culture and preservation. Some possible reasons for this lack of action are discussed in relation to the nutritional and income aspects of rice-aquaculture further below.

The finding that there is no significant association between IPM and ALM points to a potential problem if rice-aquaculture is promoted on a large scale. Aquaculture can be practiced at different levels of intensity. Pullin (1989) distinguishes between intensive, semi-intensive and extensive aquaculture systems, which differ in the amount of external inputs (feeds and fertilizers) used. Pesticides for the control of predators or antibiotics for disease treatment are other external inputs which can differ among production systems. High levels of intensity are commonly associated with adverse environmental impacts such as water and soil contamination, aquatic disease outbreaks and the danger of producing drug-resistant pathogens. Integrated agriculture-aquaculture systems such as those discussed in this study normally fall under the semi-intensive class—some feeds are used and fertilizers applied to the crop simultaneously enhance primary production in the water which can serve as fish feed. But even within these systems, differences with regard to input use can be detected. Purba (1997) reports that it is common practice among rice-fish farmers in Indonesia to apply insecticides to eliminate predatory fish and insects before stocking fish. Thus, rice-aquaculture is not an environmentally friendly farming practice per se but, just like rice production, requires knowledge of non-chemical pest control methods and ecosystem processes to become sustainable. Even though the understanding of the detrimental effects of pesticides on the ricefield ecosystem by IPM farmers gives reason to hope that these farmers, should they ever practice rice-aquaculture, will apply the same principles to the aquatic organisms as they do to their rice crop, it is imperative to develop integrated pest control for fish in the design and promotion of rice-aquaculture technologies.

In most cases, the environmental impact of different farming practices is not restricted to the individual farm. Renunciation of pesticide use on a large scale (at the village or irrigation system level) creates favorable conditions for the recovery of wild populations of aquatic organisms. The analysis of utilization pattern of wild aquatic organisms from ricefields presented in Chapter 7 has revealed that these organisms are predominantly used by landless laborers, who belong to the most nutritionally at-risk groups in the Philippines. It has been pointed out that the introduction of culture systems for aquatic organisms can deprive the landless from this cheap source of animal protein by converting the open access character of aquatic organisms in ricefields to private property. Furthermore, the notion that wild fish in rice-aquaculture systems should be controlled because they prey on the cultured fish is not only problematic because of pesticide use but can lead to conflicts between farmers and landless laborers who utilize these wild fish. From the point of view of the landless, IPM is beneficial because it improves the growing conditions for aquatic organisms. For them, rice-aquaculture can have advantages (improved supply of fresh cultured fish in the village) and disadvantages (reduced supply of wild fish) which depend on the extent of rice-aquaculture operations within a village, the control methods employed and the role of wild aquatic ricefield organisms in their diet. On the other hand, farmers who consider rice-aquaculture as an alternative to rice monoculture often fear that poaching reduces the profitability of this enterprise. The practice of ALM in rice-aquaculture operations can help to minimize these problems because it would leave wild populations of aquatic organisms in irrigation canals and non-stocked fields intact which can then be utilized by landless laborers. This could reduce the incidence of poaching in stocked fields and thus serve as an incentive to rice-aquaculture farmers not to use pesticides.

The aspect of conflicting interests with regard to wild aquatic organisms has been neglected in previous analyses of rice-aquaculture systems, even though poaching or willful poisoning of fish has been cited frequently by farmers as a constraint to successful rice-aquaculture. In addition to the promotion of ALM in future extension programs for rice-aquaculture, an agreement between farmers and landless laborers seems to be an important precondition for rice-aquaculture adoption. Such an agreement, which could for example involve landless laborers in rice-aquaculture operations for a share in the fish harvest, has to be seen as an additional cost to rice-aquaculture. If these costs become prohibitively high, they pose a constraint to rice-aquaculture which can help to explain the lack of adoption in otherwise favorable locations.

The role of rice-aquaculture in nutrition

With regard to the impact of rice-aquaculture on the nutritional situation of people in rice-based farming systems, the findings can be summarized as follows:

There are considerable differences in the average diet among groups of respondents. One difference refers to the nutritional adequacy of the diet in the provinces of Antique and Nueva Ecija. While in the case of rice-fish farmers in Nueva Ecija the nutritional requirements are met for most food groups, the diets of rice farmers in Antique and of non-rice-fish farmers in Nueva Ecija are far from adequate. However, the nutritional problems for these two groups of people are different. Rice farmers in Antique lack all important food items, including energy foods (carbohydrates), protein foods, fruit and vegetables. Compared to the non-rice-fish farmers in Nueva Ecija, they exhibit a greater intake of protein foods, but a smaller intake of energy foods. Their diet can be described as insufficient but relatively balanced. Based on the discussion of nutritional problems in Chapter 2, it seems most urgent to improve their overall calorie intake, but an additional supply of protein foods (especially if this leads to cash savings which can be used to buy more rice, vegetables and/or fruit) can also improve their nutritional situation. In contrast, non-rice-fish farmers in Nueva Ecija have the highest intake of energy foods but the lowest intake of protein foods among all monitored groups. Their diet is sufficient in terms of calories, but unbalanced. For these people, an improved supply of animal protein foods is most important.

The second difference refers to the sources of animal protein foods among different groups of respondents. Fresh fish is the most important source of animal protein for all respondents. However, the share of fresh fish in people's diet is almost twice as high in Antique as in Nueva Ecija. In contrast, the share of meat and eggs in the diet is considerably greater in Nueva Ecija than in Antique. Two possible explanations for these findings are the varying distance from the sea and the different income levels in the two provinces. With regard to the location relative to the sea, Antique is typical for all provinces in the Visayas as well as for the coastal provinces of Luzon and Mindanao. In a country comprised of more than 7 000 islands, the majority of the people live close to the sea, especially because most islands are characterized by fertile coastal plains and rough, mountainous centers. Nueva Ecija is typical for the central provinces of Luzon and Mindanao which represent only a small fraction of the total land area. It can thus be assumed that most Filipinos have ready access to fresh marine fish, which is also reflected in the high national average of per-capita fish consumption (see Chapter 2).

Two other findings are important in this context. On the one hand, prices for marine fish in the Philippines have not increased more strongly than prices for other food commodities until the early 1990s, thus the exploitation of marine resources is not yet felt by consumers. On the other hand, people in coastal provinces such as Antique prefer marine fish over freshwater fish and wild freshwater fish species over species cultured in ricefields. Unless prices for marine fish increase significantly in the future, it can thus be concluded that the market potential for the most commonly cultured fishes in ricefields (tilapia, carp) is low in coastal areas and increases with rising distance from the sea.

The big share of meat and eggs in the Nueva Ecija diet can be linked to the higher average income in this province (see Chapter 7). It has been shown that meat has a higher income elasticity of demand than fish[173]. Thus, with rising income people will substitute meat for fish in their diet or change to higher-valued fish species[174]. As will be discussed below, the consumption of wild or cultured aquatic organisms from ricefields is not likely to increase with rising incomes.

These observations have contrasting implications for the market for aquatic organisms from ricefields and thus for the potential of rice-aquaculture. High average incomes *ceteris paribus* reduce the market potential for aquatic organisms from ricefields because of people's higher preferences for meat. In contrast, a growing distance from the sea *ceteris paribus* increases the potential of rice-aquaculture (Figure 10.1). The combination of high incomes and great distance from the sea as in Nueva Ecija, or of low incomes and small distance from the sea as in Antique, present intermediate cases where the market potential of aquatic ricefield organisms is determined by the relative importance of these two variables as well as by other factors. In the case of Antique, people's dislike of tilapia and carp has to be regarded as such an 'other factor' which severely constrains the potential of rice-aquaculture in this province.

		Income	
		Low	High
Distance from the sea	Near	medium (farmers in Antique)	low
	Far	high (non-rice-fish farmers in Nueva Ecija)	medium (rice-fish farmers in Nueva Ecija)

Figure 10.1. The influence of income and distance from the sea on the market potential of aquatic ricefield organisms. Source: Own illustration.

173 This can be stated for the aggregate of all fish species. However, there are certain fish species (milkfish, Spanish mackerel, banded cavalla) which are more expensive than others and which are likely to have a high income elasticity of demand.

174 However, it should be kept in mind that in provinces with higher average incomes, there can still be a large number of people below the poverty line who would benefit from an additional supply of cheap animal protein foods.

With regard to the hypothesis that the nutritional situation of farm households can be improved through the culture and use of aquatic organisms from ricefields, the following conclusions can be drawn: if farmers in favorable locations take up rice-aquaculture as a new enterprise in their farming system, they will be able to improve their nutritional situation, either through the consumption of own aquatic organisms or through the additional income derived from this enterprise (see below). However, whether they opt for this technology depends, among other things, on the local market and on their own preferences for different types of food, particularly for different types of fish.

Catching aquatic organisms from ricefields is a common practice in the Philippines. The most commonly used organisms are fish, frogs, crabs and snails. They are available mainly during the rainy season and are used for own consumption. Only if own consumption needs are met, are they sold in the neighborhood or in the market. However, in terms of quantity, wild aquatic organisms from ricefields only play a marginal role in the diet of Philippine rice farmers. Even though no information exists on the diet composition of landless laborers, there are indications that wild aquatic organisms from ricefields are used more extensively by this group than by farmers. This finding, in addition to raising problems of access rights and the environmental impact of rice-aquaculture (see above), attaches the connotation of 'poor man's food' to these organisms. This corresponds to the review by Scoones et al. (1992) who point out that wild foods are particularly important for the poorest households and for women and children. Sanjur (1990) stresses the importance of sociocultural aspects in the choice of food and explains how foods acquire more or less social status through their association with different socioeconomic groups. The low social value of wild aquatic organisms can help to explain the lack of interest in ALM among rice farmers reported in the previous section. Consequently, an improved supply of wild aquatic organisms in ricefields, e.g. through the widespread practice of IPM, is not likely to improve farmers' nutritional situation because of the low value associated with this type of food. It can, however, improve the nutritional situation of landless laborers, who are most in need of additional protein sources.

The income effect of rice-aquaculture and IPM

In this study, the income effect of rice-aquaculture and IPM was analyzed with the help of a linear programming model. From the model computations, it has become apparent that concurrent rice-fish culture as recommended in the Philippines can be a highly profitable alternative to rice monoculture for small-scale farmers in the irrigated lowlands, provided that location factors are favorable. In the discussion of location factors which affect the comparative advantage of integrated rice-aquaculture systems, a distinction can be made between factors which favor the diversification of farming systems (i.e. the integrating forces introduced in Chapter 5) and the specific location factors for fish. While the former have been found to be favorable for a rice-aquaculture integration in Southeast Asia and the Philippines, the latter can vary widely among regions, among individual farms in one region and even among the individual fields in one farm. It should be kept in mind that the model was designed for a farm-household system which has favorable conditions for rice-aquaculture. Deviations from these conditions and their impact on the profitability of rice-aquaculture are discussed subsequently.

The increase in household gross margin due to rice-fish culture in the model is considerably higher than empirical results reported in the literature. On the one hand, empirical data are likely to underestimate the benefits from rice-fish culture because fish consumed in the household is rarely included. On the other hand, the stocking density of 20 000 fish/ha is seldom used by farmers but more likely on research stations, leading to higher fish yields in the model farm than can be found under farmers' conditions. However, the computed fish yield of 476 kg/ha/cropping season is well within the range of fish yields cited in the literature, provided that no disaster strikes the farm (Lightfoot et al. 1992).

In the optimal solution of the base model, which simulates the situation in Antique, all land is allocated to rice-fish culture, regardless of the pest management strategy employed. While this solution stresses the relative superiority of rice-fish culture as compared to rice monoculture, it is not typical for existing rice-fish systems in the Philippines (own observations) or in Indonesia (Purba 1997). Typically, farmers convert only a part of their fields, either because of differential soil quality, water control or distance from their house. These parameters were not included in the model because they are difficult to quantify. The model results suggest that a farmer with suitable fields should convert as large an area as possible to rice-fish culture.

In the scenarios which attempted to approximate the situation in Nueva Ecija, less than half of the land is converted to rice-fish culture in the first cropping season and a small part of the land is left fallow. While this solution might be optimal from an economic point of view, it is not likely to be found in reality. The first rice crop is traditionally the most important crop, dating from the times when only one crop of rice could be grown during the rainy season. It is also the crop which ends the lean months of the year. Therefore, all land will be planted with rice, even if this means that total farm gross margin is not maximized.

Even though risk was not considered directly in this model, the simulation of different price scenarios for tilapia and of different fish survival rates can give an indication of the stability of the optimal solution under varying external conditions. While price variations were associated with different locations[175], the changes in fish survival rate were included to account for catastrophes such as typhoons, floods or drought as well as for poaching, poisoning and mismanagement. Both sensitivity analyses showed an impressive stability of the optimal solution in which all land is allocated to rice-fish culture. Only if tilapia prices are reduced by 45% or if tilapia survival rates have fallen to 35% does this optimal solution start to change. Even though the formulation of rice-fish culture technology in the model was very cautious, with rather high amounts of input (labor, feeds) and no positive impact on rice yields, these results show that compared to rice monoculture, rice-fish culture is more profitable for a wide range of external conditions.

The model results also indicate, however, that there are certain constraints which might hinder the adoption of rice-fish culture. One of these is the increase in cash requirements at the beginning of each crop year when most cash resources have been exhausted. Stocking fish only in the second cropping season can be a solution to this problem which would also reduce the danger of flooding[176]. This, however, requires adequate water supply during the second cropping season. But cash requirements for rice-fish culture are not only higher at the beginning of the crop year, they are more than twice as high as for rice monoculture for the whole crop year. Farmers with fewer own funds or less access to credit than assumed in the model may not be able to finance the additional expenses[177]. Furthermore, if they perceive rice-fish culture to be more risky than rice monoculture, they might not be willing to invest their scarce resources in this enterprise. It has often been stated that initial field modification

---

175 The same sensitivity analysis can be applied to the analysis of price decreases in one location due to increased supply.
176 In the Philippines, most typhoons occur in the months of June to November (Hanisch 1989).
177 Practice of rice-fish culture on a small part of the available land can reduce this problem.

costs might be a constraint to the adoption of rice-fish culture. While this is certainly true, the additional cash requirements in every following year can be seen as another drawback of this technology to small-scale farmers.

Another constraint is the increased labor demand for rice-fish culture during peak times, especially during the harvest time for rice and fish. It has been shown that for the fish harvest, additional hired laborers are employed who are paid in cash. Thus, the labor constraint corresponds closely to the cash constraint discussed above.

Two different approaches can be visualized to circumvent these problems. With regard to labor peaks, farmers could reduce the fish culture period by stocking bigger fingerlings. While these are more expensive than smaller fingerlings, fish harvest could take place some time before the main rice harvest starts. This could help to reduce hired labor costs because family labor is not engaged in rice harvest activities. However, profitability of fish culture is reduced and the growing period might not be sufficient. Hired laborers still need to be paid in cash which only becomes available after the rice harvest[178]. On the other hand, farmers could opt for a larger, improved pond refuge which can be separated from the field. At rice harvest time, the field can be drained and the fish can be kept in the pond until more time is available. This, however, would increase the pond construction costs and might lead to overcrowding in the case of high stocking densities. In addition, labor is required to guide the fish from the field into the pond. A combination of the two options, i.e. catching the larger fish some time before rice harvest and keeping the rest in the pond until after the rice harvest, might prove to be the most viable solution to avoid labor and cash constraints.

Another way to avoid constraints in resource availability could be the attempt to de-couple the production cycles of rice and fish, as practiced in Indonesia. In places such as Nueva Ecija, where fixed irrigation schedules dictate the cropping seasons and leave some time in-between, ricefields could be converted to ponds during the fallow period. However, this requires that the farmer has access to water resources other than the irrigation system. In most cases, fallow periods exist precisely because there is not enough water available for another crop, much less so for an aquaculture operation. In Indonesia, the dry season is less pronounced than in the Philippines (Schultz 1988), thus an intricate system of rice and fish production cycles has developed over decades which maximizes the use of the available land, water, labor and cash resources. To accommodate a greater number of fish production cycles, ricefields were used as fish nurseries to produce fingerlings for intensive running water systems or cage culture in reservoirs (Koesoemadinata and Costa-Pierce 1992). Purba (1997) reports that ricefields are most suitable for growing small fish and that growing large fish in ricefields is not efficient. However, while nursery systems reduce the danger of poaching because the fish have not yet reached edible size, this can only be an option in the vicinity of large reservoirs or lakes where grow-out operations are practiced. In the Philippines, tilapia cage culture is mainly practiced in Laguna de Bay. Yater and Smith (1985) as well as Gaite et al. (1985) describe tilapia hatcheries which have developed in the vicinity of this lake largely as backyard operations. However, while many hatchery operators are also rice farmers, there is no report of rice-fish culture in these areas. This observation suggests that fish seed can be stocked directly into cages and that the additional benefit

178 There is also the possibility to pay hired laborers in kind, i.e. let them have a share of the fish harvest. However, because of storage problems in the case of fish this option can only work for small rice-fish operations.

derived from growing larger fingerlings in ricefields is too small to induce farmers to start nursery operations. The lack of traditional rice-fish systems in this area and unfamiliarity with management practices might be another reason why ricefield fish nurseries cannot be found.

Compared to the income effect of rice-fish culture, the impact of IPM on household gross margin is rather small. However, it should be kept in mind that IPM is not a fixed set of activities and that the formulation of IPM used in the model is only one of many possible manifestations of IPM. Farmers may opt to use their own seeds if weed control can be achieved through land preparation and/or water control and if they have used a variety with resistance to major pests before. This would increase the benefits from IPM. On the other hand, the need for alternative control methods can arise if pest populations are high, leading to increased costs and reduced benefits from IPM. Rice yields can be higher or lower under IPM than under conventional pest management, depending on environmental conditions, pest populations and management practices employed. Thus, incentives to practice IPM will mainly have to come from the consideration of opportunity costs due to pesticide use. One such opportunity cost was considered when health costs of pesticide use were introduced into the model. This modification increased the objective value but had no impact on household gross margin or cash balances because of the difficulty of linking health costs with individual pesticide applications. Whether or not health costs can be an incentive for farmers to stop using pesticides depends on their knowledge about the harmful effects of pesticides on human health which can be greatly improved through IPM training. Another opportunity cost of pesticide use which can have a more direct impact on farmer decision-making was considered through the effect on aquatic organisms in ricefields. Aquatic organisms were assumed to return to the field in certain quantities under IPM and only family labor was required to catch them. In the optimal solution, the maximum amount of aquatic organisms is caught and consumed in the household, leading to between 10% and 13% reduction in food expenses. The shadow prices for these aquatic organisms are higher than the cheapest source of animal protein available in the market, indicating that aquatic organisms have a considerable nutritional value. However, as the discussion of the role of aquatic ricefield organisms in people's diet has revealed, the connotation of 'poor man's food' associated with these organisms can reduce the subjective values attached to them and thus reduce the farmer's subjective opportunity costs of pesticide use.

Together with the environmental and nutritional aspects of rice-aquaculture, the model analysis has helped to identify a number of problems which can explain the low level of adoption of rice-aquaculture in the Philippines. In addition, the discussion of model results with farmers who at a first glance are potential adopters of this technology, revealed that the benefits can only be reaped if the threats of flood, drought and poaching can be overcome. These factors have never been part of economic analyses of rice-aquaculture systems. Distance of the field from the house has frequently been cited by farmers as one of the main determinants for the suitability of a field for rice-aquaculture. If this aspect is accounted for, it becomes clear that among all irrigated fields within a village, only a small fraction is actually suitable for rice-aquaculture. Thus, figures defining the potential area for rice-aquaculture in a country (e.g., Lightfoot et al. 1992) will likely have to be corrected and cannot be based on macro-level indicators alone.

The fact that rice-fish systems are practically non-existent in the Philippines (even though resource endowments and location factors are favorable in many areas) indicates that farmers can use their time and other resources more profitably (or with a higher utility, depending on their preferences) in other activities. This situation could change if fish prices would increase due to a growing scarcity of marine fish. However, in the Philippines fish prices did not increase faster than prices of other food commodities until the early 1990s. Thus, the market did not provide any incentives for farmers to practice rice-aquaculture. If small-scale farmers consider aquaculture, they seem to prefer systems which can be kept close to the house to protect themselves against poaching, e.g. small backyard ponds. They do not see the benefit of letting the fish swim in the ricefields, where they can easily either escape or be caught by other people. Furthermore, many farmers own their homestead but not the land they farm. For them, it is easier to construct a backyard pond than to negotiate with their landlord the conditions for rice-aquaculture operation. Thus, rice-fish culture as it is commonly promoted only seems to be an option for subsistence fish production and only in very particular circumstances which can be classified into technical (reliable water supply and water control, source of fingerlings, field close to the house, no danger of pesticide poisoning), institutional (secure land tenure, agreement with landless laborers on the use of aquatic organisms from the field) and individual aspects (preferences for different types of fish, acceptance of aquatic organisms as food, preferences for income and leisure). If all these factors are taken into account, it becomes clear that while there are certainly niches for rice-aquaculture in the Philippines, it is not likely to be adopted on a large scale and should not be promoted as a national program under the current conditions.

Chapter 11

Summary

Small-scale farmers in intensive rice-based farming systems in the Philippines are facing a set of three interrelated problems: maintaining an adequate income, securing a balanced diet for their families and preserving their natural resource base for future agricultural production. In the course of the Green Revolution, farmers have increasingly become dependent on external inputs such as fertilizers and pesticides. Combined with a growing cropping intensity, this development has led to the degradation of the ricefield environment and to increasing ecological and human health costs due to the injudicious and unsafe use of pesticides. On the other hand, declining marine catches due to overfishing and exploitation of stocks emphasize the need to look for alternative sources of animal protein for an ever growing population.

To combat these problems, a number of strategies have been proposed. This study has concentrated or focused on two alternative technologies to intensive rice monoculture, namely rice-aquaculture and IPM.

Rice-aquaculture has long been regarded as an environmentally sound alternative to intensive rice monoculture for small-scale farmers in Southeast Asia. While populations of wild aquatic organisms from ricefields have been drastically reduced with the spread of modern rice varieties, technological progress in aquaculture has helped to overcome many of the problems associated with rice-aquaculture systems. However, adoption of this technology has been minimal in the Philippines.

IPM seeks to minimize pesticide use in rice growing. In the Philippines, farmer field schools (FFS) for IPM have been conducted in several provinces since the early 1990s. The emergence of a new paradigm for IPM based on improved farmers' decision-making and understanding of ecosystem processes offers a way to integrate rice-aquaculture with IPM, the aquatic organisms being an additional incentive not to use pesticides. For rice-aquaculture, an analogous concept of 'Aquatic Life Management' (ALM) was developed to describe aquaculture built on ecological criteria.

Based on the theoretical background of farm production theory and farm household theory, it was hypothesized that rice-aquaculture and IPM have a positive impact on household income and household nutrition. Furthermore, IPM and ALM are seen as complementary concepts which can improve the environmental sustainability of rice production. It was expected that due to synergistic effects between the two technologies, they will reinforce each other, thus overcoming constraints which have hampered adoption of these technologies in the past.

A description of farm-household systems in two Philippine provinces showed that even in the irrigated lowlands, farms consist of a variety of different natural resource types and that rice production is only one among many different farm activities. Rice lands are classified by farmers according to their topography and drainage, which influences their suitability for rice-aquaculture. In Antique, a relatively remote and underdeveloped province, common property resources such as irrigation canals, water courses and roadsides are utilized by many farmers and a wide variety of plants and trees are grown for subsistence purposes in the homestead or in other natural resource types. In contrast, farmers in Nueva Ecija are more market-oriented, with less diversity in their farming systems and less subsistence production than in Antique. These two provinces represent typical cases of irrigated rice production environments in the Philippines.

In farm household theory, the allocation of time and capital among their different uses is the main decision problem faced by the farm household. By using secondary data from the Philippines, it could be shown that rice-aquaculture is a more labor-intensive farming practice than rice monoculture. To assess the availability of family labor for rice-aquaculture, a time allocation study was conducted among a group of farm households in the province of Antique. This study showed that while the women's time is already taken up to a large extent by farm and household activities, men have considerable leisure time which could be utilized for labor-intensive technologies such as rice-aquaculture and IPM.

With regard to the current and potential role of aquatic ricefield organisms in farm household nutrition, the study revealed the following results:

- While wild fish from ricefields are consumed by farmers and landless laborers alike, there are indications that other organisms such as frogs, crabs and edible snails are more appreciated by landless laborers than by farmers. Wild aquatic organisms in ricefields have to be regarded as a common property resource which is available to all members of the community as long as the rice is not damaged. With the introduction of rice-aquaculture systems, this situation is likely to change. From the perspective of landless laborers, it will be hard to understand that cultured organisms are different from wild ones and thus may not be caught by them anymore. What is often perceived as 'poaching' by rice-fish farmers may be regarded as rightful and traditional behavior by landless laborers.
- The food consumption pattern of farm households showed that a typical Filipino meal consists of rice, vegetables and either fish, meat or eggs. While fresh fish is the main source of animal protein in both provinces, it is consumed twice as often in Antique as in Nueva Ecija. In contrast, meat and poultry have a much higher importance in Nueva Ecija where the consumption frequency of this group almost reaches the level of fresh fish. This can be explained by the geographical location of this province in the center of the Philippine's biggest island (limited availability of fresh fish) as well as by the higher average income level in Nueva Ecija (meat has a considerably higher income elasticity of demand than fish).
- The share of aquatic organisms which can be produced or caught in ricefields amounts to only between 4% and 6% of all animal protein foods. However, only farm household members were included in the food consumption study. Based on the results reported above, it can be expected that the share of these organisms is higher in the diet of landless laborers.
- Rice-fish farmers in Nueva Ecija consume more fresh fish than non-rice-fish farmers in the same province. This is partly due to the consumption of cultured fish produced in the own ricefields. In addition, there are indications that rice-fish farmers have a higher income than non-rice-fish farmers which allows them to consume greater amounts of meat and poultry. The small sample size prevents any further conclusions.
- In terms of recommended dietary allowances, the diet of rice-fish farmers in Nueva Ecija seems to be more or less adequate. In contrast, non-rice-fish farmers in Nueva Ecija have a deficient intake of animal protein foods whereas farmers in Antique have a balanced but insufficient diet. The nutritional situation of the latter two groups of farmers could benefit greatly from rice-aquaculture systems, both directly through an increased consumption of fresh aquatic organisms and indirectly through increased income.

- However, a preference ranking of different fish species among women in Antique revealed that marine fish is highly preferred over freshwater fish and that wild fishes occurring in ricefields are valued higher than fishes suited for rice-aquaculture. Thus, as long as prices for marine fish show no significant increase, rice-aquaculture systems stand a low chance of being adopted in areas where marine fish is readily available.

The hypothesized complementary relationship between IPM and ALM was analyzed with the help of scales which measure farmers' proficiencies and skills in both technologies. Due to the lack of existing rice-aquaculture systems in the Philippines, only the impact of IPM-training on farmers' position on the ALM-scale was investigated. While significant differences between trained and untrained farmers could be detected for individual items of the IPM-scale, no such differences were found for items of the ALM-scale. A similar result was achieved by comparing the total scores for IPM and ALM between the groups of trained and untrained farmers. While a clearly significant difference could be detected for IPM-scores, no significant difference was found for ALM-scores. In order to assess whether there is an association between IPM and ALM within each group of farmers, which is masked if scores for IPM and ALM are compared separately, the correlation between IPM scores and ALM scores was determined for the two groups of farmers. No significant correlation was found for the group of trained farmers, but data for untrained farmers yielded a correlation coefficient of $r = 0.30$ at $alpha = 0.0013$. These results imply that trained farmers have increased their knowledge and skills with regard to IPM but have remained at the same level of ALM as before the training. It can thus be concluded that IPM training has no impact on proficiencies and skills with regard to ALM.

Partial analyses of the income effect of rice-aquaculture suggest that this farming practice is a profitable alternative to rice monoculture. In order to analyze this effect in a farm-household context, a linear programming model was developed which simulates the allocation of land, labor and capital for the integrated production of rice and tilapia in a typical Philippine farm- household system, both under conventional pest management and IPM. In addition, the model accounts for the nutritional requirements of the household and allows for time spent in off-farm activities.

In the base model, which simulates a typical farm-household system in Antique, all land is allocated to rice-aquaculture, leading to an increase in the objective value of 174% under conventional pest management and 141% under IPM. However, farm cash requirements for rice-aquaculture are higher by 146% under conventional pest management and by 149% under IPM. While returns to land and labor are considerably greater in the case of rice-aquaculture, returns to cash are slightly higher for rice monoculture under IPM. These results suggest that the availability of own funds or access to credit can be a serious constraint to rice-aquaculture, which is further stressed by the observation that cash requirements are particularly high in the beginning of the first cropping season when most own funds have been exhausted.

Labor requirements also increase considerably under rice-aquaculture. While the need for hired laborers for fish harvest is reflected in increased cash requirements during the last month of each cropping season, family labor is employed more equally throughout the cropping season than in the case of rice monoculture, thus reducing the labor surplus especially of male household members. However, rice-aquaculture has no impact on labor use during the fallow period in the dry season, when the labor surplus is greatest.

Due to the model formulation, a balanced diet is achieved at all times. This is only possible at considerable costs. Monthly food expenses hardly differ among technology options because the minimum cost diet remains the same. While it was expected that food expenses would decrease with the practice of rice-aquaculture, all fish produced in the farm of marketable size are sold and none is consumed in the household. This shows that there are cheaper sources of animal protein available to the farmer than own fish, but it neglects the fact that farmers in reality occasionally catch small amounts of fish for own consumption throughout the year and also consume those fish which are below the marketable size at harvest time.

A price sensitivity analysis for tilapia revealed that price reductions of up to 45% have no impact on the optimal solution of the base model. Further price decreases lead to the gradual replacement of rice-fish culture by rice monoculture. Only at 70% price reduction is rice-fish culture no longer part of the optimal solution. This high stability of the solution indicates that rice-fish culture can even be competitive in areas where the price for these fish is low. At the same time, however, the amount of own fish consumed in the household increases with decreasing prices, reflecting the lower opportunity costs of own consumption. If low prices for tilapia reflect a general dislike for this fish, increased own consumption is not likely to act as an incentive to culture this fish.

To simulate the potential loss of fish due to natural disasters, poaching, poisoning or mismanagement, a sensitivity analysis for reduced fish yields was conducted. The optimal solution of the base model is stable up to a 30% reduction in fish yields, corresponding to a total fish survival rate of 35% (in the base model, the fish survival rate is set at 50%). At a survival rate of 25%, all land is allocated to rice monoculture. In the case of natural calamities (flood, drought, typhoons), fish loss can be close to 100% which poses a considerable risk to the farmers. But in the case of poaching or mismanagement, losses of up to 30% can be tolerated and still leave rice-fish culture more profitable than rice monoculture.

A reduction of own funds available in the beginning of the crop year leads to a decrease in the total area farmed but leaves a considerable part of the land under rice-fish culture. Even though returns to cash in rice-fish culture are lower than in rice monoculture if IPM is the pest management strategy employed, the higher returns to land and labor in rice-fish culture more than offset this effect. However, while this solution might be economically optimal, it is not likely to be accepted by farmers in the Philippines. Especially in the first cropping season, all land is planted with rice and no farmer will consider leaving part of the land idle. Under this premise, cash constraints can indeed act as a constraint to rice-aquaculture.

If additional benefits of IPM such as reduced health costs due to pesticide use and increased populations of wild aquatic organisms are included in the model formulation, the main effect on the farmers is a reduction in food expenses because of the consumption of snails, frogs, crabs and fish. Whether this option presents an incentive to farmers not to use pesticides, depends to a large extent on farmers' preferences and eating habits. Health costs can often not be linked with individual pesticide applications and thus are more likely to influence policy makers in promoting IPM programs than to directly influence farmers' pest management decisions. Nonetheless, they are considerable and should therefore be part of any IPM training schedule.

In approximating the situation in Nueva Ecija, farm size was increased, household size was reduced and off-farm employment opportunities were expanded. This led to a greater reliance on hired labor and consequently to greater costs. Contrary to the scenarios for Antique, not all land is stocked with fish and returns to land are considerably reduced. It can be concluded that the competitiveness of rice-aquaculture increases with a growing ratio of family labor over land.

An interactive process between farmers and researcher was initiated to fill in data gaps and to verify model results. This process revealed that while farmers expressed an interest in rice-aquaculture, they had other priorities such as livestock raising and vegetable culture. Furthermore, farmers preferred to have backyard fishponds rather than converting their ricefields for a rice-aquaculture enterprise. Backyard ponds are easier to control in terms of flood, drought and poaching; they can be constructed near the house and tenants do not have to negotiate with their landlords the conditions of a rice-aquaculture operation. In addition, backyard ponds can be used for the culture of higher-valued fish such as catfish.

It is concluded that while there is a niche for rice-aquaculture in Philippine rice farming systems, it is not likely to be adopted on a large scale. Figures defining the potential area for rice-aquaculture in a country should be adjusted to account for the differential types of riceland as well as for the distance of fields from the farmer's house. Food consumption habits need to be considered in the promotion of new agricultural or aquaculture products and farmers should be given the opportunity to select among different options for diversification rather than facing only one alternative. IPM improves the environmental sustainability of rice production and can lead to a return of wild aquatic organisms to the ricefields. The revival of capture systems of rice-aquaculture through IPM is the least costly, least risky option which benefits landless laborers as well as farmers and steps should be taken to integrate the management of aquatic organisms in ricefields with IPM training programs.

Chapter 12

References

Acosta, B.O. and R.S.V. Pullin, Editors. 1991. Environmental impact of the golden snail (*Pomacea* sp.) on rice farming systems in the Philippines. ICLARM Conf. Proc. 28, 34 p. ICLARM Contribution No. 676.

ADB (Asian Development Bank). 1987. Handbook on the use of pesticides in the Asia-Pacific Region. ADB, Manila, Philippines.

ADB (Asian Development Bank). 1991. Agricultural sector profile of the Philippines. ADB, Manila, Philippines.

ADB (Asian Development Bank). 1993a. Fisheries sector profile of the Philippines. ADB, Manila, Philippines.

ADB (Asian Development Bank). 1993b. Key indicators of developing Asian and Pacific countries. ADB, Manila, Philippines.

Ahmed, M., M.P. Bimbao and R.C. Sevilleja. 1992. The economics of rice-fish in Asian mixed farming systems—a case study of the Philippines, p. 207-216. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

AIT (Asian Institute of Technology), Aquaculture Outreach Project. 1990. An economic comparison of the benefit of small-scale integrated fish culture against other crop options in the Northeast of Thailand. Working Paper No. 5, Aquaculture Outreach Project, AIT, Bangkok, Thailand.

Ali, B.A. 1992. Rice-fish farming development in Malaysia: past, present and future, p. 69-76. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Alsagoff, S.A.K., H.A. Clonts and C.M. Jolly. 1990. An integrated poultry, multi-species aquaculture for Malaysian rice farmers: a mixed integer programming approach. Agricultural Systems 32: 207-231.

Amaritsut, W., W. Prasartsri and I.A. Craig. 1988. Crop protection and IPM in rainfed cropping systems in Northeast Thailand, p. 135-143. *In* P.S. Teng and K.L. Heong (eds.) Pesticide Management and Integrated pest management in Southeast Asia. Consortium for International Crop Protection, College Park, Maryland, USA.

Anonymous. 1992. Severe fish shortage predicted in 3 years. Philippine Times Journal, 12 November 1992: 15.

Anonymous. 1993. RP suffers worst fish shortage, says BFAR. The Sunday Times, 21 November 1993.

Arano, R., S. Dondeyne, K. Opoku-Ameyaw, O. Puginier, N. Shrestha, C. Sumande and F. Turay. 1992. An analysis of rice-based farming practices in Valderrama, Antique, Philippines. ICRA Research Report, Wageningen, Netherlands.

Ardiwinata, P.O. 1957. Fish culture on paddy fields in Indonesia. Proc. Indo-Pac. Fish. Counc. 7: 119-162.

Barker, R. and D. Chapman. 1988. The economics of sustainable agricultural systems in developing countries. Agricultural Economics Working Paper 88-13, Cornell University, Ithaca, New York, USA.

Barker, R. and R.W. Herdt, with B. Rose. 1985. The rice economy of Asia. Resources for the Future, Washington, D.C. *In* cooperation with the International Rice Research Institute, Los Baños, Laguna, Philippines.

BAS (Bureau of Agricultural Statistics). 1988. Statistical compendium on agriculture, fishery and forestry. Bureau of Agricultural Statistics, Department of Agriculture, Quezon City, Philippines.

BAS (Bureau of Agricultural Statistics). 1990. Retail price index of the agricultural food basket 1980-1989. Bureau of Agricultural Statistics, Department of Agriculture, Quezon City, Philippines.

BAS (Bureau of Agricultural Statistics). 1991. Agricultural indicators system. Bureau of Agricultural Statistics, Department of Agriculture, Quezon City, Philippines.

Becker, G.S. 1965. A theory of the allocation of time. Econ. J. 75: 493-517.

Bimbao, M.P. and I.R. Smith. 1988. Philippine tilapia economics: industry growth and potential, p. 539-551. *In* R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maclean (eds.) The Second International Symposium on Tilapia in Aquaculture. ICLARM Conf. Proc. 15, 623 p.

Bimbao, M.P., A.V. Cruz and I.R. Smith. 1992. An economic assessment of rice-fish culture in the Philippines, p. 187-194. *In* W. Hiemstra, C. Reijntjes and E. van der Werf (eds.) Let farmers judge—experiences in assessing the sustainability of agriculture. Intermediate Technology Publications, London, U.K.

Binamira, J.S. 1991. The impacts of agricultural price policies on the adoption of integrated pest management by subsistence farmers: a case study of irrigated rice farmers in the Philippines. Dissertation, Texas A&M University, USA.

Boardman, R. 1986. Pesticides in world agriculture—the politics of international regulation. Macmillan, Basingstoke and London, U.K.

Boehlje, M.D. and V.R. Eidman. 1984. Farm management. John Wiley & Sons, New York, USA.

Borg, I. and T. Staufenbiel. 1989. Theorien und Methoden der Skalierung. Verlag Hans Huber, Bern, Switzerland.

Brinkmann, T. 1922. Die Ökonomik des landwirtschaftlichen Betriebes, p. 27-124. *In* Grundriss der Sozialökonomik. I.C.B. Mohr (Paul Siebeck), Tübingen, Germany.

Broussard, M.C., Jr. and C.G. Reyes. 1985. Cost analysis of a large-scale hatchery for the production of Orechromis niloticus fingerlings in Central Luzon, Philippines, p. 33-43. *In* I.R. Smith, E.B. Torres and E.O. Tan (eds.) Philippine tilapia economics. ICLARM Conf. Proc. 12, 261 p.

Byerlee, D. 1987. Maintaining the momentum in post-green revolution agriculture: a micro-level perspective from Asia. MSU International Development Paper No. 10, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, USA.

Cagauan, A.G. 1990. Fish toxicity, degradation period and residues of selected pesticides in rice-fish culture. Paper presented at the Workshop on the Environmental and Health Impacts of Pesticide Use in Rice Culture, 28-30 March 1990. International Rice Research Institute, Los Baños, Laguna, Philippines.

Cagauan, A.G. and R.G. Arce. 1992. Overview of pesticide use in rice-fish farming in Southeast Asia, p. 217-233. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Cagauan, A.G., C.R. dela Cruz, F. Florblanco, E.M. Cruz and R.C. Sevilleja. 1994. Impacts of fish and pesticides in lowland irrigated ricefields, p. 22-23. *In* C.R. dela Cruz (ed.) Role of fish in enhancing ricefield ecology and in integrated pest management. ICLARM Conf. Proc. 43, 56 p.

Campos, A.C. 1985. Rice-fish culture in the Philippines: state of the art, p. 315-322. *In* Proceedings, 16th Session of the International Rice Commission. Food and Agriculture Organization of the United Nations, Rome, Italy.

Carlson, G.A. and M.E. Wetzstein. 1993. Pesticides and pest management, p. 268-318. *In* G.A. Carlson, D. Zilberman and J.A. Miranowski (eds.) Agricultural and environmental resource economics. Oxford University Press, Oxford and New York.

Carson, R. 1962. Silent spring. Fawcett Publications, Greenwich, Connecticut, USA.

Casley, D.J. and K. Kumar. 1988. The collection, analysis, and use of monitoring and evaluation data. The World Bank, Washinton, D.C., USA.

Cassman, K. and P.L. Pingali. 1993. Extrapolating trends from long-term experiments to farmers fields: the case of irrigated rice systems in Asia. Paper presented at the Working Conference on 'Measuring Sustainability Using Long-Term Experiments', Rothamsted Experimental Station, UK, 28-30 April 1993, funded by the Agricultural Science Division, The Rockefeller Foundation.

Chelliah, S. and E.A. Heinrichs. 1980. Factors affecting insecticide-induced resurgence of the brown planthopper *Nilaparvata lugens* on rice. Env. Ent. 9: 773-777.

Chelliah, S. and E.A. Heinrichs. 1984. Factors contributing to brown planthopper resurgence, p. 107-115. *In* IRRI: Judicious and efficient use of insecticides on rice. International Rice Research Institute, Los Baños, Laguna, Philippines.

Contado, T.E. 1997. The strategic extension campaign: an agricultural extension approach by FAO. Entwicklung und ländlicher Raum 3/97: 27-30.

Corre, V.L. Jr. 1985. Status, potential and needs of tilapia culture on Panay Island, Philippines, p. 165-173. *In* I.R. Smith, E.B. Torres and E.O. Tan (eds.) Philippine tilapia economics. ICLARM Conf. Proc. 12, 261 p.

Costa-Pierce, B.A. 1992. Rice-fish systems as intensive nurseries, p. 117-130. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Cramer, H.H. 1967. Pflanzenschutz und Welternte. Pflanzenschutz-Nachrichten Bayer 20: 1-523.

Cruz, J.J. 1991. Chemical control of Golden Snail, p. 14-15. *In* B.O. Acosta and R.S.V. Pullin (eds.) Environmental impact of the Golden Snail (Pomacea sp.) on rice farming systems in the Philippines. ICLARM Conf. Proc. 28, 34 p.

Dalrymple, D.G. 1985. The development and adoption of high-yielding varieties of wheat and rice in developing countries. Am. J. Agric. Econ. 67: 1067-1073.

Dalsgaard, J.P.T. and R.T. Oficial. 1998. Modeling and analyzing the agroecological performance of farms with ECOPATH. ICLARM Tech. Rep. 53, 54 p.

David. C.C. 1990. The world rice economy: challenges ahead. IRRI Social Sciences Division Papers No. 90-14. International Rice Research Institute, Los Baños, Laguna, Philippines.

David, C.C. and J. Huang. 1992. Political economy of rice price protection in Asia. Paper presented at the Planning Workshop on Projections and Policy Implications of Medium and Long Term Rice Supply and Demand, 25-27 March 1992. International Rice Research Institute, Los Baños, Laguna, Philippines.

David, C.C., V.G. Cordova and K. Otsuka. 1994. Technological change, land reform, and income distribution in the Philippines, p. 51-106. *In* C.C. David and K. Otsuka (eds.) Modern rice technology and income distribution in Asia. Lynne Rienner Publishers, Boulder, USA.

De Datta, S.K. 1981. Principles and practices of rice production. John Wiley & Sons, New York, USA.

De Guzman, M.P.E., V.S. Claudio, M.S. Oliveros and G.P. Dimaano. 1988. Basic nutrition for Filipinos. Merriam & Webster Inc., Manila, Philippines.

Dehne, H-W. and F. Schönbeck. 1994. Crop protection - past and present, p. 45-71. *In* E.C. Oerke, H.W. Dehne, F. Schönbeck and A. Weber (eds.) Crop production and crop protection. Elsevier, Amsterdam, Netherlands.

dela Cruz, C.R. 1980. Integrated agriculture-aquaculture farming systems in the Philippines, with two case studies on simultaneous and rotational rice-fish culture, p. 209-223. *In* R.S.V. Pullin and Z.H. Shehadeh (eds.) Integrated agriculture-aquaculture farming systems. ICLARM Conf. Proc. 4, 258 p.

dela Cruz, C.R. 1990. The pond refuge in rice-fish systems. Aquabyte 3(2): 6-7.

dela Cruz, C.R., C. Lightfoot and R.C. Sevilleja. 1992. A user perspective on rice-fish culture in the Philippines, p. 195-204. *In* W. Hiemstra, C. Reijntjes and E. van der Werf (eds.) Let farmers judge. Intermediate Technology Publications, London, U.K.

dela Cruz, C.R. and H. Montalvo. 1993. Selection of the best rice-fish system option using the linear programming techniques. Research report (unpublished). ICLARM, Manila, Philippines.

Delmendo, M.N. 1980. A review of integrated livestock-fowl-fish farming systems, p. 59-71. *In* R.S.V. Pullin and Z.H. Shehadeh (eds.) Integrated agriculture-aquaculture farming systems. ICLARM Conf. Proc. 4, 258 p.

Dewan, S. 1992. Rice-fish farming systems in Bangladesh: past, present and future, p. 11-16. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Diekmann, A. 1996. Empirische Sozialforschung. Rowohlt Verlag, Reinbek bei Hamburg, Germany.

Edwards, P. and K. Kaewpaitoon. 1984. Fish culture for small-scale farmers. Environmental Sanitation Information Center, Asian Institute of Technology, Bangkok, Thailand.

Edwards, P., H. Demaine, S. Komolmari, D.C. Little, N.L. Innes-Taylor, D. Turongruang, A. Yakupitiyage and T.J. Warren. 1991. Towards the improvement of fish culture by small-scale farmers in Northeast Thailand. Asian Farming Sys. Asso. 1(2): 287-302.

Ellis, F. 1988. Peasant economics. Cambridge University Press, Cambridge, U.K.

Emerson, T. 1994. Fished out. Newsweek, April 25, 1994: 30-33.

FAO (Food and Agriculture Organization). 1968. Report of the First Session of the FAO Panel of Experts on Integrated Pest Control. FAO Meeting Report No. PL/1967/M/7. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO (Food and Agriculture Organization). 1993. Compendium of food consumption statistics from household surveys in developing countries. FAO Economic and Social Development Paper 116/1. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO (Food and Agriculture Organization). 1994. Trade Yearbook. Food and Agriculture Organization of the United Nations, Rome, Italy.

Fedoruk, A. and W. Leelapatra. 1992. Ricefield fisheries in Thailand, p. 91-104. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Fermin, F. 1985. The introduction of integrated backyard fishponds in lowland Cavite, Philippines, p. 151-164. *In* I.R. Smith, E.B. Torres and E.O. Tan (eds.) Philippine tilapia economics. ICLARM Conf. Proc. 12, 261 p.

Fernando, C.H., J.I. Furtado and R.P. Lim. 1979. The aquatic fauna of the world's ricefields. Wallaceana Suppl. 2, 105 pp.

Fernando, C.H., J.I. Furtado and R.P. Lim. 1980. The ecology of ricefields with special reference to the aquatic fauna, p. 943-951. *In* J.I. Furtado (ed.) Tropical ecology and development. Proceedings of the 5th International Symposium of Tropical Ecology. 16-21 April 1979. Kuala Lumpur, Malaysia. The International Society of Tropical Ecology.

FishBase. 1998. FishBase 98 CD-ROM. ICLARM, Manila, Philippines.

Flinn, J.C., S.K. De Datta and E. Labadan. 1982. An analysis of long-term rice yields in a wetland soil. Field Crops Res. 5: 201-216.

Flinn, J.C. and S.K. De Datta. 1984. Trends in irrigated-rice yields under intensive cropping at Philippine research stations. Field Crops Res. 9: 1-15.

Flint, M.L. and R. Van den Bosch. 1981. Introduction to integrated pest management. Plenum Press, New York, USA.

FNRI (Food and Nutrition Research Institute). 1981. First nationwide nutrition survey: Philippines, 1978. Department of Science and Technology, Manila, Philippines.

FNRI (Food and Nutrition Research Institute). 1984. Second nationwide nutrition survey: Philippines, 1982. Department of Science and Technology, Manila, Philippines.

FNRI (Food and Nutrition Research Institute). 1987. Third nationwide nutrition survey: Philippines, 1987. Department of Science and Technology, Manila, Philippines.

FNRI (Food and Nutrition Research Institute). 1990. Food composition tables recommended for use in the Philippines. Department of Science and Technology, Manila, Philippines.

Folbre, N. 1986. Hearts and spades: paradigms of household economics. World Dev. 14(2): 245-255.

Fujisaka, S. and C. Vejpas. 1990. Capture and culture paddy fisheries in Khu Khat, Northeast Thailand. Thai J. Agri Sc 23: 167-176.

Fujisaka, S., R. Guino, P. Medrano and L. Obusan. 1992. Establishing a farmer-participatory pest management experiment. Paper presented at the joint meeting of the Asian Rice Farming Systems Working Group, International Network on Soil Fertility and Sustainable Rice Farming (INSURF), Integrated Pest Management Network and the Crop and Resource Management Advisory Committee of the International Rice Research Institute (IRRI), 12-17 October 1992, Ho Chi Minh City, Vietnam.

Gaite, M.C.B., J.N.A. Morales, O.C.R. Orilla and B.B. Pili. 1985. The adoption of tilapia farming and its impact on the community of Sto. Domingo, Bay, Laguna, Philippines, p. 44-49. *In* I.R. Smith, E.B. Torres and E.O. Tan (eds.) Philippine tilapia economics. ICLARM Conf. Proc. 12, 261 p.

Garcia, M. and P. Pinstrup-Andersen. 1987. The pilot food price subsidy scheme in the Philippines: its impact on income, food consumption, and nutritional status. IFPRI Research Report 61. International Food Policy Research Institute, Washington. D.C., USA.

Gonzales, L.A. 1985. Philippine tilapia marketing in the context of structural demand for protein: a comment, p. 232-237. *In* I.R. Smith, E.B. Torres and E.O. Tan (eds.) Philippine tilapia economics. ICLARM Conf. Proc. 12, 261 p.

Griffin, K. 1974. The political economy of agrarian change. Macmillan, London, U.K.

Griffin, K. 1989. Alternative strategies for economic development. St. Martin's Press, New York, USA.

Gross, D. et al. 1979. Ecology and acculturation among native peoples of Central Brazil. Science 206: 1043-50.

Guerrero, R.D. III. 1985. Tilapia farming in the Philippines: practices, problems and prospects, p. 3-14. *In* I.R. Smith, E.B. Torres and E.O. Tan (eds.) 1985. Philippine tilapia economics. ICLARM Conf. Proc. 12, 261 p.

Gupta, M.V., J.D. Sollows, M.A. Mazid, A. Rahman, M.G. Hussain and M.M. Dey. 1998. Integrating aquaculture with rice farming in Bangladesh: feasibility and economic viability, its adoption and impact. ICLARM Tech. Rep. 55, 90 p.

Hailu, Z. and A. Runge-Metzger. 1993. Sustainability of land use systems. Tropical Ecology 7. Verlag Josef Margraf, Weikersheim, Germany.

Halwart, M. 1992. Fish as a component of integrated pest management (IPM) in rice production*. In* IIRR and ICLARM (eds.) Farmer-proven integrated agriculture-aquaculture: A technology information kit. International Institute of Rural Reconstruction, Silang, Cavite, and ICLARM, Manila, Philippines.

Halwart, M. 1994a. The impact of fish on arthropod communities in irrigated rice in the Philippines, p. 32*. In* C.R. dela Cruz (ed.) Role of fish in enhancing ricefield ecology and in integrated pest management. ICLARM Conf. Proc. 43, 50 p.

Halwart, M. 1994b. The potential of fish as biological plant protection agents in irrigated rice. Final report, IRRI - University of Stuttgart-FAC/CLSU collaborative research project. Institute of Landscape Planning and Ecology, University of Stuttgart, Germany.

Hanisch, R. 1989. Philippinen. Beck'sche Reihe Aktuelle Länderkunde, Verlag C.H. Beck, Munich, Germany.

Hazell, P.B.R. and R.D. Norton. 1986. Mathematical programming for economic analysis in agriculture. Macmillan Publishing Company, New York, USA.

Heckman, C.W. 1979. Rice field ecology in Northeastern Thailand. Dr. W. Junk bv Publishers, The Hague, Netherlands.

Heinrichs, E.A. and G.B. Aquino. 1978. Root zone application of carbofuran in rice-fish culture. International Rice Research Newsletter 3(5): 16-17.

Hendarsih, S., S. Suriapermana, A. Fagi and I. Manwan. 1994. Potential of fish in rice-fish culture as a biological control agent of rice pests, p. 32-33. *In* C.R. dela Cruz (ed.) Role of fish in enhancing ricefield ecology and in integrated pest management. ICLARM Conf. Proc. 43, 60 p.

Heong, K.L., M.M. Escalada and A.A. Lazaro. 1992. Pest management practices of rice farmers in Leyte, Philippines. International Rice Research Institute, Los Baños, Laguna, Philippines.

Heong, K.L., M.M. Escalada and A.A. Lazaro. 1994. Misuse of pesticides among rice farmers in Leyte, Philippines. *In* P.L. Pingali and P.A. Roger (eds.) Impact of pesticides on farmers' health and the rice environment. International Rice Research Institute, Los Baños, Laguna, Philippines and ORSTOM, France.

Herdt, R.W. and C. Capule. 1983. Adoption, spread, and production impact of modern rice varieties in Asia. International Rice Research Institute, Los Baños, Laguna, Philippines.

Herdt, R.W., L.L. Castillo and S.K. Jayasuriya. 1984. The economics of insect control on rice in the Philippines, p. 41-56. *In* IRRI: Judicious and efficient use of insecticides on rice. International Rice Research Institute, Los Baños, Laguna, Philippines.

Holmes, B. 1992. The joy ride is over - farmers are discovering that pesticides increasingly don't kill pests. U.S. News and World Report, September 14, 1992: 73-74.

Horstkotte, G., C. Lightfoot, H. Waibel and P. Kenmore. 1992. Integrated pest management and aquatic life management: a natural partnership for rice farmers? Naga, The ICLARM Q. 15(3): 15-16.

IBON. 1988. Land reform in the Philippines. IBON Primer Series. IBON Databank Phils., Inc., Manila, Philippines.

ICLARM (International Center for Living Aquatic Resources Management). 1981. The ICLARM-CLSU integrated animal-fish farming project: poultry-fish and pig-fish trials. ICLARM Tech. Rep. 2, 91 p.

ICLARM (International Center for Living Aquatic Resources Management). 1993. ICLARM Report 1993. ICLARM, Manila, Philippines.

IRRI (International Rice Research Institute). 1983. Field problems of tropical rice. International Rice Research Institute, Los Baños, Laguna, Philippines.

IRRI (International Rice Research Institute). 1984. Terminology for rice growing environments. International Rice Research Institute, Los Baños, Laguna, Philippines.

IRRI (International Rice Research Institute). 1991. World rice statistics 1990. International Rice Research Institute, Los Baños, Laguna, Philippines.

IRRI (International Rice Research Institute). 1995. World rice statistics 1993-94. International Rice Research Institute, Los Baños, Laguna, Philippines.

Israel, D.C., R.C. Sevilleja, A.V. Circa and R.D. Cocio. 1994. Rice-fish culture in the Philippines: an output risk programming analysis. AFSSRN-SEAFDEC/AQD Team, Freshwater Aquaculture Center, Central Luzon State University, Nueva Ecija, Philippines.

Johnson, A. 1975. Time allocation in a Machiguenga community. Ethnology 14: 301-10.

Kallmann, A. 1979. Skalierung in der empirischen Forschung. Verlag V. Florentz, München, Germany.

Kenmore, P.E. 1978. Mean density, mean crowding, mean brown planthoppers. Paper presented at the 9th National Conference of the Pest Control Council of the Philippines, 3-5 May 1978, Manila, Philippines.

Kenmore, P.E. 1983. Returning (pest) control to villagers: the FAO Inter-Country IPC (Rice) Programme. Paper presented at the IRRI Thursday Seminar, March 3, 1983. International Rice Research Institute, Los Baños, Laguna, Philippines.

Kenmore, P.E., J.A. Litsinger, J.P. Bandong, A.C. Santiago and M.M. Salac. 1987. Philippine rice farmers and insecticides: thirty years of growing dependency and new options for change, p. 98-108. *In* J. Tait and B. Napompeth (eds.) Management of pests and pesticides - farmers' perceptions and practices. Westview Press, Boulder and Colorado, USA.

Kenmore, P.E. 1991. Indonesia's IPM—a model for Asia. FAO Intercountry Programme for Integrated Pest Control in Rice in South and Southeast Asia, Manila, Philippines.

Kenmore, P.E., K.D. Gallagher and P.A.C. Ooi. 1995. Empowering farmers: experiences with integrated pest management. Entwicklung und ländlicher Raum 1/95: 27-28.

Khoo, K.H. and E.S.P. Tan. 1980. Review of rice-fish culture in Southeast Asia, p. 1-14. *In* R.S.V. Pullin and Z.H. Shehadeh (eds.) Integrated agriculture-aquaculture farming systems. ICLARM Conf. Proc. 4, 258 p.

Koesoemadinata, S. 1980. Pesticides as a major constraint to integrated agriculture-aquaculture farming systems, p. 45-51. *In* R.S.V. Pullin and Z.H. Shehadeh (eds.) Integrated agriculture-aquaculture farming systems. ICLARM Conf. Proc. 4, 258 p.

Koesoemadinata, S. and B.A. Costa-Pierce. 1992. Development of rice-fish farming in Indonesia: past, present and future, p. 45-62. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Kyaw Myint Oo. 1993. Safe use of pesticides in rice-fish culture. Naga, the ICLARM Q. 16(4): 23-25.

Lanzona, L., Jr. 1988. The value and the allocation of time in favorable and unfavorable areas, p. 269-313. *In* Filipino women in rice farming systems. University of the Philippines at Los Baños, International Rice Research Institute and Philippine Institute for Development Studies, Philippines.

Latham, M.C. 1990. Malnutrition in developing countries, p. 4-17. *In* T.A. Brun and M.C. Latham (eds.) World food issues, Vol. 2, Cornell University, Ithaca, USA.

Li, K. 1992. Rice-fish farming systems in China: past, present and future, p. 17-26. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Lightfoot, C., B.A. Costa-Pierce, M.P. Bimbao and C.R. dela Cruz. 1992a. Introduction to rice-fish research and development in Asia, p. 1-10. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Lightfoot, C., A. Van Dam and B.A. Costa-Pierce. 1992b. What's happening to the rice yields in rice-fish systems?, p. 177-183. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Lightfoot, C., P.A. Roger, A.G. Cagauan and C.R. dela Cruz. 1993. Preliminary steady-state nitrogen models of a wetland ricefield ecosystem with and without fish, p. 56-64. *In* V. Christensen and D. Pauly (eds.) Trophic models of aquatic ecosystems. ICLARM Conf. Proc. 26, 390 p.

Lightfoot, C. and R.S.V. Pullin. 1995. An integrated resource management approach to the development of integrated aquaculture farming systems, p. 145-167. *In* J.J. Symoens and J.C. Micha (eds.) The management of integrated freshwater agro-piscicultural ecosystems in tropical areas. Proceedings of the International Seminar, Brussels, 16-19 May 1994, the Technical Center for Agricultural and Rural Co-operation (CTA), Wageningen, the Belgian Royal Academy of Overseas Sciences (ARSOM), Brussels. 587 p.

Lightfoot, C., M.P. Bimbao, T.S. Lopez, F.D. Villanueva, E.A. Orencia, J.P.T. Dalsgaard, F.C. Gayanilo, Jr., M. Prein and H.J. McArthur, Jr. 1996 forthcoming. RESTORE: Research tool for natural resource management, monitoring and evaluation: field guide. ICLARM Software 9, Vol. 1.

Lim, G.S. and S.H. Ong. 1987. Environmental problems of pesticide usage in Malaysian rice fields—perceptions and future considerations, p. 10-21. *In* J. Tait and B. Napompeth (eds.) Management of pests and pesti–cides—farmers' perceptions and practices. Westview Press, Boulder and Colorado, USA.

Lipton, M. with R. Longhurst. 1989. New seeds and poor people. Unwin Hyman, London, U.K.

Litsinger, J.A., E.C. Price and R.T. Herrera. 1980. Small farmer pest control practices for rainfed rice, corn, and grain legumes in three Philippine provinces. Phil. Ent. 4: 65-86.

Litsinger, J.A. 1984. Assessment of need-based insecticide application for rice. Paper presented at the Technology Transfer Workshop, 15-16 March 1984. Philippine Ministry of Agriculture and International Rice Research Institute, Los Baños, Laguna, Philippines.

Litsinger, J.A., B.L. Canapi, J.P. Bandong, C.G. dela Cruz, R.F. Apostol, P.C. Pantua, M.D. Lumaban, A.L. Alviola III, F. Raymundo, E.M. Libertario, M.E. Loevinsohn and R.C. Joshi. 1987. Rice crop loss from insect pests in wetland and dryland environments of Asia with emphasis on the Philippines. Insect Science Applications 8: 677-692.

Luckenbach, H. 1975. Theorie des Haushalts. Vandenhoeck & Ruprecht, Göttingen, Germany.

Mang-umphan, K. and R.G. Arce. 1988. Culture of Nile tilapia (*Oreochromis niloticus*) in a rice-fish culture system using chemical and commercial fertilizer, p. 59-62. *In* R.S.V. Pullin, T. Bhukaswan, K. Tonguthai and J.L. Maclean (eds.) The Second International Symposium on Tilapia in Aquaculture. ICLARM Conf. Proc. 15, 623 p.

Margraf, J. 1988. Faunistische Untersuchungen an Ifugao Reisterrassen. Part II. *In* M. Voggesberger and J. Margraf: Ifugao Reisterrassen–Agrarökologische Untersuchungen im Bergland der Philippinen. PLITS 1988/6(3). Verlag Josef Margraf, Weikersheim, Germany.

Martinez, L. 1991. Ricefield fish culture is good farming idea. AgricSope 5 (Jan./Feb. 1991): 24-27.

Maxwell, S. and C. Bart. 1995. Beyond ranking: exploring relative preferences in P/RRA. PLA Notes 22: 28-35.

Mayntz, R., K. Holm and P. Hübner. 1978. Einführung in die Methoden der empirischen Soziologie. Westdeutscher Verlag, Opladen, Germany.

McClellan, S. 1991. Integrated systems: re-thinking a panacea. Ceres 1991: 22-24.

McNamara, R.S. 1973. Address to the Board of Governors. Nairobi, Kenya, September 24, 1972. International Bank for Reconstruction and Development, Washington, D.C., USA.

Medrano, F.G., B.L. Canapi, F.M. Olivares Jr., V.G. Sagun, G.F. Estoy, J.S. Rosario, P. Pacada, S.R. Obien and D.G. Bottrell. 1993. Barangay IPM project in irrigated rice in Nueva Ecija, Philippines: re-examining the need for wet season insecticide treatments. Philippine Rice Research Institute, International Rice Research Institute, Department of Agriculture of the Philippines and Food and Agriculture Organization of the United Nations. Philippines.

Mellor, J.W. 1976. The new economics of growth: a strategy for India and the developing world. Cornell University Press, Ithaca, New York, USA.

Metcalf, R.L. 1984. Trends in the use of chemical insecticides, p. 69-89. *In* IRRI: Judicious and efficient use of insecticides on rice. International Rice Research Institute, Los Baños, Laguna, Philippines.

Mitchell, D.O. 1987. Rice market prospects to the year 2000. Paper presented at the Seminar on Recent and Future Movements in World Rice Prices, Jakarta, Indonesia, January 13-14, 1987.

Nalim, S. 1994. The impact of fish in enhancing ricefield ecosystems, p. 22. *In* C.R. dela Cruz (ed.) Role of fish in enhancing ricefield ecology and in integrated pest management. ICLARM Conf. Proc. 43, 50 p.

Nie, D., Y. Chen and J. Wang. 1992. Mutualism of rice and fish in ricefields, p. 173-175. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p

Norton, G.A. and M.L. Way. 1990. Rice pest management - past and future, p. 1-14. *In* B.T. Grayson, M.B. Green and L.G. Copping (eds.) Pest management in rice. Elsevier, London and New York.

NSCB (National Statistical Coordination Board). 1990. Food balance sheet of the Philippines, CY 1987 to CY 1989. National Statistical Coordination Board, Manila, Philippines.

NSCB (National Statistical Coordination Board). 1991. Philippine Statistical Yearbook 1991. National Statistical Coordination Board, Manila, Philippines.

NSCB (National Statistical Coordination Board). 1993. Philippine Statistical Yearbook 1993. National Statistical Coordination Board, Manila, Philippines.

NSO (National Statistics Office). 1989. 1988 Family Income and Expenditures Survey. National Statistics Office, Manila, Philippines.

NSO (National Statistics Office). 1990. 1990 Census of Population and Housing. National Statistics Office, Manila, Philippines.

NSO (National Statistics Office). 1993. 1991 Family Income and Expenditures Survey. Volume I (National summary). Integrated Survey of Households Bulletin Series No. 72. National Statistics Office, Manila, Philippines.

NSO (National Statistics Office). 1994a. 1991 Census of Agriculture - Volume 1. National Statistics Office, Manila, Philippines.

NSO (National Statistics Office). 1994b. 1991 Family Income and Expenditures Survey. Volume II (Provincial/ key city final report). Integrated Survey of Households Bulletin Series 72. National Statistics Office, Manila, Philippines.

NSO (National Statistics Office). 1995. 1991 Census of Agriculture - Volume 2, Nueva Ecija. National Statistics Office, Manila, Philippines.

Oerke, E.C. 1994. Estimated crop losses due to pathogens, animal pests and weeds, p. 72-741. *In* E. C. Oerke, H.W. Dehne, F. Schönbeck and A. Weber. Crop production and crop protection—estimated losses in major food and cash crops. Elsevier, Amsterdam, Netherlands.

Okoth-Ogendo, H.W.O. 1995. Reform of land tenure and resource management—a comment. Entwicklung und ländlicher Raum 6/95: 16-17.

Palis, F.G., P.L. Pingali and J.A. Litsinger. 1990. A multiple-pest economic threshold for rice (a case study in the Philippines), p. 229-242. *In* IRRI: Crop loss assessment in rice. International Rice Research Institute, Los Baños, Laguna, Philippines.

Panzar, J.C. and R.D. Willig. 1981. Economies of scope. AEA Papers and Proceedings 71(2): 268-272.

Pathak, M.D. and K.A. Gomez. 1991. Rice production trends in selected Asian countries. IRRI Res. Pap. Ser. 147. International Rice Research Institute, Los Baños, Laguna, Philippines.

Pauly, D. and J. Saeger. 1992. Im Schatten von Malthus. Kleinfischerei der Philippinen, p. 125-139. *In* N.K. Gelpke (ed.). Un-endliches Meer: Zerstörung des marinen ökosystems—wirtschaftliche, politische, ökologische und kulturelle Hintergründe. Focus: Ökozid 8, Giessen, Germany, 1992.

Pauly, D., J. Saeger and M. Prein. 1998. Malthus und die Küstenfischerei der Tropen: eine philippinische Fallstudie. Entwicklung und ländlicher Raum 32(2): 17-20.

PCARRD (Philippine Council for Agriculture and Resources Research and Development). 1985. Tilapia research—state of the art. Fisheries Research Series No. 4/1985. Philippine Council for Agriculture and Resources Research and Development, National Science and Technology Authority, Los Baños, Laguna, Philippines.

Pineda, R., B. Duff, E.A. Heinrichs and P. Carbonell. 1984. Insect control practices on irrigated and rainfed rice farms in Nueva Ecija, Philippines. The Consequences of Small Rice Farm Mechanization Project Working Pap No. 102. International Rice Research Institute, Los Baños, Laguna, Philippines.

Pingali, P.L., P.F. Moya, and L.E. Velasco. 1990. The post-green revolution blues in Asian rice production: The diminished gap between experiment station and farmers yields. IRRI Social Sciences Division Pap. No. 90-01. International Rice Research Institute, Los Baños, Laguna, Philippines.

Pingali, P.L. 1992. Diversifying Asian rice farming systems: a deterministic paradigm, p. 107-126. *In* S. Barghouti, L. Garbux and D. Umali (eds.) Trends in Agricultural Diversification: Regional Perspectives. World Bank Tech. Pap. No. 180. The World Bank, Washington, D.C., USA.

Pingali, P.L., F.G. Palis, V. Rodriguez, M. Angeles and P. Cristobal. 1992. Impact of pesticides on the lowland paddy eco-system: results from a multi-disciplinary study in the Philippines. Paper presented at the 8th Scientific Meeting of the Federation of Crop Science Societies of the Philippines held in Western Mindanao State University, 24-28 May 1992.

Pingali, P.L. and M.W. Rosegrant. 1995. Agricultural commercialization and diversification: processes and policies. Food Policy 20(3): 171-185.

Pitt, M.M. and M.R. Rosenzweig. 1986. Agricultural prices, food consumption, and the health and productivity of Indonesian farmers, p. 153-182. *In* I. Singh, L. Squire and J. Strauss (eds.) Agricultural household models. The Johns Hopkins University Press, Baltimore and London.

Prein, M. 1993. Multiple regression and path analysis of Nile tilapia growth in integrated livestock-fish culture in the Philippines, p. 50-66. *In* M. Prein, G. Hulata and D. Pauly (eds.) Multivariate methods in aquaculture research: case studies of tilapias in experimental and commercial systems. ICLARM Stud. Rev. 20, 221 p.

Pullin, R.S.V. 1989. Third-world aquaculture and the environment. Naga, the ICLARM Q. 12(1): 10-13.

Purba, S. 1997. The economics of rice-fish production systems in North Sumatra, Indonesia: an empirical and model analysis. Dissertation, University of Göttingen, Germany.

Quintana, J.T., M.Z.I.T. Azanza and A.C. Rola. 1991a. Economic profile of rice farmers in the different agro-climatic environments of Western Visayas. Social Science and Policy Research Division Working Pap. 00191. Philippine Rice Research Institute, Maligaya, Muñoz, Nueva Ecija, Philippines.

Quintana, J.T., M.Z.I.T. Azanza and A.C. Rola. 1991b. Resource use among rice farmers in the different production environments of Region III: A production function approach. Social Science and Policy Research Division Working Pap 00591. Philippine Rice Research Institute, Maligaya, Muñoz, Nueva Ecija, Philippines.

Rajasekaran, B. and M.B. Whiteford. 1993. Rice-crab production in south India. Food Policy 18(3): 237-247.

Rehm, S. and G. Espig. 1984. Die Kulturpflanzen der Tropen und Subtropen. Ulmer, Stuttgart, Germany.

Reissig, W.H., E.A. Heinrichs, J.A. Litsinger, K. Moody, L. Fiedler, T.W. Mew and A.T. Barrion. 1986. Illustrated guide to integrated pest management in rice in tropical Asia. International Rice Research Institute, Los Baños, Laguna, Philippines.

Rola, A.C., J.T. Quintana-Alejandrino and M.Z.I.T. Azanza. 1991. Economic profile of rice farm households in Western Visayas, Philippines. Social Science and Policy Research Program, Philippine Rice Research Institute, Maligaya, Muñoz, Nueva Ecija, Philippines.

Rola, A.C. and P.L. Pingali. 1993. Pesticides, rice productivity, and farmers' health - an economic assessment. International Rice Research Institute, Los Baños, Laguna, Philippines; and World Resources Institute, Washington, D.C., USA.

Rola, A.C. 1994. The dynamics of pesticide policy reform in the Philippines, p. 51-60. *In* S. Agne, G. Fleischer and H. Waibel (eds.). Proceedings of the Göttingen Workshop on Pesticide Policies. Institut für Agrarökonomie der Universität Göttingen, Germany.

Ruddle, K. 1982. Traditional integrated farming systems and rural development: the example of ricefield fisheries in Southeast Asia. Agricultural Administration 10: 1-11.

Runge-Metzger, A. 1991. Entscheidungskalküle kleinbäuerlicher Betriebs-Haushalte in Bezug auf Wirtschaftlichkeit und Akzeptanz ausgewählter landwirtschaftlicher Innovationen. Wissenschaftsverlag Vauk, Kiel, Germany.

Ruttan, V.W. 1990. Models of agricultural development, p. 89-96. *In* C.K. Eicher and J.M. Staatz (eds.) Agricultural development in the Third World. The Johns Hopkins University Press, Baltimore and London.

Samonte, V.P.B., G.O. Redondo, C.B. Carlos, G.N.A. Abrigo and I.R. Tanzo. 1993. Technological base of rice farmers in Regions I, II, III, V, VI and XII. Social Science and Policy Research Program, Philippine Rice Research Institute, Maligaya, Muñoz, Nueva Ecija, Philippines.

Sanjur, D. 1990. Sociocultural factors in food choice and malnutrition, p. 18-25. *In* T.A. Brun and M.C. Latham (eds.) World food issues, Vol. 2, Cornell University, Ithaca, USA.

SAS Institute Inc. 1988. SAS, Procedures Guide, Release 6.03 Edition. SAS Institute, Cary, NC, USA.

SAS Institute Inc. 1989a. SAS/STAT, User s Guide, Version 6, Vol 1. SAS Institute, Cary, NC, USA.

SAS Institute Inc. 1989b. SAS/ORUser's Guide, Version 6, First Ed. SAS Institute, Cary, NC, USA.

Sastradiwirja, F. 1992. Resource utilization in rice-fish farming, p. 201-206. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Schmitt, G. 1990. Book review: Frank Ellis, Peasant Economics. Agrarwirtschaft 39(2): 57-59.

Schmitt, G. 1993a. Über die Besonderheiten der landwirtschaftlichen Produktion, das 'Wesen' und die Zukunft des landwirtschaftlichen Betriebes. Diskussionsbeitrag 9307. Institut für Agrarökonomie der Universität Göttingen, Germany.

Schmitt, G. 1993b. The organization of agriculture and its contribution to economic development. Q. J. Int. Agri. 32(1): 12-19.

Schnell, R., P.B. Hill and E. Esser. 1995. Methoden der empirischen Sozialforschung. R. Oldenbourg Verlag, München, Germany.

Schultz, J. 1988. Die Ökozonen der Erde. UTB, Stuttgart, Germany.

Schultz, T.W. 1964. Transforming traditional agriculture. Yale University Press, New Haven and London.

Scoones, I., M. Melnyk and J.N. Pretty. 1992. The hidden harvest - wild foods and agricultural systems. A literature review and annotated bibliography. International Institute for Environment and Development, London, U.K.

Setboonsarng, S. 1994. Farmer's perception towards wild fish in ricefields: 'Product not predators'—an experience in rice-fish development in Northeast Thailand, p. 43-44. *In* C.R. dela Cruz (ed.) Role of fish in enhancing ricefield ecology and in integrated pest management. ICLARM Conf. Proc. 43, 50 p.

Sevilleja, R.C. 1992. Rice-fish farming development in the Philippines: past, present and future, p. 77-89. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Sevilleja, R.C., A.G. Cagauan. E.A. Lopez, C.R. dela Cruz and A.A. van Dam. 1992. Component technology research in rice-fish systems in the Philippines, p. 373-384. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Shepard, B.M., A.T. Barrion and J.A. Litsinger. 1987. Helpful insects, spiders, and pathogens. International Rice Research Institute, Los Baños, Laguna, Philippines.

Singh, I., L. Squire and J. Strauss. 1986. The basic model: theory, empirical results, and policy conclusions, p. 17-47. *In* I. Singh, L. Squire and J. Strauss (eds.) Agricultural household models. The Johns Hopkins University Press, Baltimore and London.

Singh, V.P., A.C. Early and T.H. Wickham. 1980. Rice agronomy in relation to rice-fish culture, p. 15-34. *In* R.S.V. Pullin and Z.H. Shehadeh (eds.) Integrated agriculture-aquaculture farming systems. ICLARM Conf. Proc. 4, 258 p.

Smith, I.R., E.B. Torres and E.O. Tan (eds.). 1985. Philippine tilapia economics. ICLARM Conf. Proc. 12, Philippine Council for Agriculture and Resources Research and Development and ICLARM, Manila, Philippines.

Smith, J., J.A. Litsinger, J.P. Bandong, M.D. Lumaban and C.G. dela Cruz. 1989. Economic thresholds for insecticide application to rice: profitability and risk analysis to Filipino farmers. J. Plant Prot. Tropics 6 (1):61-87.

Sollows, J.D. and N. Thongpan. 1986. Comparative economics of rice-fish culture and rice monoculture in Ubon Province, northeast Thailand, p. 149-152. *In* J.L. Maclean, L.B. Dizon and L.V. Hosillos (eds.) The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.

Staatz, J.M. and C.K. Eicher. 1990. Agricultural development ideas in historical perspective, p. 3-38. *In* C.K. Eicher and J.M. Staatz (eds.) Agricultural development in the Third World. The Johns Hopkins University Press, Baltimore and London.

Steinhauser, H., C. Langbehn and U. Peters. 1982. Einführung in die landwirtschaftliche Betriebslehre Band 1: Allgemeiner Teil. 3. Auflage. Verlag Eugen Ulmer, Stuttgart, Germany.

Stern, V.M., R.F. Smith, R. Van den Bosch and K.S. Hagen. 1959. The integrated control concept. Hilgardia 29: 81-101.

Sutrisno. 1987. Development of resistance of green rice leafhopper and brown planthopper to insecticides in Indonesia, p. 281-286. *In* E.D. Magallona (ed.) International plant protection: focus on the developing world. Proceedings of the 11th International Congress of Plant Protection. Manila, Philippines.

Syamsiah, I., S. Suriapermana and A.M. Fagi. 1992. Research on rice-fish culture: past experiences and future research program, p. 287-293. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Tagarino, R.N. 1985. Economics of rice-fish culture systems, Luzon, Philippines, p. 127-150. *In* I.R. Smith, E.B. Torres and E.O. Tan (eds.) Philippine tilapia economics. ICLARM Conf. Proc. 12. 261 p.

The Pesticides Trust. 1993. The pesticide hazard—a global health and environmental audit, compiled by B. Dinham. Zed Books, London & New Jersey.

Thuenen, J.H. von. 1990 (1826). Der isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie. Akademie-Verlag, Berlin, Germany.

Thurston, H.D. 1992. Sustainable practices for plant disease management in traditional farming systems. Westview Press, Boulder, USA.

Tietenberg, T. 1988. Environmental and natural resource economics. Scot, Foresman and Company, Glenview, Illinois, USA.

Tirole, J. 1989. The theory of industrial organization. MIT Press, Cambridge, Massachusetts, USA.

Todd, H. 1988. When pesticides help pests and harm people. International Herald Tribune, June 18, 1988.

Tripp, R. 1982. Time allocation in Northern Ghana: An example of the random visit method. J. Dev. Areas 16: 391-400.

van de Fliert, E. 1993. Integrated pest management: farmer field schools generate sustainable practices. Wageningen Agricultural University Papers 93-3. Wageningen Agricultural University, Netherlands.

Villavieja, G.M., T.E. Valerio, E.R. Red, C.A. Nones, B.E. Raymundo, C.M. Cerdena, H.S.P. Abaya and C.C. Tanchoco. 1989. Trends in Philippine nutrition situation in relation with some development indicators. FNRI RP No. 3/89. Food and Nutrition Research Institute, Department of Science and Technology, Manila, Philippines.

Vincke, M. and J.C. Micha. 1985. Fish culture in rice fields, p. 297-314. *In* Proceedings of the 16th Session of the International Rice Commission. FAO of the United Nations, Rome, Italy.

Waibel, H. 1986. The economics of integrated pest control in irrigated rice—a case study from the Philippines. Springer Verlag, Berlin, Germany.

Waibel, H. 1987. Farmers' practices and recommended economic threshold levels in irrigated rice in the Philippines, p. 191-197. *In* J. Tait and B. Napompeth (eds.) Management of pests and pesticides—farmers' perceptions and practices. Westview Press, Boulder and Colorado, USA.

Waibel, H. 1990. Requirement for an economic interpretation of crop losses, p. 313-320. *In* IRRI: Crop loss assessment in rice. International Rice Research Institute, Los Baños, Laguna, Philippines.

Waibel, H. 1992. Comparative economics of pesticide use in rice and rice-fish farming, p. 245-254. *In* C.R. dela Cruz, C. Lightfoot, B.A. Costa-Pierce, V.R. Carangal and M.P. Bimbao (eds.) Rice-fish research and development in Asia. ICLARM Conf. Proc. 24, 457 p.

Waibel, H., G. Horstkotte and S. Purba. 1993. The economics of rice fish production systems in Asia. Entwicklung und ländlicher Raum 3/93: 8-12.

Waibel, H., G. Horstkotte and S. Purba. 1994. Integration of fish into intensive rice-based farming systems in Asia, p. 340-343. *In* Systems-oriented research in agriculture and rural development. Communications and papers of the International Symposium, Montpellier, France, 21-25 November 1994.

Waibel, H. and G. Fleischer. 1996. Nutzen-Kosten-Untersuchung zur Produktion, Distribution und dem Einsatz chemischer Pflanzenschutzmittel in Deutschland und in ausgewählten Weltwirtschaftskulturen. Unpublished research report, Institut für Gartenbauökonomie der Universität Hannover, Germany.

Waibel, H. and A. Waters-Bayer. 1996. Integrierte Betriebssysteme—Definition und Rentabilität, p. 17-26. *In* H. Franzen and H. Rosenthal (eds.) Integrierte Aquakultur—Perspektiven für die entwicklungspolitische Zusammenarbeit. ATSAF e.V., Bonn, Germany.

Watanabe, I. and P.A. Roger. 1985. Ecology of flooded ricefields, p. 229-243. *In* IRRI: Wetland soils: characterization, classification, and utilization. International Rice Research Institute, Los Baños, Laguna, Philippines.

Wesseler, J. 1995. Eliciting the time preference of farmers. J. Asian Farm. Syst. Assoc. 3(1): 101-109.

Wesseler, J. 1997. Die Ökonomik der Einführung von Obstkulturen in der Cordillera Central von Nordluzon, Philippinen. Forschungsberichte zur Ökonomie im Gartenbau No. 84. Shaker Verlag, Aachen, Germany.

Williams, M. 1996. The transition in the contribution of living aquatic resources to food security. Food, Agriculture, and the Environment Discuss. Pap. 13. International Food Policy Research Institute, Washington, D.C., USA.

Woodburn, A. 1990. The current rice agrochemicals market. p. 15-30. *In* B.T. Grayson, M.B. Green and L.G. Copping (eds.) Pest management in rice. Elsevier, London and New York.

Wood Mackenzie. 1993. East Asian agrochemical markets. Consultancy Report.

Yater, L.R. and I.R. Smith. 1985. Economics of private tilapia hatcheries in Laguna and Rizal Provinces, Philippines, p. 15-32. *In* I.R. Smith, E.B. Torres and E.O. Tan (eds.). Philippine tilapia economics. ICLARM Conf. Proc. 12, 261 p.

Zadoks, J.C. 1987. The concept of thresholds: warning, action and damage thresholds, p. 168-175. *In* P.S. Teng (ed.) Crop loss assessment and pest management. APS Press, St. Paul, USA.

Zilberman, D., M. Wetzstein and M. Marra. 1993. The economics of nonrenewable and renewable resources, p. 69-141. *In* G.A. Carlson, D. Zilberman and J.A. Miranowski (eds.) Agricultural and environmental resource economics. Oxford University Press, Oxford and New York.

Chapter13

Appendices

Appendix 1
List of plants, animals and local terms mentioned in the text

Table A1.1 Local, English and scientific names of fish species included in the text.

Local name (Kinaray-a, Visayan, Tagalog)	English name	Scientific name	Preferred environment
aloy	yaito tuna	*Euthynnus yaito*	marine
alumahan	striped mackerel	*Rastrelliger kanagurta*	marine
bangus	milkfish	*Chanos chanos*	brackishwater/marine
bayang	speckled drepane	*Drepane punctata*	marine
bilong-bilong	spotted moonfish	*Mene maculata*	marine
bisugo	ribbon-finned nemipterid; threadfin bream	*Nemipterus taenipterus; Nemipterus delagoae*	marine
dalagang bukid	golden caesio	*Caesio* sp.	marine
dilis	long-jawed anchovy	*Stolephorus commersonii*	marine
galunggong	big-bodied round scad	*Decapterus macrosoma*	marine
haruan, dalag	mudfish, striated murrel, snakehead	*Channa striata*	freshwater
hasa-hasa	Short-bodied mackerel	*Rastrellinger brachysomus*	marine
juju	Japanese eel	*Misgurnus anguillicaudatus*	freshwater
karpa	common carp	*Cyprinus carpio*	fresh/ brackishwater
mamsa	banded cavalla; long-finned cavalla; jack; pampano	*Caranx sexfasciatus; Citula armata; Caranx* sp.	marine
maya-maya	Malabar red snapper; red snapper	*Lutjanus malabaricus; Lutjanus bohar*	marine
panit	yellowfin tuna	*Thunnus albaceres; Nethunnus macropterus*	marine
pantat	catfish	*Clarias batrachus*	freshwater
pasa-pasa	blue-spotted sting ray	*Dasyatis kuhlii*	marine
puyo	common climbing perch	*Anabas testudineus*	freshwater; estuaries
sapsap	common slipmouth; black-finned slipmouth	*Leiognathus equulus*	marine
talakitok	banded cavalla	*Caranx sexfasciatus*	marine
tamban	fimbriated sardine	*Sardinella fimbriata*	marine
tanigi; tangigi	Spanish mackerel	*Cybium commersoni; Scomberomorus commerson*	marine
tilapia	tilapia	*Tilapia nilotica, Tilapia* sp.	fresh/brackishwater
tuloy	Indian sardine	*Sardinella longiceps*	marine
	goldfish	*Carassius auratus*	freshwater
	grasscarp	*Ctenopharyngodon idella*	freshwater
	silver barb	*Puntius gonionotus*	freshwater
	snakeskin gourami	*Trichogaster pectoralis*	freshwater

Source: own observations (local names); FishBase 1998 (English and scientific names).

Table A1.2. Scientific names of insects and aquatic organisms mentioned in the text.

English name	Scientific name
armyworm, cutworm	*Spodoptera* sp., *Mythimna separata* (Lepidoptera: Noctuidae)
brown planthopper	*Nilaparvata lugens* (Homoptera: Delphacidae)
caseworm	*Nymphula depunctalis* (Lepidoptera: Pyralidae)
damselfly	*Agriocnemis* sp. (Odonata: Coenagrionidae)
green leafhopper	*Nephotettix* sp. (Homoptera: Cicadellidae)
lady beetle	*Micraspis* sp.; *Harmonia octomaculata; Menochilus sexmaculatus* (Coleoptera: Coccinellidae)
rice bug	*Leptocorisa* sp. (Hemiptera: Alydidae)
spider	various species (Araneae: Lycosidae, Oxyopidae, Salticidae)
stemborer	*Chilo* sp., *Scirpophaga* sp., *Sesamia inferens* (Lepidoptera)
edible frog	*Rana vittigera, Rana limnocharis*
freshwater shrimp	*Palaemonidae*
Golden Apple snail	*Pomacea canaliculata*
native edible snail	*Thiara asperata*; other species
ricefield crab	*Potamon grapsoides*; other species

Source: IRRI 1983; Reissig et al. 1986; Shepard et al. 1987; FNRI 1990.

Table A1.3. Botanical name of plants mentioned in the text.

English name	Scientific name
acacia	*Acacia* sp., Leguminosae
avocado	*Persea americana* Mill., Lauraceae
bamboo	*Dendrocalamus* asper (Schult.) Backer ex Heyne
banana	*Musa x paradisiaca* L., Musaceae
bell pepper	*Capsicum annuum* L., Solanaceae
bilimbi	*Averrhoa bilimbi* L., Oxalidaceae
bitter gourd	*Momordica charantia* L., Cucurbitaceae
cacao	*Theobroma cacao* L., Sterculiaceae
camachili	*Phytecellobium* dulce (Roxb.) Benth.
calamansi	*Artocarpus camansi* Blanco, Moraceae
carristel fruit	*Pouteria campechiana* (H.B.K.) Beechni, Sapotaceae
cassava	*Manihot esculent*a Crantz, Euphorbiaceae
chico	*Manilkara zapota* (L.) von Royen, Sapotaceae
chili pepper	*Capsicum frutescens* L., Solanaceae
coconut	*Cocos nucifera* L., Cocoideae
coffee	*Coffea arabica* L., Rubiaceae
corn	*Zea mays* L., Maydeae
custard apple	*Annona squamosa* L., Annonaceae
eggplant	*Solanum melongena* L., Solanaceae
guava	*Psidium guajava* L., Myrtaceae
horse-radish tree	*Moringa oleifera* Lam., Moringaceae
jackfruit	*Artocarpus heterophyllus* L., Malvaceae
java plum	*Syzygium cumini* (L.) Skeels
jute	*Corchorus capsularis* L., Tiliaceae
Leucaena	*Leucena leucocephala* (Lam.) de Wit
malabar spinach	*Basella alba* L., Basellaceae
mango	*Mangifera indica* L., Anacardiaceae
mungbeans	*Vigna radiata* L., Leguminosae
okra	*Abelmoschus esculentus* (L.) Moench, Malvaceae
onion	*Allium cepa* L., Alliaceae
papaya	*Carica papaya* L., Caricaceae
peanut	*Arachis hypogaea* L., Leguminosae
pomelo	*Citrus grandis* (L.) Osbeck, Rutaceae
radish	*Raphanus sativus* L., Cruciferae
rice	*Oryza sativa* L., Gramineae

Table A1.3, continued

English name	Scientific name
santol	*Sandoricum koetjape* (Burm.f.) Merr., Meliaceae
soursop	*Annona muricata* L., Annonaceae
squash	*Cucurbita pepo* L., Cucurbitaceae
starapple	*Chrysophyllum cainito* L., Sapotaceae
stringbean, yard-long bean	*Vigna unguiculata* ssp. *sesquipedalis* L., Leguminosae
sugar cane	*Saccharum officinarum* L., Gramineae
sweet potato	*Ipomoea batatas* L., Convulvulaceae
tamarind	*Tamarindus indica* L., Leguminosae
taro	*Colocasia esculenta* (L.) Schott, Araceae
tomato	*Lycopersicon lycopersicum* (L.) Farw., Solanaceae
water spinach	*Ipomoea aquatica* Forsk., Convulvulaceae
winged bean	*Psophocarpus tetragonolobus* DC., Leguminosae
yam	*Dioscorea alata* L., Discoreaceae

Source: Rehm and Espig 1984.

Table A1.4. Glossary of local terms used.

Term	Description
barangay	smallest administrative unit in the Philippines
carabao	water buffalo
cavan	volume measure for rice One cavan of rough rice = 42-50 kg, depending on the region; one cavan of milled rice = 50 kg
tuba	coconut wine
bolo	big knife
bagoong	fermented small fish or shrimps
sari- sari store	small grocery store

Appendix 2
Chapter 2 figures and tables

Table A2.1. Mean one-day per capita food consumption: Philippines, 1978, 1982 and 1987.

	Food consumption, g/day			% increase/(decrease)	
Food group/ subgroup	1978	1982	1987	1978 to 1982	1982 to 1987
Cereals and cereal products	367	356	345	(3.0)*	(3.1)*
rice and products	308	304	303	(1.3)	(0.3)
corn and products	38	34	24	(10.5)*	(29.4)*
cereal products	21	18	18	(14.3)*	—
Starchy roots and tubers	37	42	22	13.5*	(47.6)*
Sugars and syrups	19	22	24	15.8*	9.1*
Fats and oils	13	14	14	7.7	—
Fish, meat and poultry	133	154	157	15.8*	1.9
fish and products	102	113	111	10.8*	(1.8)
meat and products	23	32	37	39.1*	15.6*
poultry	7	10	9	42.8*	(10)
Eggs	8	9	10	12.5	11.1
Milk and milk products	42	44	43	4.8	(2.3)
whole milk	31	30	36	(3.2)	20.0*
milk products	11	14	7	27.2*	(50.0)*
Dried beans, nuts and seeds	8	10	10	25.0*	—
Vegetables	145	130	111	(10.3)*	(14.6)*
green leafy/ yellow	34	37	29	8.8	(21.6)*
other vegetables	111	93	82	(16.2)*	(11.8)*
Fruit	104	102	107	(1.9)	4.9
vitamin C–rich fruit	30	18	24	(40.0)*	33.3*
other fruit	74	84	83	13.5*	(1.2)
Miscellaneous	21	32	26	52.4*	(18.7)*
beverages	8	16	12	100.0*	(25.0)*
condiments and others	12	15	14	25.0*	(6.7)

Source: Villavieja et al. 1989.
* Statistically significant

Table A2.2. Mean one-day per capita nutrient intake and percent adequacy: Philippines, 1978, 1982 and 1987.

Nutrients and particulars	1978	1982	1987	% increase/ (decrease) 1978 to 1982	1982 to 1987
Energy					
intake (kcal)	1804	1808	1753	0.2	(3.0)*
% adequacy	88.6	89.0	87.1		
Protein					
intake (g)	48.0	50.6	49.7	5.4*	(1.8)*
% adequacy	93.2	99.6	98.2		
Iron					
intake (mg)	10.6	10.8	10.7	1.9	(0.9)
% adequacy	88.3	91.5	91.5		
Calcium					
intake (g)	0.44	0.45	0.42	2.3	(6.7)*
% adequacy	78.60	80.40	75.0		
Thiamin					
intake (mg)	0.73	0.74	0.68	1.4	(8.1)*
% adequacy	70.7	71.8	66.7		
Niacin					
intake (mg)	15.3	16.4	16.3	7.2	(0.6)
% adequacy	115.5	119.7	119.9		
Vitamin C					
intake (mg)	66.8	61.6	53.6	(7.8)*	(13.0)*
% adequacy	99.2	91.1	80.0		
Fats					
intake (g)	28	30	30	7.1*	—
Carbohydrates					
intake (g)	332	313	(1.5)	(4.3)*	

Source: Villavieja et al. 1989.
* Statistically significant

Appendix 3
Listing of surveys and monitoring activities

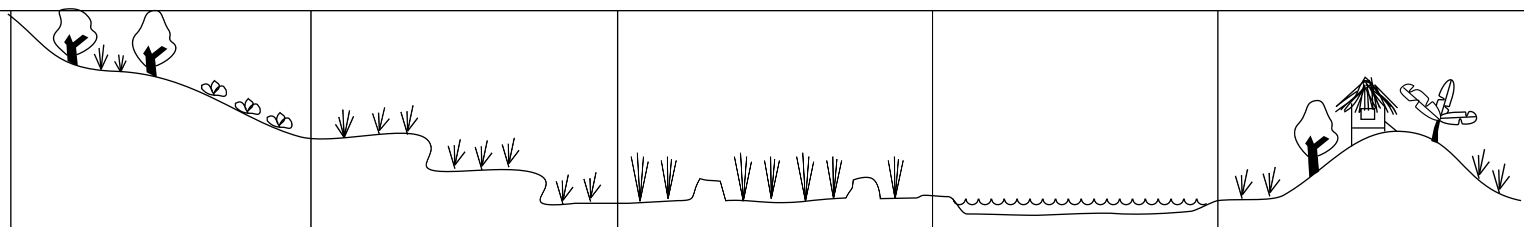
Name/Topic	Method	Sample[1]	Location	Time	Discussed in section
'IRRI data set' Rice production practices, inputs and outputs	Secondary data obtained from IRRI Social Sciences Division	132 farmers	Central Luzon	5 cropping seasons between 1979 and 1988	6 Rice production technology
'Antique IPM/ ALM survey' IPM and aquatic organisms in ricefields	Structured survey, field observations, identification of insect specimen	229 farmers (115 trained, 114 untrained in IPM), selected by stratified two-stage sampling (1. villages,2. farmers)	19 villages in 7 municipalities in Antique province	November 1993	6 Rice production technology 8 Exploring complementarities between IPM and ALM
'Antique rice labor survey' Labor requirements and division of labor (family/hired, men/ women/children) in rice production	Structured survey	30 farmers, systematic selection	1 village in Antique province (Catungan IV in the municipality	August 1994	6 Rice production technology 6 Labor requirements for rice production activities
'Antique/Nueva Ecija farming systems data set' Rice-based farming systems, use of resources and farming activities	Participatory data collection method involving village and farm transect walks, farmer-prepared bioresource flow diagrams and researcher-completed recording forms	50 farmers in Nueva Ecija and 27 farmers in Antique, informal sampling	2 villages in Nueva Ecija (Maragol and Rangayan in Muñoz) and 4 villages (Igpalje, San Antonio and Palma in Barbaza and Catungan IV in Sibalom)	September 1994-March1999 for Antique (2 rounds of data collection) and December 1994-February 1999 for Nueva Ecija (1 round of data collection in Antique	6 Diversity in rice-based farming systems
'Antique time allocation study' Time allocation of farm families in rice-based farming systems	Random visit method	12 farm households systematic selection	2 villages in Antique (San Antonio and Igpalje in Barbaza)	March 1993-April 1994	6 Time allocation of rice farm households in Antique

'Antique aquatic ricefield organisms survey' Presence and utilization of aquatic organisms in ricefields	Structured survey	30 farmers and 20 landless laborers, systematic selection	1 village in Antique province (Catungan IV in the municipality of Sibalom)	July-August 1994	7 Utilization pattern of aquatic organisms from ricefields
'Food consumption study' Food consumption of farm families in rice-based farming systems	24-hour recall	12 households in Antique and 13 households (7 rice-fish farmers plus 6 control households) in Nueva Ecija, systematic selection (Antique) and informal sampling (Nueva Ecija)	2 villages in Antique (San Antonio and Igpalje in Barbaza) and 2 villages in Nueva Ecija (Maragol and Rangayan in Muñoz)	February 1993-March 1994 (July 1993-March 1994 for 6 non-rice-fish households in Nueva Ecija	7 Food consumption of rice farmers in two Philippine provinces
'Antique fish preference ranking' Preferences for different kinds of fish	Ranking of fish species according to preferences and frequency of consumption	39 respondents (only women) from 4 villages, informal sampling	4 villages in Antique (San Antonio, Igpalje and Palma in Barbaza and Catungan IV in Sibalom)	June 1995	7 Preferences for different types of fish among women in Antique
'Farm activity monitoring' Weekly monitoring of farm activities in Antique and Nueva Ecija	Weekly recall of farm activities	16 households in Antique (systematic selection) and 7 households in Nueva Ecija (informal sampling)	3 villages in Antique (San Antonio, Igpalje and Palma in Barbaza) and 2 villages in Nueva Ecija (Maragol and Rangayan in Muñoz)	March 1993-February 1994	6 Rice production technology

[1] The classification of sample designs (systematic selection, stratified sampling, informal sampling, etc.) is based on Casley and Kumar (1988).

Appendix 4
Chapter 6 figures and tables

Figure A4.1. Village transect for Catungan IV, Sibalom, Antique.

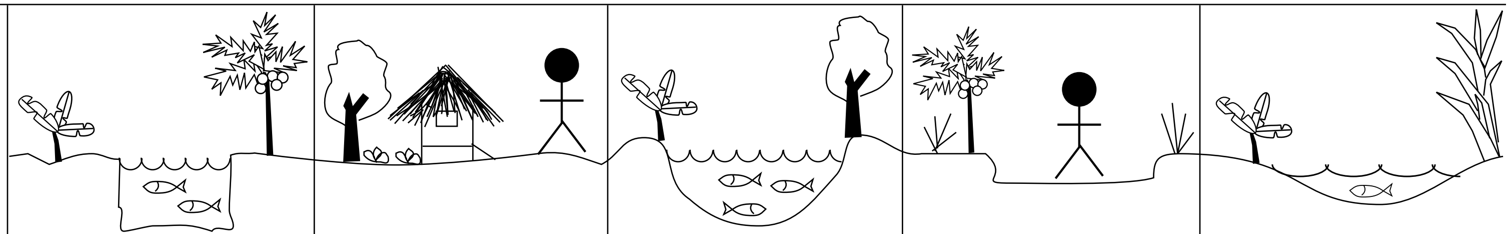


Local name	*Banglid*	*Vacantihan*	Irrigated land	*Lungasog*	*Turumpihan*
Common name	upland	midland, slightly terraced	irrigated land, lowland	lowland badly drained	small hill (man-made between ricefields)
Topography	sloping	slightly terraced 'step by step'	flat	flat	small hill in flat terrain
Access	exclusive	exclusive	exclusive	exclusive	exclusive
Access after harvest (for pasture)	common or open	common or open	common or open	common or open	exclusive
Value (on average) in Pesos/ha	50 000/ha (sale value)	150-200 000/ha (irrigated); more expensive if there are trees (mahogany, mango); 80 000/ha (non-irrigated)	150-20 000/ha	150-200 000/ha	same as riceland around
Soil type, local name	*dalipi, buga*	*dalipi, baras*	*laohon, laog* (?)	*laohon, laog*	same as riceland
Soil type, common name	hard soil, stony, rocks	hard soil, sandy	muddy	muddy	same as riceland
Water source	1. rain 2. spring	1. rain 2. irrigation 3. pump (river)	1. irrigation 2. spring 3. rain	1. irrigation 2. spring 3. rain	same as riceland

Figure A4.1, continued

Local name	*Banglid*	*Vacantihan*	Irrigated land	*Lungasog*	*Turumpihan*
Availability of water	seasonal	seasonal	seasonal (but longer)	seasonal (long, badly drained)	seasonal
Crops	corn munggo rootcrops (camote, cassava, peanuts)	rice munggo corn watermelon	rice munggo corn watermelon	rice munggo corn watermelon	
Vegetables	tomatoes eggplant onions cabbage sayote	squash tomatoes eggplant	squash tomatoes eggplant	squash	eggplant squash camote gabi tomato malunggay
Trees	ipil-ipil mahogany coconut bamboo banana madre-de-cacao many others		ipil-ipil madre-de-cacao balabago	ipil-ipil madre-de-cacao balabago	ipil-ipil banana papaya
Forage	grasses - *kogon* - *lagonoy* - *bungarngar*	grasses on dikes rice stubbles	grasses on dikes rice stubbles	grasses on dikes rice stubbles	
Livestock (or animals in general)	carabao cattle wild pig goat wild birds snakes	carabao cattle goat snake wild birds	carabao cattle goat wild birds	carabao cattle goat wild birds	rat snake frog turtle
Poultry			ducks chicken	ducks chicken	
Aquatic animals					
Problems	grass – hard to cultivate	water shortages		water logging (difficult to drain)	rats, snakes, dapaw (insects)

Figure A4.1, continued



Local name	*Irrigasyon*	*Baralayan*	Fishpond	*Birut karsada*	River/creek
Common name Topography	irrigation canal and dikes flat	homestead flat	fishpond flat	roadside flat	river/creek flat
Access	open or common	exclusive	exclusive	open or common	open
Access after harvest (for pasture)	—	—	—	—	
Value (on average) in pesos/ha	doesn't apply	200/m² 200 000/100m²	415/m²	doesn't apply	doesn't apply
Soil type, local name	*baras*		*laohon, laog*		*baraso*
Soil type, common name	sandy (from river)		muddy		sandy
Water source	irrigation (reservoir)	1. rain 2. irrigation 3. creek	1. spring 2. irrigation	rain	1. spring in the mountains 2. rain
Availability of water	seasonal	seasonal	seasonal (but long)	seasonal	year-round
Crops		sugarcane		sugarcane	
Vegetables	stringbeans eggplant tomatoes camote ampalaya	all types, also flowers	gabi, kangkong (water spinach) waterlily		

Local name	*Irrigasyon*	*Baralayan*	Fishpond	*Birut karsada*	River/creek
Trees		banana jackfruit papaya star apple coconut santol orange calamansi	ipil-ipil mahogany banana jackfruit coconut duhat guava tamarind *kabugaw* (pomelo) betelnut	ipil-ipil madre-de-cacao banana guava papaya jackfruit	mango bamboo *tambuyog* (like lanzones, but not edible) *dalisay* *tipolo* mahogany *lumboy* others
Forage	grasses on dikes				
Livestock	carabao	carabao pig cattle	pig	carabao cattle goat pig dog cat	
Poultry	ducks	chicken turkey	ducks	chicken	
Aquatic animals	tilapia mudfish catfish golden *kuhol*		tilapia mudfish catfish *Yangya* (?) *kalampay* golden *kuhol* *tibo-tibo* *igi*		*puyo* (climbing perch) mudfish *sili* (eel) shrimps crab *awis* (snail) golden *kuhol* *agihis* (clam) *tibo-tibo* (snail)
Problems	maintaining dikes	money, food, flooding (rainy season) drought (dry season)	flood, pesticides, setaling, finding buyers, people's preference	mosquitoes, carabao is a traffic hazard	flooding-erosion

Table A4.1. Seasonal calendar of factors relevant to rice–aquaculture, Catungan IV, Sibalom, Antique.

	January	February	March	April	May	June	July	August	September	October	November	December
Water availability	+/–	–	–	–	–/+	+ typhoons[1] (flooding)	+ typhoons (flooding)	+ typhoons (flooding)	+ typhoons (flooding	+	+/–	+/–
Fish source	+ sea – own field	+ sea – own field	++ sea – own field	++ sea –own field	++ sea – own field	– sea – own field	– sea + own field	– sea + own field	– sea + own field	– sea + own field	– sea + own field	+ sea – own field
Other aquatic organisms					frogs shrimps	frogs shrimps	(frogs)[2] crabs shrimps	(frogs) crabs shrimps	(frogs) crabs shrimps[3]	frogs crabs	frogs crabs	
Rice varieties		harvest 2nd crop/plant 3rd crop	plant 3rd crop		harvest 3rd crop/plant 1st crop	plant 1st crop		harvest 1st crop	harvest 1st crop	plant 2nd crop	plant 2nd crop	
Other crops		mungbeans	mungbeans watermelon vegetables	mungbeans watermelon vegetables	vegetables							
Labor		+ harvest (+ LP)[4 5]			++LP 1st crop (+ harvest)[4]	++LP 1st crop			+harvest 1st crop	+harvest 1st crop +LP 2nd	+LP 2nd crop	

[1] Typhoon season is normally just "sit-back-and-relax" time.
[2] Frogs are there from May until November (when there is water in the field), but when the rice for the first crop is too big, they cannot be caught in the field anymore. After the first crop is harvested, they can be caught again.
[3] Shrimps are only caught in the river/creek.
[4] Only for farmers who have a third crop, depending on water availability.
[5] LP=land preparation.

Table A4.2. Aggregation of cultured species to enterprise groups.

		Antique		Nueva Ecija	
Enterprise Group	Plant/animal	No. of farmers	%	No. of farmers	%
Cereals	rice	26	96	50	100
	corn	2	7	1	2
Livestock	pig	21	78	23	46
	water buffalo	13	48	21	42
	cow	10	37	14	28
	goat	2	7	13	26
Poultry	chicken	23	85	32	64
	duck	5	18	17	34
Roots and tubers	taro	19	70	5	10
	sweet potato	8	30	4	8
	cassava	8	30	1	2
	yam	4	15	–	–
Vegetables	stringbean	15	56	11	22
	eggplant	11	41	4	8
	water spinach	9	33	5	10
	okra	9	33	5	10
	tomato	6	22	4	8
	squash	8	30	–	–
	bitter gourd	4	15	4	8
	chili or bell pepper	7	26	–	–
	radish	6	22	–	–
	onion	6	22	–	–
	Malabar spinach	4	15	–	–
	sweet potato leaves	4	15	–	–
	jute leaves	4	15	–	–
	others	7	26	13	26
Fruit	coconut	25	93	22	44
	guava	19	70	24	48
	mango	14	52	28	56
	banana	22	81	15	30
	soursop	5	18	23	46
	papaya	11	41	16	32
	jackfruit	18	67	8	16
	camachili	5	18	15	30
	star apple	–	–	19	38
	santol	9	33	9	18
	carristel fruit	9	33	5	10
	avocado	6	22	7	14
	tamarind	–	–	12	24
	cacao	11	41	–	–
	camansi	3	11	5	10
	custard apple	4	15	3	6
	coffee	7	26	–	–
	Java plum	7	26	–	–
	bilimbi	5	18	–	–
	pomelo	4	15	–	–
	chico	–	–	4	8
	others	6	22	12	24

Table A4.2, continued

Enterprise Group	Plant/animal	Antique		Nueva Ecija	
		No. of farmers	%	No. of farmers	%
Trees	acacia	–	–	33	66
	Leucaena	11	41	17	34
	bamboo	13	48	14	28
	horse–radish tree	9	33	10	20
	mahogany	9	33	–	–
	others	7	26	9	18
Aquatic animals	tilapia	6	22	13	26
	mudfish	8	30	6	12
	catfish	11	41	–	–
	shrimps	9	33	–	–
	climbing perch	8	30	–	–
	crabs	7	26	–	–
	malay (fish)	5	18	–	–
	tabios (fish)	5	18	–	–
	edible snails	4	15	–	–
	others	10	37	5	10
Forage	grass	16	60	47	94
	rice straw	6	22	1	2
Others	sugarcane	5	18	–	–
	Azolla	–	–	1	2
Total		580	100	610	100

Source: Own computations.

Appendix 5
Description of activity categories used in the time allocation study (in alphabetical order)

absence: outside the barangay, for not more than a day (in case of longer absence, the observation was deleted).

acquisition of food and daily needs: buy food in the market (barangay, municipality); buy things (cigarettes; oil; sugar) in the store; buy non-food daily needs in the market; buy fish from traveling vendors; buy food (vegetables, rice, meat) in the neighborhood.

animal husbandry activities: bring cow/carabao to and from the pasturing range; cut grasses for cow/carabao; tend chicken and pig; construct and repair animal shelters and pens; house animals; feed animals; care for offspring of animals; clean animal housing; slaughter and sell animals.

backyard gardening: clean backyard and surroundings; construct fence; cultivate vegetables; cultivate fruit trees, pick fruit, cultivate flowers.

child care: fetch children to and from school; attend school ceremonies; help with school assignments; feed and tend smaller children; clean/wash children; provide health care for children.

church/ritual: attend church meetings and ceremonies, processions; attend mass, priest ordination; voluntary church work; attend funeral ceremony, nuptial ceremony, death anniversary, prayer/blessing of river.

CIVAC (civic action, community labor): construct houses in army camp; flood control on river dikes; stage construction for barangay benefit dance; clean main irrigation canal; transfer barangay hall to another place.

craft: make rope; make bolo; make bamboo toys; make pillows; weave baskets, mats, winnowers; make fish trap.

eating: eat meals or snacks.

finance: send money to student children; collect debts from customers; borrow money.

firewood: prepare coconuts for firewood; gather firewood; dry firewood; split firewood.

fishing: trap/catch fish at the seashore; catch fish in the river; install and maintain fishtrap.

food preparation: gather and prepare food items for cooking; sort, pound and winnow rice; cook and serve meals and snacks; build and maintain fire for cooking; set and clean the table; bring food to farm laborers.

housekeeping: arrange and maintain things inside the house; clean the house and the kitchen; sweep the floor; fetch water; wash dishes; fix beddings; gather rice sacks for washing.

house repair: minor repairs of old house; major repairs of old house; weave coconut leaves for roofing; change roofing; acquire building materials; build new house; construct makeshift; construct toilet; dig well for drinking water; move the old house to a nearby place.

laundry: wash clothes; dry clothes; fold washed clothes; iron clothes.

leisure: sleep; rest/relax; chat with friends/neighbors/relatives; chew betel nut; listen to the radio; watch video show; watch cockfight in the cockpit arena; watch performances in barangay plaza; attend barangay fiesta; drive around on motorcycle/bicycle; walk around the barangay; play basketball / watch basketball game; play cards; read books or comics.

meeting/discussion: cooperative meeting; barangay council meeting; meeting of the National Irrigation Association (NIA); attend land boundary dispute.

non-farm labor: work as barangay captain; work as health center attendant; work as fish vendor in the market; work as manager of restaurant (at cockpit arena); work as carpenter; work as mechanic; work as cook; work as video show operator; work as domestic helper in Iloilo/San Jose; work as tricycle driver; work as house construction laborer; work in road construction; ironing/laundrying for pay; work as laborer for National Irrigation Association; work in beauty parlor.

off-farm labor: work as farm laborer on other people's farms; make copra for pay; cut bamboo poles for pay; work as farm laborer out of town; work in sugar plantation out of town.

other farm activities: work in own mahogany tree plantation; work in upland farm (root crops, vegetables, trees); work in bamboo grove; construct/maintain water reservoir in upland farm; cut and haul lumber trees; cut and prepare nipa leaves for cigarette making; work in own coconut plantation; construct fence around farm boundary; cultivate vegetables (in ricefarm, upland farm, on ricefield dikes); work in own sugar cane plantation.

personal hygiene: change clothes; take a bath; wash feet; trim nails on hands and feet; comb hair, remove white hairs; get a haircut.

post harvest activities: thresh harvested off-type rice by foot; dry rice on bamboo mat in the sun; store dried rice in sacks; mill rice in travelling ricemill; sort bean seeds attacked by pests.

ricefarm activities: on the way to/from the farm; farm visit/inspection; scrape dike sides, repair of dikes; clean the irrigation canal in the farm, put bamboo pegs on canal entrance; collect stones from the land; plow the field by carabao or handtractor; harrow the field; level the field; bring carabao to the field for levelling; adjust/check water level in the field; soak rice seeds; direct seeding of rice/ transplanting of rice seedlings; irrigate the field; discuss results of soil analysis; close entrance of irrigation canal in preparation for applying fertilizer; fetch, mix and apply fertilizer; scare birds; put scaring materials in the farm; borrow sprayer to spray pesticides; spray pesticides (insecticides, herbicides, molluscicides); remove weeds; pick snails; transplant empty spots; look for laborers to hire; drain the field; harvest rice, supervise harvesters; gather harvested rice for piling/threshing; conduct rice threshing; haul harvested rice to the house; pile rice hay ; divide harvested rice between owner and tenant; haul machines to/from the farm; repair/maintenance of machines.

school/training: attend family life seminar, health seminar; IPM class and related activities (crop cut, field day, etc.); regular schooling; studying school lessons.

sick: at the hospital; at the doctor's; recovering from sickness; sick, resting at home.

sick care: care for sick relatives at home; bring sick relatives to the hospital; care for sick relatives in the hospital or relatives' house; give first aid to sick persons.

tailoring/mending: mend clothes; mend sleeping mats; mend sacks; sew dresses/costumes; sew fish trap netting.

town: visit student children in town; secure copies of official papers (marriage contract, jeep registration, etc.); attend to official business (land matters, money transactions, etc.).

tuba (coconut wine) production: tap coconut shoots and collect tuba from trees; strain tuba; measure tuba; sell tuba and entertain customers.

visit: visit neighbors or relatives.

Appendix 6
Wealth ranking in Catungan IV

Wealth ranking is a rapid appraisal tool which can be used to achieve a stratification of households based on general economic well-being and to elicit local criteria used to distinguish between wealth strata. For this study, a wealth ranking was conducted in the village of Catungan IV, Sibalom, Antique in order to identify people with different economic status. This information was used in the sample selection for interviews on the utilization of aquatic organisms from ricefields, because wealth and consumption pattern are closely related and a bias towards rich or poor people could have distorted the results. Furthermore, identification of wealth criteria can give valuable insights into the village economy and the preference ordering of local people.

In preparation for the wealth ranking a survey of houses was conducted in Catungan IV in June 1994. This resulted in a list of 151 names who stood as representatives for the households. The names of the households were written on index cards and five people were selected for the ranking exercise who all knew the people in the village very well. They were asked to sort the index cards into piles according to similarities and differences in the wealth of the households and to rank the piles from rich to poor. The number of piles was left open to each person doing the ranking. Among the five persons, three chose to make four piles while one made five and another one six piles. They were then asked to explain the main differences between the piles. This information is summarized below.

Rich people own large areas of land, machinery (handtractors, jeeps, threshers) and/or large numbers of livestock. They come from rich families and/or they have a steady income from non-farm sources, preferably from abroad (remittances; pensions). All respondents agreed that the richest person in Catungan IV is a retired US Navy officer who receives a pension from the USA. People are rich if both husband and wife earn a non-farm income and if they don't have many children. Rich people can afford to send their children to high-class schools where the children can become medical doctors.

The *medium rich* have some riceland of their own but not as much as the very rich people. They might also own some machinery (handtractor, thresher, tricycle) or a large flock of ducks. They have better food than the majority. They have non-farm jobs (teacher, blacksmith, worker for the irrigation authority) but not as remunerating jobs as the rich people. Some of them own large parcels in the uplands or have tenants on parts of their land. They can also send their children to school, but to less prestigious ones than the rich. In some cases, the husband works abroad and sends remittances.

The *medium poor* or average people are tenants or they own some small parcels of land. Even though they have a simple living, they have a little extra which they can save. Some have small businesses like sari-sari stores (small grocery stores). They do not have stable non-farm jobs. They normally have no machinery, but some have their children working in Manila who send remittances so that they can buy machinery.

The *very poor* are laborers who have no land to farm. The very poor people don't even own their residential lots where they could grow root crops or vegetables. They might have one pig and two chickens but definitely no carabao. Some of them are helpers on the land of bigger landowners. They are laborers who have occasional jobs. It is hard for them to find a job because they have no official qualifications and low educational attainment. To earn money, they catch and gather everything that is free: fish and snails from the river and wild plants which they then sell on the market. They come from families where the parents were already very poor.

Appendix 7
Rationale for items included in the IPM and ALM scale

Appendix 7.1 The IPM scale.
Items were selected to cover the three dimensions of practices, attitude and knowledge as stated in the main text. They represent key topics of IPM and can thus serve as a profile of the overall awareness of IPM among farmers.

Practice:
Use of insecticides/herbicides/molluscicides:

The reduction of pesticide use is a central objective of IPM (see Chapter 4).

Insecticide application during the first 30 days of the cropping cycle:

Crop damage during the first 30 days of the cropping cycle is dominantly caused by leaf-feeding insects. Rice plants can usually recover from leaf damages that occur at the tillering stage (from 22 to 40 days after seeding) without showing any yield loss (Heong et al. 1992). Thus, insecticide applications at this time may not only be wasted, but may also put the crop at risk to secondary brown planthopper problems at a later stage.

Use of rice straw:

Integrated nutrient management is a concept closely related to the IPM principle of growing a healthy crop. Rice straw is a valuable source of nutrients which, if burned, is lost to the soil. In addition, burning the rice straw on the field is a considerable source of air pollution. Thus, the burning of rice straw is considered to contradict good IPM practice.

Use of organic fertilizer (other than rice straw):

Long-term soil fertility is often enhanced by the use of organic fertilizers, even though they release nutrients (mainly nitrogen) more slowly than mineral fertilizers (Thurston 1992). Organic fertilizers provide a way to recycle on-farm substances (manure, compost) and reduce the danger of soil acidity. It has been recommended that organic sources of nitrogen should remain as an important supplemental source of nutrients for rice in tropical Asia (De Datta 1981).

Use of `old'rice varieties (before IR-60) vs. use of`new' rice varieties (after and including IR-60):

While the `first generation' HYVs released in the 1960s were susceptible to a broad range of pests, plant breeders have subsequently generated varieties which are resistant to major insects and diseases in Asia. The number of insect pests against which rice varieties are resistant or moderately resistant has increased from almost zero in the 1960s to 6 in the late 1980s (Rola and Pingali 1993). Unfortunately, resistance can only be retained by constantly breeding (and using) new varieties. Farmers who use modern varieties are more likely to capture the latest resistance effect than farmers using older varieties.

Attitude:

These items asked for farmer's attitudes (agree/disagree/no opinion/it depends) towards the following statements:

`The use of chemical pesticides will increase rice yields'

Unlike fertilizers, insecticides generally exhibit diminishing marginal returns (IRRI 1989, as cited in Heong et al. 1992). In addition, frequent insecticide use increases the danger of pest outbreaks. Kenmore (1991) reports that in one outbreak-afflicted province of Thailand, the greater the number of insecticide applications, the lower the yield, regardless of variety. Thus, IPM farmers are expected to disagree with this statement.

`If the leaves are damaged early in the cropping season it is important to spray'

This item corresponds closely to the practice of early season insecticide spraying described above. However, while early season insecticide applications are most probably wasted, the practice does not fully explain the mechanism or attitude behind this behavior. This item tries to capture farmers'awareness of the ability of rice plants to recover from leaf damage, especially early in the cropping season.

`There are enough natural enemies in the field to control the rice pests'

Natural control of rice pests by natural enemies is a key concept in IPM (see Kenmore et al. 1995). If not disrupted by pesticide applications, natural enemy populations are normally strong enough to keep pests in check. Thus, IPM-farmers are expected to agree with this statement.

`Expected yield loss if no insecticides are used'

Farmers were asked how much yield loss they expected to suffer if they would not use any insecticides on their rice. Several studies from Indonesia, Vietnam and the Philippines have shown that yields from untreated fields are often equal to or even higher than yields from insecticide-treated fields (e.g. Kenmore 1991; Medrano et al. 1993; van de Fliert 1993). IPM-farmers are expected to trust in the power of natural enemies (see previous item) and not fear any yield losses.

Knowledge:

Farmer correctly identifies insects/spiders presented to him/her as harmful or beneficial:

It is not only important to know that there are both harmful and beneficial insects and spiders in the rice field, but knowing which ones are the good and the bad ones (without necessarily knowing their names) is essential for an assessment of the ecological balance in the field.

Farmer correctly describes the damage symptoms of the identified insect pests:

Knowing the damage symptoms of major insect pests in rice is another important precondition for informed decision-making with regard to control measures.

Farmer states `resistance to pests' as a reason for choosing a rice variety:

Varietal resistance is an important concept in IPM. Farmers who select resistant rice varieties demonstrate their knowledge of this fact and their intention to utilize it as part of their strategies against pests.

Farmer knows that pesticide applications are harmful to beneficial organisms:

Preserving the beneficial organisms in the field is the key to natural or biological control which is the core of IPM (Kenmore et al. 1995). If farmers are aware that the natural pest-predator balance will be disrupted by the application of pesticides, they are less likely to use pesticides indiscriminately.

Appendix 7.2 The ALM scale.

Items were selected to cover the three dimensions of knowledge, attitude and practices as stated in the main text. They represent key topics of ALM and can thus serve as a profile of the overall awareness of ALM among farmers.

Practice:

Farmer has a pond or trench in his/her field…

A pond or a trench in the field is an indication for the fact that the farmer takes actions towards the management of aquatic organisms in the ricefield.

Farmer stocks/feeds aquatic organisms in his/her field…

The deliberate stocking and/or feeding of aquatic organisms are fairly advanced levels of management. In an initial version of the scale, it was considered to rank practices like utilizing–stocking–feeding in an ascending order according to the management skills required. However, it soon turned out that only few farmers actually implement these practices and that the construction of a meaningful sequence is not possible with other manifestations of ALM. Therefore, a simple additive index was chosen in which each indicator has an equal weight.

Farmer utilizes aquatic organisms for food, animal feed or as pest control agents…

This item evaluates farmers' awareness of the value of aquatic organisms in the field. No difference was made between the various ways in which the organisms are utilized, assuming that as soon as the farmer associates a positive value with these organisms, he or she will try to preserve them.

Attitude:

Reasons for non-use of aquatic organisms (not using aquatic organisms because of pesticide use/not using aquatic organisms for reasons other than pesticide use):

As described earlier, ALM stands for the environmentally friendly management of aquatic organisms in the field. A farmer who does not utilize these organisms because he or she fears that they are contaminated by pesticides implies that a change in pest management practices is needed for rice-aquaculture to become feasible. This farmer is more likely to practice ALM than a farmer who shows no interest in aquatic organisms regardless of pesticide use.

Farmer names aquatic organisms when asked for organisms living in the ricefield:

This item shows a general awareness of the aquatic fauna of the ricefield, a first step towards ALM.

Knowledge:

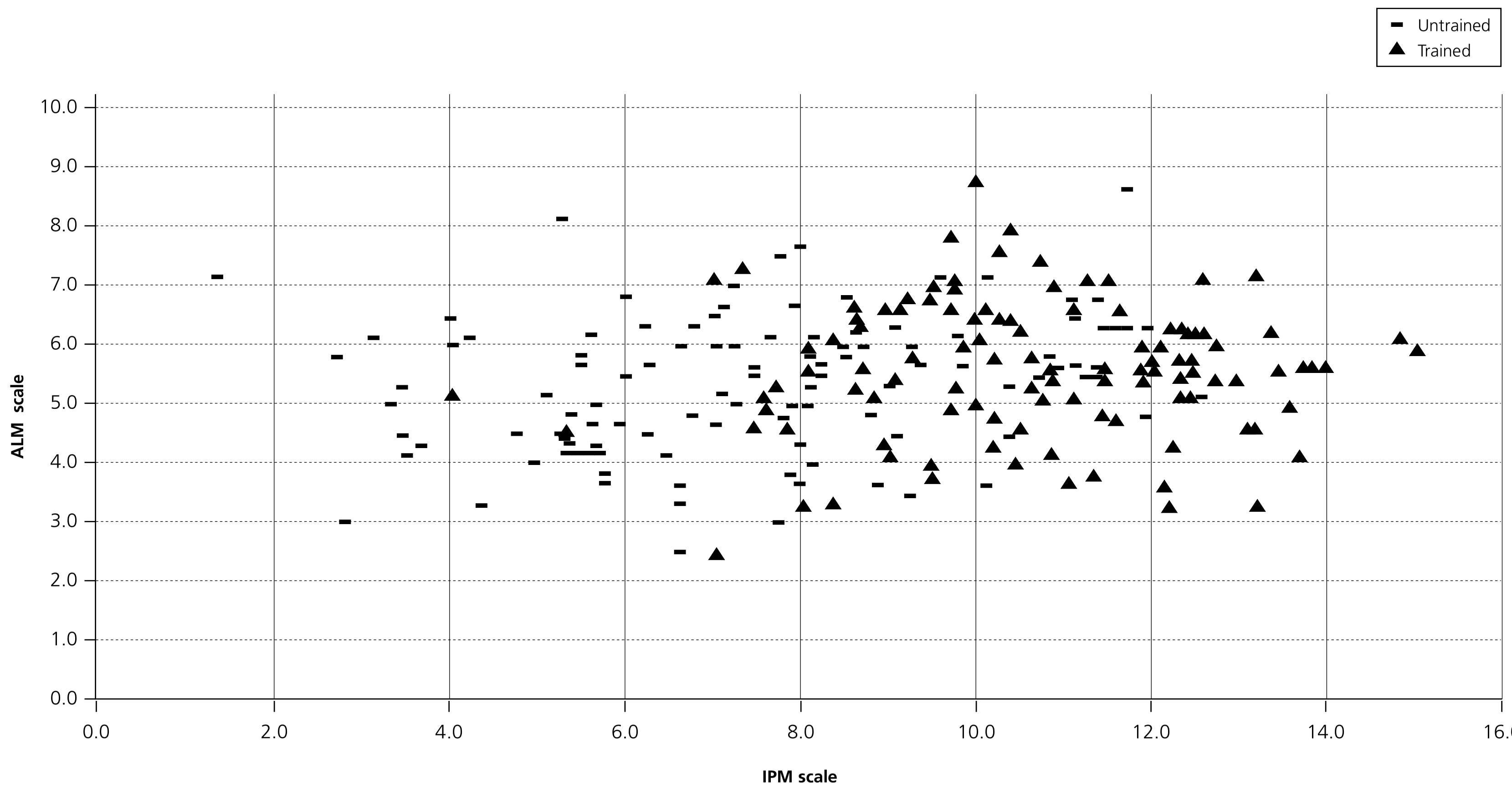
Farmer correctly describes the habitat/diet of 5 key aquatic ricefield organisms:

Knowledge of the feeding habit and preferred living environment of aquatic organisms is a precondition to their successful management. Five key organisms were identified from informal interviews with farmers in Antique, namely edible frogs, a common species of edible snails, the Golden Apple snail, ricefield crabs, and shrimps. Fish, one of the most commonly utilized organisms, was excluded from these items because the pre-test revealed that a) there was no variation in answers relating to the habitat (all respondents stated that fish live 'in places where there is sufficient water') and b) the diet of fish varies according to species, environment and growth stage, which is difficult to evaluate.

Farmer knows that tadpoles are the babies of frogs:

This fairly specific item tests for farmers' knowledge of biology and ecosystem linkages. Tadpoles are visible and they occur in most irrigated ricefields. If farmers are not aware that they will turn into frogs, they will take no steps to preserve them.

Appendix 8
Scatterplot of scale values for IPM and ALM, trained and untrained farmers



Appendix 9
Chapter 9 Tables

Table A9.1. Labor requirements of rice production, seasonality and division of labor as used in the LP-model.

Activity	Month	Performed by	Wage rate	Days/ha	Source	Notes
Fixing the dikes	1st month of each cropping season (June, October)	family labor (men, children); hired labor	PhP50/person/day	2.5 persondays	own data (Antique rice labor survey)	
Plowing the sides of the field with a carabao (water buffalo)	1st month of each cropping season (June, October)	hired labor; family labor (men)	PhP100/team of person and carabao/day	1 person-animal-day + 0.5 days of FL for supervision	own data (Antique rice labor survey)	This task is performed by a team of person and carabao; mostly hired, if no own carabao is available. One team can manage at least 1 hectare in 1 day.
Plowing/ harrowing the whole field with a hand tractor	1st month of each cropping season (June, October)	hired labor; family labor (men)	PhP1 200/ha or PhP360/ha if farmer owns a handtractor	not applicable; 0.5 days of FL for supervision	own data (Antique rice labor survey)	Plowing and harrowing is normally done under a contractual arrangement (per hectare, not per day). PhP1 200/ha are paid for the hiring of operator and tractor. If the farmer owns a handtractor, the payment is reduced to PhP360 for the labor of the operator.
Leveling the field with a carabao	1st month of each cropping season (June, October)	hired labor; family labor (men)	PhP100/ team of person and carabao/ day	1 person-animal-day + 0.5 days of FL for supervision	own data (Antique rice labor survey)	This task is performed by a team of person and carabao; mostly hired, if no own carabao is available. One team can manage at least 1 hectare in 1 day.
Applying molluscicides	1st month of each cropping season (June, October)	family labor (men); hired labor	PhP50/person/day	1 person-animal-day		Molluscicides are applied after the final land preparation, before broadcasting the seeds. No molluscicides are applied in the third cropping because water is scarce and not many snails occur, so snail control is not needed.
Making canals and broadcasting seeds	1st month of each cropping season (June, October)	family labor (men); hired labor	PhP50/person/day	3 persondays		In some cases, the wage rate is PhP60/person/day plus food; this applies when the field is far away from the house and the hired person has to haul the sacks of seeds to the field.

Table A9.1, continued

Activity	Month	Performed by	Wage rate	Days/ha	Source	Notes
Applying herbicides	1st month of each cropping season (June, October)	family labor (men); hired labor	PhP50/person/day	1 personday		Herbicides are applied during the first week after seeding.
Replanting empty spots	2nd month of each cropping season (July, November)	family labor (men, women, children); hired labor	PhP50/person/day	20 persondays		Empty spots are mainly caused by snail damage. Seedlings are taken from more densely planted areas of the field. In the third cropping season, no extra labor is required for the replanting of empty spots since snail damage is negligible. If replanting is necessary, it is assumed to be included in general crop care activities.
Applying fertilizer	2nd month of each cropping season (July, November)	family labor (men); hired labor	PhP50/person/ day	2 persondays (for 2 applications)		Fertilizer is normally applied twice per cropping season; first application: 3 weeks (20 days) after seeding (= 2nd month of each cropping season); second application: 5-7 weeks (35-45 days) after seeding (= 3rd month of each cropping Season). If the hired person has to haul the sacks of fertilizer to the field, an additional PhP10/ person/day are paid.
Applying insecticides	2nd and 3rd month of each cropping season (July/August, November/ December)	family labor (men); hired labor	PhP50/person/ day	1 personday per application (= 2 per cropping)		Two applications of insecticides, one in the second and one in the third month after seeding (after fertilizer application).
Other crop care activities (weeding, water management, field monitoring)	2nd, 3rd and 4th month of each cropping season	family labor (men, women, children), hired labor	PhP50/ person/day	2nd and 3rd month: 12 persondays 4th month: 9 persondays		Assumed: 3 persondays/ha/week for general crop care activities. In the 4th month, crop care activities include preparations for harvest.
Harvesting rice	4th month of each cropping season (September, January)	hired labor	Contractual arrangement (16.67% of gross yield)	not applicable; 7 days of FL for supervision		Family labor (adult men only) is needed for supervising the harvesters and threshers, to store and sell the harvested rice.

Source: Own computations.

Table A9.2. Material input prices (in Philippine pesos) used in the model formulation, crop year 1993/94.

Rice seeds (certified)	PhP8/kg
Fertilizers[8]	
Urea	PhP235/50 kg
Compound fertilizer	PhP287.50/50 kg
Ammonium phosphate	PhP270/50 kg
Ammonium sulfate	PhP166/50 kg
Muriate of potash	PhP235/50 kg
Pesticides[9]	
Thiodan (Endosulfan; insecticide)	PhP284/l
Fosferno (Methyl-parathion, insecticide)	PhP275/l
Sofit (Pretilachlor, herbicide)	PhP560/l
Tilapia fingerlings[10]	PhP0.24/piece
Rice bran[11]	PhP1.80/kilo
Piglet	PhP600 each

Table A9.3. Monthly farm gate and retail prices (in Philippine pesos) for rice used in the model formulation.

	Rough rice (PhP/kg)[12]	Milled rice (PhP/kg)[13]
June	6	10.25
July	6	11.50
August	6	11.50
September	5.75	12
October	4.75	10.75
November	5	10
December	5	10
January	5.50	10.50
February	6	11
March	6	11
April	6.25	11.25
May	6.25	11.50

---

8 Fertilizer prices for Antique were obtained from the weekly cereal and fertilizer price monitoring of the An tique office of the Bureau of Agricultural Statistics. Values are averaged for the years 1993 and 1994.

9 Pesticide prices for both Antique and Nueva Acija were obtained from a price survey of various agricultural supply dealers in both provinces in 1993.

10 Prices for tilapia fingerlings (improved breeds) were obtained from unpublished data collected by ICLARM.

11 Prices for rice bran were estimated based on data privided by Israel et al. (1994) for Nueva Ecija and key in formant interviews in Antique.

12 Source: Weekly cereal and fertilizer price monitoring of the Bureau of Agricultural Statistics, Antique Office, San Jose, Antique. Monthly averages for the model period (own computations).

13 Source: Weekly cereal and fertilizer price monitoring of the Bureau of Agricultural Statistics, Antique Office, San Jose, Antique. Monthly averages for the model period (own computations).

Table A9.4. Retail prices (in Philippine pesos) and farm gate prices[14] for food commodities used in the model formulation.

Food commodity	Retail (market) price (Pesos/kg)	Farm gate price (Pesos/kg)
Tilapia	34	30
Round scad	26	
Yaito tuna	20	
Milkfish	60	
Sardine	29	
Fermented fish paste	20	
Dried anchovies	67.50	
Dressed chicken	64	
Beef	91	
Pork	61.50	
Chicken eggs	2.40*	2*
Mungbeans	22	
Peanuts	31	
Taro	9.50	
Sweet potato	8.60	
Chinese cabbage	9.90	
Water spinach	2.70	
Squash	9.80	
Stringbeans	9.40	
Eggplant	12.30	
Bitter gourd	13.50	
Papaya	18.60	
Guava	23.50	
Mango	33.50	
Banana	11.60	
Finished pig		2 100*
Live chicken	60*	55*
Tilapia fingerlings		0.20*

Source: Bureau of Agricultural Statistics, San Jose, Antique, Philippines
*= price per piece

Table A9.5. Recommended dietary allowances (RDAs), maximum and minimum consumption requirements for the model family.

Food group	RDA (kg/family/month)	Maximum consumption level (RDA + 20%)	Minimum consumption level (RDA – 10%)
Cereals (rice)	71.68	86.01	64.51
Roots and tubers	18.30	21.96	16.47
Fish/meat/poultry	32.33	38.80	29.10
Eggs	3.66	4.39	3.29
Dried beans/ nuts/ seeds	3.66	4.39	3.29
Leafy green/yellow vegetables	18.30	1.96	16.47
Vitamin C-rich fruit	15.55	18.66	14.00
Other fruits/vegetables	27.45	32.94	24.71

Source: Own computations based on de Guzman et al. (1988).

[14] Farm gate prices are listed only for those food commodities which are produced for sale in the model farm.

Table A9.6. Recommended dietary allowances (RDAs), maximum and minimum consumption requirements of various nutrients for the model family.

Nutrient	RDA (kg/family/month)	Maximum consumption level (RDA + 20%)	Minimum consumption (RDA – 10%)
Energy (kcals/month)	415 105	498 126	373 594.50
Protein (g/month)	10 187	12 224.40	9 168.30
Calcium (g/month)	112.85	135.42	101.57
Iron (mg/month)	2 684	3 220.8	2 415.60
Vitamin A (RE, mcg/month)	103 700	124 440	93 330
Vitamin C (mg/month)	13 572.50	16 287	12 215.25

Source: Own computations based on de Guzman et al. (1988).

Table A9.7. Nutrient composition of food items included in the model diet (per kg "as purchased").

portion	% edible (kcals)	Energy (g)	Protein (mg)	Calcium (mg)	Iron (RE)	Vitamin A (mg)	Vitamin C
Rice (milled)	100	3 650	74	270	10	—	—
Tilapia	39	437	68	300	0.39	809	—
Round scad	41	381	77	308	3.69	277	—
Yaito tuna	63	800	154	328	102.69	320	—
Milkfish	68	904	125	326	6.80	827	—
Sardine	52	572	95	468	8.84	247	—
Fermented fish paste	100	610	103	5 350	109.00	3 600	—
Dried anchovies	100	3 210	602	21 840	130.00	4 208	—
Chicken	70	812	144	602	10.50	140	—
Beef	100	1 360	229	960	32.00	1 858	—
Pork	100	3 330	143	280	9.00	1 150	—
Chicken eggs	87	1 427	108	644	24.36	2 632	8.70
Mungbeans	100	3 370	244	1 420	57.00	133	100
Peanuts	100	5 670	258	670	27.00	—	—
Taro	77	739	18	300	6.93	39	69
Sweet potato	88	1 162	10	484	6.16	792	308
Chinese cabbage	84	151	17	1 411	31.08	1 792	454
Water spinach	58	151	20	534	26.68	2 489	174
Squash	71	249	10	433	4.97	1 041	142
Stringbeans	93	335	29	567	8.37	388	205
Eggplant	91	200	9	319	5.46	121	46
Bitter gourd	82	148	7	344	6.56	273	328
Mango	67	409	4	67	4.02	1 301	308
Papaya	64	288	3	218	6.40	480	474
Guava	99	743	9	337	5.94	107	1 564
Banana	69	759	10	145	5.52	414	173
Frog	31	295	65	143	5.58	—	—
Crab	45	567	62	9 500	4.50	—	—
Snail	41	340	50	6 765	35.67	2 047	—
Mudfish	62	546	127	484	8.68	124	—

Source: Own computations based on FNRI (1990).

Table A9.8. Seasonal calendar for the production of fruits and vegetables in the backyard garden, Antique.

	January	February	March	April	May	June	July	August	September	October	November	December
Mungbeans	X	X	X	X								X
Sweet potato					X	X	X	X				
Chinese cabbage	X	X	X	X								
Eggplant	X	X	X	X	X	X						
Bitter gourd	X	X	X	X								
Squash	X	X	X	X	X							X
Water spinach					X	X	X	X	X	X	X	X
Stringbeans	X	X	X	X				X	X	X	X	X
Mango	X	X	X	X	X						X	x

Source: Survey of 16 key informants in Antique, June 1995.
No seasonality could be detected for peanuts, banana, papaya, and guava. They were thus assumed to be available year-round in constant quantities.
The selected food items are assumed to be available in the market one month before and one month after the season indicated above, reflecting some regional trade in food items from places with slightly different seasons.

Table A9.9. Estimated backyard garden production of food items included in the model.

Food item	RDA (kg/family/ month)	% adequate	Total production (kg/year)	Total productive months	Production per food item (kg/productive month)
Root crops (taro, sweet potato)	18.30	10	21.96	16	1.37
Beans, nuts, seeds (mungbeans, peanuts)	3.66	42.26	18.60	17	1.09
Green leafy / yellow vegetables (squash, water spinach, Chinese cabbage)	18.30	43.33	95.16	18	5.29
Vitamin C-rich fruit (papaya, mango, guava)	15.55	29.20	54.48	31	1.76
Other fruit and vegetables (bitter gourd, stringbeans, eggplant, banana)	27.45	69.50	228.96	31	7.39

Source: Own computations.
Total production per food group was estimated from the identified RDAs for each food group for the model family (see Table A9.5) and the percentage adequacy of actual food consumption for this food group as reported in Chapter 7. The resulting amount was divided by the total number of productive months for all food items in the respective group, based on the seasonal calendar presented in Table A9.8, thus providing production estimates for each food item per productive month.

Table A9.10. Fish weight (kg/ha) at different stocking densities and different times during the 90-day culture period.

Stocking densities (fish/ha)	5,000	10,000	15,000	20,000
initial	1.91	3.82	5.73	7.64
15 days AS	12.25	22.24	30.92	38.61
45 days AS	70.15	120.93	161.09	193.66
75 days AS	160.44	271.77	356.72	423.14
90 days AS	182.96	308.36	403.03	476.23
first harvest[15] (25%)	45.74	77.09	100.76	119.06
second harvest (75%)	137.22	231.27	302.27	357.17

Source: Own computations based on Prein (1993).
AS = after stocking
Loss in each period is computed as 12.5% of the original number of fish (= 50% over the whole culture period).

[15] The computation of first and second harvest quantities is based on the total yield after 90 days, even though 25% of the fish is harvested earlier. It was assumed that these fish reach their final weight faster (because of higher stocking weights or other parameters) and can thus be harvested first.

Table A9.11. Computed feeding rates for rice bran (kg/month/ha) corresponding to 5% of fish body weight/day.

	Stocking densities (fish/ha)			
	5 000	10 000	15 000	20 000
15 days AS	9.34	16.96	23.58	29.44
45 days AS	106.97	184.42	245.67	295.33
75 days AS	244.67	414.45	544.00	645.28
90 days AS	139.05	235.12	307.32	363.13
total	500.94	850.95	1 120.55	1 333.17

Source: Own computations.
AS = after stocking
For the first (15 days AS) and last (90 days AS) period, feeding rates were computed for 0.5 months only.

[16] Only 50% of these rates were used in the model formulation, see text in chapter 8.

Table A9.12. Balanced minimum cost diet for the model family, base model (in pesos).

	January	February	March	April	May	June	July	August	September	October	November	December
Rice	83.87	81.49	81.49	82.49	80.93	80.07	80.37	80.55	80.55	80.83	82.26	82.09
Yaito tuna	7.93	10.02	10.02	9.64	10.80	10.57	10.11	9.81	9.81	9.10	8.72	9.03
Round scad	19.31	—	—	17.57	16.35	16.38	16.88	17.20	17.20	17.92	18.37	18.09
Tilapia	—	16.92	16.92	—	—	—	—	—	—	—	—	—
Dried anchovies	1.61	1.91	1.91	1.64	1.71	1.90	1.85	1.83	1.83	1.83	1.76	1.73
Fermented fish paste	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Eggs (pieces)	65.80	87.80	87.80	65.80	65.80	65.80	65.80	65.80	65.80	65.80	65.80	65.80
Taro	16.47	16.47	16.47	12.24	9.96	8.42	13.91	14.12	14.12	16.47	16.47	16.47
Sweet potato	—	—	—	4.23	6.51	8.05	2.56	2.35	2.35	—	—	—
Mungbeans	2.20	1.09	1.09	1.09	—	—	—	—	—	—	2.20	2.20
Peanuts	1.09	2.20	2.20	2.20	3.29	3.29	3.29	3.29	3.29	3.29	1.09	1.09
Bitter gourd	2.54	2.54	2.54	2.54	—	—	—	—	—	—	—	—
Stringbeans	7.39	7.39	7.39	7.39	7.71	—	6.48	7.39	7.39	7.39	7.39	7.39
Eggplant	7.39	7.39	7.39	7.39	7.39	7.39	—	—	—	—	—	—
Squash	1.30	11.31	11.31	3.74	5.26	—	—	—	—	—	—	3.50
Water spinach	20.66	—	—	18.22	16.70	18.63	19.57	19.68	19.68	20.47	19.91	18.46
Chinese cabbage	—	10.65	10.65	—	—	—	—	—	—	—	—	—
Papaya	11.49	1.76	1.76	12.24	12.24	14.00	14.00	14.00	14.00	13.61	11.70	11.92
Banana	7.39	7.39	7.39	7.39	9.61	17.32	18.23	17.32	17.32	17.32	17.32	17.32
Mango	1.76	12.24	12.24	1.76	1.76	—	—	—	—	—	1.76	1.76
Guava	0.75	—	—	—	—	—	—	—	—	0.39	0.54	0.32
Total	259.20	278.82	278.82	257.82	256.27	251.57	253.30	253.59	253.59	254.28	255.54	257.42

Table A9.13. Change in key parameters under different price scenarios (in Philippine pesos) for tilapia, without IPM.

% price reduction	Objective value	Household gross margin	Farm cash expenses	Food expenses	Area under rice-fish culture		Area under rice monoculture		Consumption of own tilapia	Purchase of tilapia	Total tilapia consumption
	(PhP/farm/ year)	(PhP/farm/ year)	(PhP/farm/ year)	(PhP/farm/ year)	Season 1 (ha)	Season 2 (ha)	Season 1 (ha)	Season 2 (ha)	(kg/family year)	(kg/family year)	(kg/family year)
0%	42 020.14	61 947.77	45 564.45	19 155.81	1.7	1.7	0	0	0	33.84	33.84
-10%	37 174.19	55 030.62	43 453.92	17 107.25	1.7	1.7	0	0	63.77	34.19	97.95
-0%	32 360.06	49 920.68	41 773.25	16 862.19	1.7	1.7	0	0	65.62	133.08	198.70
-30%	27 829.39	44 771.86	40 093.05	16 170.66	1.7	1.7	0	0	69.69	149.76	219.45
-40%	23 369.31	39 282.39	38 414.24	15 141.26	1.7	1.7	0	0	95.65	150.09	245.74
-45%	21 194.42	36 800.66	37 573.30	14 834.43	1.7	1.7	0	0	95.65	191.47	287.12
-50%	19 235.37	30 257.44	28 576.14	14 631.21	0.32	1.7	1.38	0	95.65	191.47	287.12
-52.5%	18 736.60	24 488.29	20 331.78	14 479.56	0.20	0.20	1.50	1.50	95.65	191.47	287.12
-55%	18 893.62	24 134.95	18 924.14	14 816.95	0.07	0.07	1.63	1.63	63.79	223.33	287.12
-60%	19 278.93	24 195.32	18 807.85	14 543.66	0.06	0.06	1.64	1.64	56.03	231.09	287.12
-70%	20 105.34	24 443.50	18 449.35	14 338.16	0	0	1.7	1.70	0	290.50	290.50
-80%	21 149.67	24 459.43	18 433.21	13 309.76	0	0	1.7	1.7	0	306.56	306.56
-90%	22 210.65	24 474.26	18 416.91	12 263.61	0	0	1.7	1.7	0	308.62	308.62
-100%	23 443.84	24 533.94	18 398.35	11 090.10	0	0	1.7	1.7	0	415.61	415.61

Source: Own computations

Table A9.14. Change in key parameters under different price scenarios for tilapia, with IPM.

% price reduction	Objective value	Household gross margin	Farm cash expenses	Food expenses	Area under rice-fish culture		Area under rice monoculture		Consumption of own tilapia	Purchase of tilapia	Total tilapia consumption
	(PhP/farm/ year)	(PhP/farm/ year)	(PhP/farm/ year)	(PhP/farm/ year)	Season 1 (ha)	Season 2 (ha)	Season 1 (ha)	Season 2 (ha)	(kg/family/ year)	(kg/family/ year)	(kg/family/ year)
0%	45 233.11	64 366.89	44 624.65	18 361.97	1.7	1.7	0	0	0.00	33.84	33.84
-10%	40 210.44	57 140.08	42 958.97	16 180.48	1.7	1.7	0	0	63.77	34.19	97.95
-20%	35 383.51	52 137.21	41 284.73	16 055.27	1.7	1.7	0	0	65.62	133.08	198.70
-30%	30 853.63	46 961.83	39 605.19	15 336.38	1.7	1.7	0	0	69.69	149.76	219.45
-40%	26 393.79	41 463.35	37 926.53	14 297.74	1.7	1.7	0	0	95.65	150.14	245.79
-45%	24 219.27	38 969.89	37 085.96	13 978.80	1.7	1.7	0	0	95.65	191.47	287.12
-50%	22 467.63	31 589.86	27 378.78	13 077.30	0.21	1.7	0	1.49	95.65	191.47	287.12
-52.5%	22 133.80	26 154.13	18 976.65	13 171.39	0.07	0.20	1.50	1.63	79.75	207.37	287.12
-55%	22 305.70	25 969.32	18 296.68	13 239.23	0.07	0.07	1.63	1.63	63.79	223.33	287.12
-60%	22 692.73	26 030.64	18 179.97	12 965.18	0.06	0.06	1.64	1.64	56.03	231.09	287.12
-70%	23 531.58	26 285.67	17 818.44	12 754.09	0	0	1.7	1.7	0.00	290.50	90.50
-80%	24 575.95	26 301.60	17 802.29	11 725.65	0	0	1.7	1.7	0.00	306.56	306.56
-90%	25 638.82	26 316.60	17 785.82	10 677.78	0	0	1.7	1.7	0.00	308.62	308.62
-100%	26 867.53	26 375.88	17 767.66	9 508.34	0	0	1.7	1.7	0.00	415.61	415.61

Source: Own computations.

Table A9.15. Changes in land allocation due to increasing wage rates, Nueva Ecija, conventional pest management only (in hectares).

	Season 1			Season 2		
Original wage level	Rice	Rice-fish	Fallow	Rice	Rice-fish	Fallow
+50%	1.19	0.99	0.12	—	2.3	—
+100%	0.74	0.99	0.57	—	2.3	—
+200%	—	0.99	1.31	—	2.3	—
+300%	0.05	0.73	1.52	—	1.76	0.54
+400%	0.53	0.11	1.66	—	1.15	1.15

Source: Own computations.
*Changes in wage level concern both on-farm and off-farm wages.

Appendix 10
Simplified matrix of the LP model

Simplified structure of the linear programming model used for the economic analysis of technology options.

Period 1			Production system			Select stocking density				Other farm activities	Labor		Material inputs		Sell output	Transfer output	Gather aquatic organisms	Buy and consume food	Consume own produce	Credit		Transfer cash	Off-farm activites
			rice mono-culture	rice-fish culture	pond	5 000	10 000	15 000	20 000		hired	family	own	purchased						formal	informal		
	Objective function		0	0	-34850	0	0	0	0	0	-w	0	0	-q	+p	0	0	-p	0	$-i_f$	$-i_{if}$	0	+w
Period 1	rice and fish 1	total rice land	1	1	1																		
		rice-fish land		1	1																		
		pond area		0.1	-1																		
		stocking density				1	1	1	1														
		stock fish		1	1	-1	-1	-1	-1														
		labor tasks	l_1	l_1	l_1						-0.9	-1											
		material inputs	m_1	m_1	m_1								-1	-1									
		output	$-y_1$			$-y_1$	$-y_1$	$-y_1$	$-y_1$						1	1			1				
	other farm 1	extent								1													
		labor tasks								l_1	-0.9	-1											
		material inputs								m_1			-1	-1									
		output								$-y_1$					1	1			1				
	aquatic	labor tasks										-1					l_1						
	organisms 1	output															$-y_1$		1				
	nutrition 1	minimum consumption																c_1	c_1				
		maximum consumption																c_1	c_1				
	cash balance 1										+w			+q	-p			+p		-1	-1	1	-w
Period 2	rice and fish	total rice land																					
		rice-fish land																					
		pond area																					
		stocking density																					
		stock fish																					
		labor tasks																					
		material inputs																					
		output																					
	other farm 2	extent																					
		labor tasks																					
		material inputs																					
		output																					
	aquatic	labor tasks																					
	organisms 2	output																					
	nutrition2	minimum consumption																					
		maximum consumption																					
	cash balance 2																			$+(1+i_f)$	$+(1+i_f)$	-1	
Period 3	other farm	extent																					
	activities 3	labor tasks																					
		material inputs																					
		output																					
	nutrition3	minimum consumption																					
		maximum consumption																					
	cash balance 3																						
Monthly limits	off-farm labor																						
	credit	formal																		1			
		informal																			1		
Own fund maintenance																							

Appendix 10, continued

Period 1			Production system			Select stocking density				Other farm activities	Labor		Material inputs		Sell output	Transfer output	Gather aquatic organisms	Buy and consume food	Consume own produce	Credit		Transfer cash	Off-farm activites
			rice mono-culture	rice-fish culture	pond	5 000	10 000	15 000	20 000		hired	family	own	purchased						formal	informal		
	Objective function		0	0	-34850	0	0	0	0	0	-w	0	0	-q	+p	0	0	-p	0	$-i_f$	$-i_{if}$	0	+w
Period 1	rice and fish 1	total rice land																					
		rice-fish land																					
		pond area																					
		stocking density																					
		stock fish																					
		labor tasks																					
		material inputs																					
		output																					
	other farm 1	extent																					
		labor tasks																					
		material inputs																					
		output																					
	aquatic organisms 1	labor tasks																					
		output																					
	nutrition 1	minimum consumption																					
		maximum consumption																					
	cash balance																						
Period 2	rice and fish 2	total rice land	1	1	1																		
		rice-fish land		1	1																		
		pond area		0.1	-1																		
		stocking density				1	1	1	1														
		stock fish		1	1	-1	-1	-1	-1														
		labor tasks	l_2	l_2	l_2						-0.9	-1											
		material inputs	m_2	m_2	m_2								-1	-1									
		output	$-y_2$			$-y_2$	$-y_2$	$-y_2$	$-y_2$						1	1			1				
	other farm 2	extent								1													
		labor tasks								l_2	-0.9	-1											
		material inputs								m_2			-1	-1									
		output								$-y_2$					1	1			1				
	aquatic organisms 2	labor tasks										-1					l_2						
		output															$-y_2$		1				
	nutrition2	minimum consumption																c_2	c_2				
		maximum consumption																c_2	c_2				
	cash balance 2										+w			+q	-p			+p		-1	-1	1	w
Period 3	other farm activities 3	extent																					
		labor tasks																					
		material inputs																					
		output																					
	nutrition3	minimum consumption																					
		maximum consumption																					
	cash balance 3																			$+(1+i_f)$	$+(1+i_f)$		
Monthly limits	off-farm labor																						
	credit	formal																		1			
		informal																			1		
Own fund maintenance																							

Appendix 10, continued

Period 3			Other farm activities	Labor		Material inputs		Sell output	Transfer output	Buy and consume food	Consume own produce	Credit		Off-farm activites	Year end cash balance		RHS	
				hired	family	own	purchased					formal	informal					
	Objective function		0	-w	0	0	-q	+p	0	-p	0	$-i_f$	$-i_{if}$	+w	0			max!
Period 1	rice and fish 1	total rice land														LE		1.7
		rice-fish land														LE		1.7
		pond area														LE		0
		stocking density														SOSLE		1
		stock fish														EQ		0
		labor tasks														LE		0
		material inputs														LE		0
		output														LE		0
	other farm 1	extent														EQ	x_1	
		labor tasks														LE		0
		material inputs														LE		0
		output														LE		0
	aquatic	labor tasks														LE		0
	organisms 1	output														LE		0
	nutrition 1	minimum consumption														GE	RDA-10%	
		maximum consumption														LE	RDA+20%	
	cash balance 1															LE	own funds	
Period 2	rice and fish 2	total rice land														LE		1.7
		rice-fish land														LE		1.7
		pond area														LE		0
		stocking density														SOSLE		1
		stock fish														EQ		0
		labor tasks														LE		0
		material inputs														LE		0
		output														LE		0
	other farm 2	extent														EQ	x_2	
		labor tasks														LE		0
		material inputs														LE		0
		output														LE		0
	aquatic	labor tasks														LE		0
	organisms 2	output														LE		0
	nutrition2	minimum consumption														GE	RDA-10%	
		maximum consumption														LE	RDA+20%	
	cash balance 2															LE		0
Period 3	other farm	extent	1													EQ	x_3	
	activities 3	labor tasks	l_3	-0.9	-1											LE		0
		material inputs	m_3			-1	-1									LE		0
		output	$-y_3$					1	1		1					LE		0
	nutrition3	minimum consumption								c_3	c_3					GE	RDA-10%	
		maximum consumption								c_3	c_3					LE	RDA+20%	
	cash balance 3			+w			+p	-p				-1	-1	-w	1	LE		0
Monthly	off-farm labor															LE		
limits	credit	formal										1				LE		7650
		informal											1			LE		4000
Own fund maintenance												$-(1+i_f)$	$-(1+i_{if})$		1	GE	own funds	

Chapter13

Appendices

Appendix 1
List of plants, animals and local terms mentioned in the text

Table A1.1 Local, English and scientific names of fish species included in the text.

Local name (Kinaray-a, Visayan, Tagalog)	English name	Scientific name	Preferred environment
aloy	yaito tuna	*Euthynnus yaito*	marine
alumahan	striped mackerel	*Rastrelliger kanagurta*	marine
bangus	milkfish	*Chanos chanos*	brackishwater/marine
bayang	speckled drepane	*Drepane punctata*	marine
bilong-bilong	spotted moonfish	*Mene maculata*	marine
bisugo	ribbon-finned nemipterid; threadfin bream	*Nemipterus taenipterus; Nemipterus delagoae*	marine
dalagang bukid	golden caesio	*Caesio* sp.	marine
dilis	long-jawed anchovy	*Stolephorus commersonii*	marine
galunggong	big-bodied round scad	*Decapterus macrosoma*	marine
haruan, *dalag*	mudfish, striated murrel, snakehead	*Channa striata*	freshwater
hasa-hasa	Short-bodied mackerel	*Rastrellinger brachysomus*	marine
juju	Japanese eel	*Misgurnus anguillicaudatus*	freshwater
karpa	common carp	*Cyprinus carpio*	fresh/ brackishwater
mamsa	banded cavalla; long-finned cavalla; jack; pampano	*Caranx sexfasciatus; Citula armata; Caranx* sp.	marine
maya-maya	Malabar red snapper; red snapper	*Lutjanus malabaricus; Lutjanus bohar*	marine
panit	yellowfin tuna	*Thunnus albaceres; Nethunnus macropterus*	marine
pantat	catfish	*Clarias batrachus*	freshwater
pasa-pasa	blue-spotted sting ray	*Dasyatis kuhlii*	marine
puyo	common climbing perch	*Anabas testudineus*	freshwater; estuaries
sapsap	common slipmouth; black-finned slipmouth	*Leiognathus equulus*	marine
talakitok	banded cavalla	*Caranx sexfasciatus*	marine
tamban	fimbriated sardine	*Sardinella fimbriata*	marine
tanigi; *tangigi*	Spanish mackerel	*Cybium commersoni; Scomberomorus commerson*	marine
tilapia	tilapia	*Tilapia nilotica, Tilapia* sp.	fresh/brackishwater
tuloy	Indian sardine	*Sardinella longiceps*	marine
	goldfish	*Carassius auratus*	freshwater
	grasscarp	*Ctenopharyngodon idella*	freshwater
	silver barb	*Puntius gonionotus*	freshwater
	snakeskin gourami	*Trichogaster pectoralis*	freshwater

Source: own observations (local names); FishBase 1998 (English and scientific names).

Table A1.2. Scientific names of insects and aquatic organisms mentioned in the text.

English name	Scientific name
armyworm, cutworm	*Spodoptera* sp., *Mythimna separata* (Lepidoptera: Noctuidae)
brown planthopper	*Nilaparvata lugens* (Homoptera: Delphacidae)
caseworm	*Nymphula depunctalis* (Lepidoptera: Pyralidae)
damselfly	*Agriocnemis* sp. (Odonata: Coenagrionidae)
green leafhopper	*Nephotettix* sp. (Homoptera: Cicadellidae)
lady beetle	*Micraspis* sp.; *Harmonia octomaculata; Menochilus sexmaculatus* (Coleoptera: Coccinellidae)
rice bug	*Leptocorisa* sp. (Hemiptera: Alydidae)
spider	various species (Araneae: Lycosidae, Oxyopidae, Salticidae)
stemborer	*Chilo* sp., *Scirpophaga* sp., *Sesamia inferens* (Lepidoptera)
edible frog	*Rana vittigera, Rana limnocharis*
freshwater shrimp	*Palaemonidae*
Golden Apple snail	*Pomacea canaliculata*
native edible snail	*Thiara asperata*; other species
ricefield crab	*Potamon grapsoides*; other species

Source: IRRI 1983; Reissig et al. 1986; Shepard et al. 1987; FNRI 1990.

Table A1.3. Botanical name of plants mentioned in the text.

English name	Scientific name
acacia	*Acacia* sp., Leguminosae
avocado	*Persea americana* Mill., Lauraceae
bamboo	*Dendrocalamus* asper (Schult.) Backer ex Heyne
banana	*Musa x paradisiaca* L., Musaceae
bell pepper	*Capsicum annuum* L., Solanaceae
bilimbi	*Averrhoa bilimbi* L., Oxalidaceae
bitter gourd	*Momordica charantia* L., Cucurbitaceae
cacao	*Theobroma cacao* L., Sterculiaceae
camachili	*Phytecellobium* dulce (Roxb.) Benth.
calamansi	*Artocarpus camansi* Blanco, Moraceae
carristel fruit	*Pouteria campechiana* (H.B.K.) Beechni, Sapotaceae
cassava	*Manihot esculent*a Crantz, Euphorbiaceae
chico	*Manilkara zapota* (L.) von Royen, Sapotaceae
chili pepper	*Capsicum frutescens* L., Solanaceae
coconut	*Cocos nucifera* L., Cocoideae
coffee	*Coffea arabica* L., Rubiaceae
corn	*Zea mays* L., Maydeae
custard apple	*Annona squamosa* L., Annonaceae
eggplant	*Solanum melongena* L., Solanaceae
guava	*Psidium guajava* L., Myrtaceae
horse-radish tree	*Moringa oleifera* Lam., Moringaceae
jackfruit	*Artocarpus heterophyllus* L., Malvaceae
java plum	*Syzygium cumini* (L.) Skeels
jute	*Corchorus capsularis* L., Tiliaceae
Leucaena	*Leucena leucocephala* (Lam.) de Wit
malabar spinach	*Basella alba* L., Basellaceae
mango	*Mangifera indica* L., Anacardiaceae
mungbeans	*Vigna radiata* L., Leguminosae
okra	*Abelmoschus esculentus* (L.) Moench, Malvaceae
onion	*Allium cepa* L., Alliaceae
papaya	*Carica papaya* L., Caricaceae
peanut	*Arachis hypogaea* L., Leguminosae
pomelo	*Citrus grandis* (L.) Osbeck, Rutaceae
radish	*Raphanus sativus* L., Cruciferae
rice	*Oryza sativa* L., Gramineae

Table A1.3, continued

English name	Scientific name
santol	*Sandoricum koetjape* (Burm.f.) Merr., Meliaceae
soursop	*Annona muricata* L., Annonaceae
squash	*Cucurbita pepo* L., Cucurbitaceae
starapple	*Chrysophyllum cainito* L., Sapotaceae
stringbean, yard-long bean	*Vigna unguiculata* ssp. *sesquipedalis* L., Leguminosae
sugar cane	*Saccharum officinarum* L., Gramineae
sweet potato	*Ipomoea batatas* L., Convulvulaceae
tamarind	*Tamarindus indica* L., Leguminosae
taro	*Colocasia esculenta* (L.) Schott, Araceae
tomato	*Lycopersicon lycopersicum* (L.) Farw., Solanaceae
water spinach	*Ipomoea aquatica* Forsk., Convulvulaceae
winged bean	*Psophocarpus tetragonolobus* DC., Leguminosae
yam	*Dioscorea alata* L., Discoreaceae

Source: Rehm and Espig 1984.

Table A1.4. Glossary of local terms used.

Term	Description
barangay	smallest administrative unit in the Philippines
carabao	water buffalo
cavan	volume measure for rice One cavan of rough rice = 42-50 kg, depending on the region; one cavan of milled rice = 50 kg
tuba	coconut wine
bolo	big knife
bagoong	fermented small fish or shrimps
sari- sari store	small grocery store

Appendix 2
Chapter 2 figures and tables

Table A2.1. Mean one-day per capita food consumption: Philippines, 1978, 1982 and 1987.

	Food consumption, g/day			% increase/(decrease)	
Food group/ subgroup	1978	1982	1987	1978 to 1982	1982 to 1987
Cereals and cereal products	367	356	345	(3.0)*	(3.1)*
rice and products	308	304	303	(1.3)	(0.3)
corn and products	38	34	24	(10.5)*	(29.4)*
cereal products	21	18	18	(14.3)*	—
Starchy roots and tubers	37	42	22	13.5*	(47.6)*
Sugars and syrups	19	22	24	15.8*	9.1*
Fats and oils	13	14	14	7.7	—
Fish, meat and poultry	133	154	157	15.8*	1.9
fish and products	102	113	111	10.8*	(1.8)
meat and products	23	32	37	39.1*	15.6*
poultry	7	10	9	42.8*	(10)
Eggs	8	9	10	12.5	11.1
Milk and milk products	42	44	43	4.8	(2.3)
whole milk	31	30	36	(3.2)	20.0*
milk products	11	14	7	27.2*	(50.0)*
Dried beans, nuts and seeds	8	10	10	25.0*	—
Vegetables	145	130	111	(10.3)*	(14.6)*
green leafy/ yellow	34	37	29	8.8	(21.6)*
other vegetables	111	93	82	(16.2)*	(11.8)*
Fruit	104	102	107	(1.9)	4.9
vitamin C–rich fruit	30	18	24	(40.0)*	33.3*
other fruit	74	84	83	13.5*	(1.2)
Miscellaneous	21	32	26	52.4*	(18.7)*
beverages	8	16	12	100.0*	(25.0)*
condiments and others	12	15	14	25.0*	(6.7)

Source: Villavieja et al. 1989.
* Statistically significant

Table A2.2. Mean one-day per capita nutrient intake and percent adequacy: Philippines, 1978, 1982 and 1987.

Nutrients and particulars	1978	1982	1987	% increase/ (decrease) 1978 to 1982	% increase/ (decrease) 1982 to 1987
Energy					
intake (kcal)	1804	1808	1753	0.2	(3.0)*
% adequacy	88.6	89.0	87.1		
Protein					
intake (g)	48.0	50.6	49.7	5.4*	(1.8)*
% adequacy	93.2	99.6	98.2		
Iron					
intake (mg)	10.6	10.8	10.7	1.9	(0.9)
% adequacy	88.3	91.5	91.5		
Calcium					
intake (g)	0.44	0.45	0.42	2.3	(6.7)*
% adequacy	78.60	80.40	75.0		
Thiamin					
intake (mg)	0.73	0.74	0.68	1.4	(8.1)*
% adequacy	70.7	71.8	66.7		
Niacin					
intake (mg)	15.3	16.4	16.3	7.2	(0.6)
% adequacy	115.5	119.7	119.9		
Vitamin C					
intake (mg)	66.8	61.6	53.6	(7.8)*	(13.0)*
% adequacy	99.2	91.1	80.0		
Fats					
intake (g)	28	30	30	7.1*	—
Carbohydrates					
intake (g)	332	313	(1.5)	(4.3)*	

Source: Villavieja et al. 1989.
* Statistically significant

Appendix 3
Listing of surveys and monitoring activities

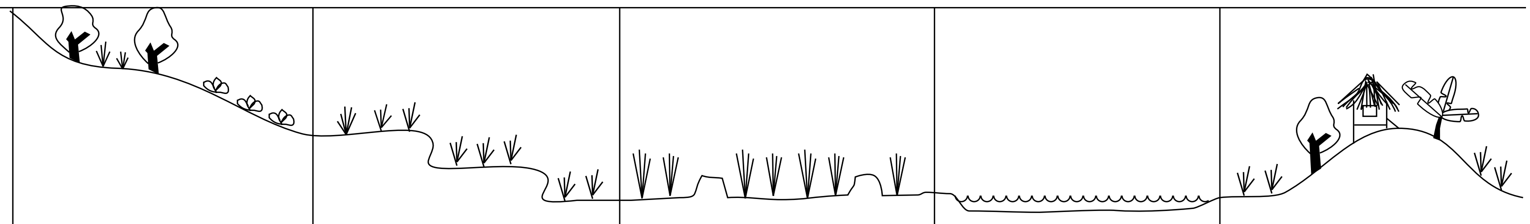
Name/Topic	Method	Sample[1]	Location	Time	Discussed in section
'IRRI data set' Rice production practices, inputs and outputs	Secondary data obtained from IRRI Social Sciences Division	132 farmers	Central Luzon	5 cropping seasons between 1979 and 1988	6 Rice production technology
'Antique IPM/ ALM survey' IPM and aquatic organisms in ricefields	Structured survey, field observations, identification of insect specimen	229 farmers (115 trained, 114 untrained in IPM), selected by stratified two-stage sampling (1. villages,2. farmers)	19 villages in 7 municipalities in Antique province	November 1993	6 Rice production technology 8 Exploring complementarities between IPM and ALM
'Antique rice labor survey' Labor requirements and division of labor (family/hired, men/ women/children) in rice production	Structured survey	30 farmers, systematic selection	1 village in Antique province (Catungan IV in the municipality	August 1994	6 Rice production technology 6 Labor requirements for rice production activities
'Antique/Nueva Ecija farming systems data set' Rice-based farming systems, use of resources and farming activities	Participatory data collection method involving village and farm transect walks, farmer-prepared bioresource flow diagrams and researcher-completed recording forms	50 farmers in Nueva Ecija and 27 farmers in Antique, informal sampling	2 villages in Nueva Ecija (Maragol and Rangayan in Muñoz) and 4 villages (Igpalje, San Antonio and Palma in Barbaza and Catungan IV in Sibalom)	September 1994-March1999 for Antique (2 rounds of data collection) and December 1994-February 1999 for Nueva Ecija (1 round of data collection in Antique	6 Diversity in rice-based farming systems
'Antique time allocation study' Time allocation of farm families in rice-based farming systems	Random visit method	12 farm households systematic selection	2 villages in Antique (San Antonio and Igpalje in Barbaza)	March 1993-April 1994	6 Time allocation of rice farm households in Antique

'Antique aquatic ricefield organisms survey' Presence and utilization of aquatic organisms in ricefields	Structured survey	30 farmers and 20 landless laborers, systematic selection	1 village in Antique province (Catungan IV in the municipality of Sibalom)	July-August 1994	7 Utilization pattern of aquatic organisms from ricefields
'Food consumption study' Food consumption of farm families in rice-based farming systems	24-hour recall	12 households in Antique and 13 households (7 rice-fish farmers plus 6 control households) in Nueva Ecija, systematic selection (Antique) and informal sampling (Nueva Ecija)	2 villages in Antique (San Antonio and Igpalje in Barbaza) and 2 villages in Nueva Ecija (Maragol and Rangayan in Muñoz)	February 1993-March 1994 (July 1993-March 1994 for 6 non-rice-fish households in Nueva Ecija	7 Food consumption of rice farmers in two Philippine provinces
'Antique fish preference ranking' Preferences for different kinds of fish	Ranking of fish species according to preferences and frequency of consumption	39 respondents (only women) from 4 villages, informal sampling	4 villages in Antique (San Antonio, Igpalje and Palma in Barbaza and Catungan IV in Sibalom)	June 1995	7 Preferences for different types of fish among women in Antique
'Farm activity monitoring' Weekly monitoring of farm activities in Antique and Nueva Ecija	Weekly recall of farm activities	16 households in Antique (systematic selection) and 7 households in Nueva Ecija (informal sampling)	3 villages in Antique (San Antonio, Igpalje and Palma in Barbaza) and 2 villages in Nueva Ecija (Maragol and Rangayan in Muñoz)	March 1993-February 1994	6 Rice production technology

[1] The classification of sample designs (systematic selection, stratified sampling, informal sampling, etc.) is based on Casley and Kumar (1988).

Appendix 4
Chapter 6 figures and tables

Figure A4.1. Village transect for Catungan IV, Sibalom, Antique.

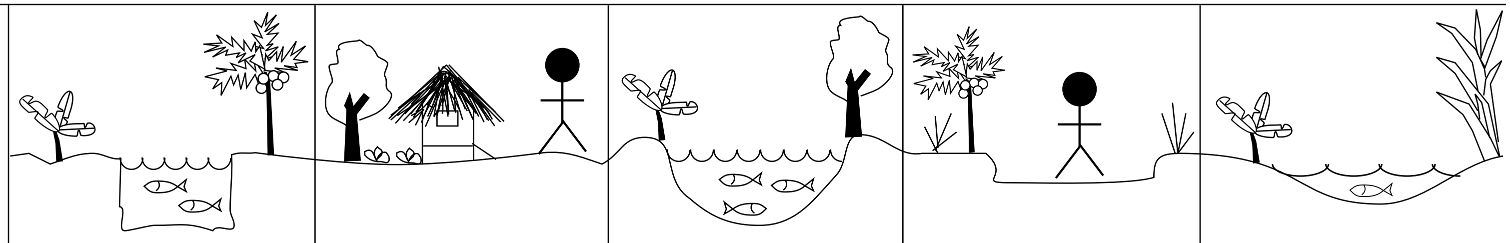


Local name	*Banglid*	*Vacantihan*	Irrigated land	*Lungasog*	*Turumpihan*
Common name	upland	midland, slightly terraced	irrigated land, lowland	lowland badly drained	small hill (man-made between ricefields)
Topography	sloping	slightly terraced 'step by step'	flat	flat	small hill in flat terrain
Access	exclusive	exclusive	exclusive	exclusive	exclusive
Access after harvest (for pasture)	common or open	common or open	common or open	common or open	exclusive
Value (on average) in Pesos/ha	50 000/ha (sale value)	150-200 000/ha (irrigated); more expensive if there are trees (mahogany, mango); 80 000/ha (non-irrigated)	150-20 000/ha	150-200 000/ha	same as riceland around
Soil type, local name	*dalipi, buga*	*dalipi, baras*	*laohon, laog* (?)	*laohon, laog*	same as riceland
Soil type, common name	hard soil, stony, rocks	hard soil, sandy	muddy	muddy	same as riceland
Water source	1. rain 2. spring	1. rain 2. irrigation 3. pump (river)	1. irrigation 2. spring 3. rain	1. irrigation 2. spring 3. rain	same as riceland

Figure A4.1, continued

Local name	*Banglid*	*Vacantihan*	Irrigated land	*Lungasog*	*Turumpihan*
Availability of water	seasonal	seasonal	seasonal (but longer)	seasonal (long, badly drained)	seasonal
Crops	corn munggo rootcrops (camote, cassava, peanuts)	rice munggo corn watermelon	rice munggo corn watermelon	rice munggo corn watermelon	
Vegetables	tomatoes eggplant onions cabbage sayote	squash tomatoes eggplant	squash tomatoes eggplant	squash	eggplant squash camote gabi tomato malunggay
Trees	ipil-ipil mahogany coconut bamboo banana madre-de-cacao many others		ipil-ipil madre-de-cacao balabago	ipil-ipil madre-de-cacao balabago	ipil-ipil banana papaya
Forage	grasses - *kogon* - *lagonoy* - *bungarngar*	grasses on dikes rice stubbles	grasses on dikes rice stubbles	grasses on dikes rice stubbles	
Livestock (or animals in general)	carabao cattle wild pig goat wild birds snakes	carabao cattle goat snake wild birds	carabao cattle goat wild birds	carabao cattle goat wild birds	rat snake frog turtle
Poultry			ducks chicken	ducks chicken	
Aquatic animals					
Problems	grass – hard to cultivate	water shortages		water logging (difficult to drain)	rats, snakes, dapaw (insects)

Figure A4.1, continued



Local name	*Irrigasyon*	*Baralayan*	Fishpond	*Birut karsada*	River/creek
Common name Topography	irrigation canal and dikes flat	homestead flat	fishpond flat	roadside flat	river/creek flat
Access	open or common	exclusive	exclusive	open or common	open
Access after harvest (for pasture)	—	—	—	—	
Value (on average) in pesos/ha	doesn't apply	200/m² 200 000/100m²	415/m²	doesn't apply	doesn't apply
Soil type, local name	*baras*		*laohon, laog*		*baraso*
Soil type, common name	sandy (from river)		muddy		sandy
Water source	irrigation (reservoir)	1. rain 2. irrigation 3. creek	1. spring 2. irrigation	rain	1. spring in the mountains 2. rain
Availability of water	seasonal	seasonal	seasonal (but long)	seasonal	year-round
Crops		sugarcane		sugarcane	
Vegetables	stringbeans eggplant tomatoes camote ampalaya	all types, also flowers	gabi, kangkong (water spinach) waterlily		

Local name	*Irrigasyon*	*Baralayan*	Fishpond	*Birut karsada*	River/creek
Trees		banana jackfruit papaya star apple coconut santol orange calamansi	ipil-ipil mahogany banana jackfruit coconut duhat guava tamarind *kabugaw* (pomelo) betelnut	ipil-ipil madre-de-cacao banana guava papaya jackfruit	mango bamboo *tambuyog* (like lanzones, but not edible) *dalisay* *tipolo* mahogany *lumboy* others
Forage	grasses on dikes				
Livestock	carabao	carabao pig cattle	pig	carabao cattle goat pig dog cat	
Poultry	ducks	chicken turkey	ducks	chicken	
Aquatic animals	tilapia mudfish catfish golden *kuhol*		tilapia mudfish catfish *Yangya* (?) *kalampay* golden *kuhol* *tibo-tibo* *igi*		*puyo* (climbing perch) mudfish *sili* (eel) shrimps crab *awis* (snail) golden *kuhol* *agihis* (clam) *tibo-tibo* (snail)
Problems	maintaining dikes	money, food, flooding (rainy season) drought (dry season)	flood, pesticides, setaling, finding buyers, people's preference	mosquitoes, carabao is a traffic hazard	flooding-erosion

Table A4.1. Seasonal calendar of factors relevant to rice–aquaculture, Catungan IV, Sibalom, Antique.

	January	February	March	April	May	June	July	August	September	October	November	December
Water availability	+/–	–	–	–	–/+	+ typhoons[1] (flooding)	+ typhoons (flooding)	+ typhoons (flooding)	+ typhoons (flooding	+	+/–	+/–
Fish source	+ sea – own field	+ sea – own field	++ sea – own field	++ sea –own field	++ sea – own field	– sea – own field	– sea + own field	– sea + own field	– sea + own field	– sea + own field	– sea + own field	+ sea – own field
Other aquatic organisms					frogs shrimps	frogs shrimps	(frogs)[2] crabs shrimps	(frogs) crabs shrimps	(frogs) crabs shrimps[3]	frogs crabs	frogs crabs	
Rice varieties		harvest 2nd crop/plant 3rd crop	plant 3rd crop		harvest 3rd crop/plant 1st crop	plant 1st crop		harvest 1st crop	harvest 1st crop	plant 2nd crop	plant 2nd crop	
Other crops		mungbeans	mungbeans watermelon vegetables	mungbeans watermelon vegetables	vegetables							
Labor		+ harvest (+ LP)[4 5]			++LP 1st crop (+ harvest)[4]	++LP 1st crop			+harvest 1st crop	+harvest 1st crop +LP 2nd	+LP 2nd crop	

[1] Typhoon season is normally just "sit–back–and–relax" time.
[2] Frogs are there from May until November (when there is water in the field), but when the rice for the first crop is too big, they cannot be caught in the field anymore. After the first crop is harvested, they can be caught again.
[3] Shrimps are only caught in the river/creek.
[4] Only for farmers who have a third crop, depending on water availability.
[5] LP=land preparation.

Table A4.2. Aggregation of cultured species to enterprise groups.

		Antique		Nueva Ecija	
Enterprise Group	Plant/animal	No. of farmers	%	No. of farmers	%
Cereals	rice	26	96	50	100
	corn	2	7	1	2
Livestock	pig	21	78	23	46
	water buffalo	13	48	21	42
	cow	10	37	14	28
	goat	2	7	13	26
Poultry	chicken	23	85	32	64
	duck	5	18	17	34
Roots and tubers	taro	19	70	5	10
	sweet potato	8	30	4	8
	cassava	8	30	1	2
	yam	4	15	–	–
Vegetables	stringbean	15	56	11	22
	eggplant	11	41	4	8
	water spinach	9	33	5	10
	okra	9	33	5	10
	tomato	6	22	4	8
	squash	8	30	–	–
	bitter gourd	4	15	4	8
	chili or bell pepper	7	26	–	–
	radish	6	22	–	–
	onion	6	22	–	–
	Malabar spinach	4	15	–	–
	sweet potato leaves	4	15	–	–
	jute leaves	4	15	–	–
	others	7	26	13	26
Fruit	coconut	25	93	22	44
	guava	19	70	24	48
	mango	14	52	28	56
	banana	22	81	15	30
	soursop	5	18	23	46
	papaya	11	41	16	32
	jackfruit	18	67	8	16
	camachili	5	18	15	30
	star apple	–	–	19	38
	santol	9	33	9	18
	carristel fruit	9	33	5	10
	avocado	6	22	7	14
	tamarind	–	–	12	24
	cacao	11	41	–	–
	camansi	3	11	5	10
	custard apple	4	15	3	6
	coffee	7	26	–	–
	Java plum	7	26	–	–
	bilimbi	5	18	–	–
	pomelo	4	15	–	–
	chico	–	–	4	8
	others	6	22	12	24

Table A4.2, continued

Enterprise Group	Plant/animal	Antique		Nueva Ecija	
		No. of farmers	%	No. of farmers	%
Trees	acacia	–	–	33	66
	Leucaena	11	41	17	34
	bamboo	13	48	14	28
	horse–radish tree	9	33	10	20
	mahogany	9	33	–	–
	others	7	26	9	18
Aquatic animals	tilapia	6	22	13	26
	mudfish	8	30	6	12
	catfish	11	41	–	–
	shrimps	9	33	–	–
	climbing perch	8	30	–	–
	crabs	7	26	–	–
	malay (fish)	5	18	–	–
	tabios (fish)	5	18	–	–
	edible snails	4	15	–	–
	others	10	37	5	10
Forage	grass	16	60	47	94
	rice straw	6	22	1	2
Others	sugarcane	5	18	–	–
	Azolla	–	–	1	2
Total		580	100	610	100

Source: Own computations.

Appendix 5
Description of activity categories used in the time allocation study (in alphabetical order)

absence: outside the barangay, for not more than a day (in case of longer absence, the observation was deleted).

acquisition of food and daily needs: buy food in the market (barangay, municipality); buy things (cigarettes; oil; sugar) in the store; buy non-food daily needs in the market; buy fish from traveling vendors; buy food (vegetables, rice, meat) in the neighborhood.

animal husbandry activities: bring cow/carabao to and from the pasturing range; cut grasses for cow/carabao; tend chicken and pig; construct and repair animal shelters and pens; house animals; feed animals; care for offspring of animals; clean animal housing; slaughter and sell animals.

backyard gardening: clean backyard and surroundings; construct fence; cultivate vegetables; cultivate fruit trees, pick fruit, cultivate flowers.

child care: fetch children to and from school; attend school ceremonies; help with school assignments; feed and tend smaller children; clean/wash children; provide health care for children.

church/ritual: attend church meetings and ceremonies, processions; attend mass, priest ordination; voluntary church work; attend funeral ceremony, nuptial ceremony, death anniversary, prayer/blessing of river.

CIVAC (civic action, community labor): construct houses in army camp; flood control on river dikes; stage construction for barangay benefit dance; clean main irrigation canal; transfer barangay hall to another place.

craft: make rope; make bolo; make bamboo toys; make pillows; weave baskets, mats, winnowers; make fish trap.

eating: eat meals or snacks.

finance: send money to student children; collect debts from customers; borrow money.

firewood: prepare coconuts for firewood; gather firewood; dry firewood; split firewood.

fishing: trap/catch fish at the seashore; catch fish in the river; install and maintain fishtrap.

food preparation: gather and prepare food items for cooking; sort, pound and winnow rice; cook and serve meals and snacks; build and maintain fire for cooking; set and clean the table; bring food to farm laborers.

housekeeping: arrange and maintain things inside the house; clean the house and the kitchen; sweep the floor; fetch water; wash dishes; fix beddings; gather rice sacks for washing.

house repair: minor repairs of old house; major repairs of old house; weave coconut leaves for roofing; change roofing; acquire building materials; build new house; construct makeshift; construct toilet; dig well for drinking water; move the old house to a nearby place.

laundry: wash clothes; dry clothes; fold washed clothes; iron clothes.

leisure: sleep; rest/relax; chat with friends/neighbors/relatives; chew betel nut; listen to the radio; watch video show; watch cockfight in the cockpit arena; watch performances in barangay plaza; attend barangay fiesta; drive around on motorcycle/bicycle; walk around the barangay; play basketball / watch basketball game; play cards; read books or comics.

meeting/discussion: cooperative meeting; barangay council meeting; meeting of the National Irrigation Association (NIA); attend land boundary dispute.

non-farm labor: work as barangay captain; work as health center attendant; work as fish vendor in the market; work as manager of restaurant (at cockpit arena); work as carpenter; work as mechanic; work as cook; work as video show operator; work as domestic helper in Iloilo/San Jose; work as tricycle driver; work as house construction laborer; work in road construction; ironing/laundrying for pay; work as laborer for National Irrigation Association; work in beauty parlor.

off-farm labor: work as farm laborer on other people's farms; make copra for pay; cut bamboo poles for pay; work as farm laborer out of town; work in sugar plantation out of town.

other farm activities: work in own mahogany tree plantation; work in upland farm (root crops, vegetables, trees); work in bamboo grove; construct/maintain water reservoir in upland farm; cut and haul lumber trees; cut and prepare nipa leaves for cigarette making; work in own coconut plantation; construct fence around farm boundary; cultivate vegetables (in ricefarm, upland farm, on ricefield dikes); work in own sugar cane plantation.

personal hygiene: change clothes; take a bath; wash feet; trim nails on hands and feet; comb hair, remove white hairs; get a haircut.

post harvest activities: thresh harvested off-type rice by foot; dry rice on bamboo mat in the sun; store dried rice in sacks; mill rice in travelling ricemill; sort bean seeds attacked by pests.

ricefarm activities: on the way to/from the farm; farm visit/inspection; scrape dike sides, repair of dikes; clean the irrigation canal in the farm, put bamboo pegs on canal entrance; collect stones from the land; plow the field by carabao or handtractor; harrow the field; level the field; bring carabao to the field for levelling; adjust/check water level in the field; soak rice seeds; direct seeding of rice/ transplanting of rice seedlings; irrigate the field; discuss results of soil analysis; close entrance of irrigation canal in preparation for applying fertilizer; fetch, mix and apply fertilizer; scare birds; put scaring materials in the farm; borrow sprayer to spray pesticides; spray pesticides (insecticides, herbicides, molluscicides); remove weeds; pick snails; transplant empty spots; look for laborers to hire; drain the field; harvest rice, supervise harvesters; gather harvested rice for piling/threshing; conduct rice threshing; haul harvested rice to the house; pile rice hay ; divide harvested rice between owner and tenant; haul machines to/from the farm; repair/maintenance of machines.

school/training: attend family life seminar, health seminar; IPM class and related activities (crop cut, field day, etc.); regular schooling; studying school lessons.

sick: at the hospital; at the doctor's; recovering from sickness; sick, resting at home.

sick care: care for sick relatives at home; bring sick relatives to the hospital; care for sick relatives in the hospital or relatives' house; give first aid to sick persons.

tailoring/mending: mend clothes; mend sleeping mats; mend sacks; sew dresses/costumes; sew fish trap netting.

town: visit student children in town; secure copies of official papers (marriage contract, jeep registration, etc.); attend to official business (land matters, money transactions, etc.).

tuba (coconut wine) production: tap coconut shoots and collect tuba from trees; strain tuba; measure tuba; sell tuba and entertain customers.

visit: visit neighbors or relatives.

Appendix 6
Wealth ranking in Catungan IV

Wealth ranking is a rapid appraisal tool which can be used to achieve a stratification of households based on general economic well-being and to elicit local criteria used to distinguish between wealth strata. For this study, a wealth ranking was conducted in the village of Catungan IV, Sibalom, Antique in order to identify people with different economic status. This information was used in the sample selection for interviews on the utilization of aquatic organisms from ricefields, because wealth and consumption pattern are closely related and a bias towards rich or poor people could have distorted the results. Furthermore, identification of wealth criteria can give valuable insights into the village economy and the preference ordering of local people.

In preparation for the wealth ranking a survey of houses was conducted in Catungan IV in June 1994. This resulted in a list of 151 names who stood as representatives for the households. The names of the households were written on index cards and five people were selected for the ranking exercise who all knew the people in the village very well. They were asked to sort the index cards into piles according to similarities and differences in the wealth of the households and to rank the piles from rich to poor. The number of piles was left open to each person doing the ranking. Among the five persons, three chose to make four piles while one made five and another one six piles. They were then asked to explain the main differences between the piles. This information is summarized below.

Rich people own large areas of land, machinery (handtractors, jeeps, threshers) and/or large numbers of livestock. They come from rich families and/or they have a steady income from non-farm sources, preferably from abroad (remittances; pensions). All respondents agreed that the richest person in Catungan IV is a retired US Navy officer who receives a pension from the USA. People are rich if both husband and wife earn a non-farm income and if they don't have many children. Rich people can afford to send their children to high-class schools where the children can become medical doctors.

The *medium rich* have some riceland of their own but not as much as the very rich people. They might also own some machinery (handtractor, thresher, tricycle) or a large flock of ducks. They have better food than the majority. They have non-farm jobs (teacher, blacksmith, worker for the irrigation authority) but not as remunerating jobs as the rich people. Some of them own large parcels in the uplands or have tenants on parts of their land. They can also send their children to school, but to less prestigious ones than the rich. In some cases, the husband works abroad and sends remittances.

The *medium poor* or average people are tenants or they own some small parcels of land. Even though they have a simple living, they have a little extra which they can save. Some have small businesses like sari-sari stores (small grocery stores). They do not have stable non-farm jobs. They normally have no machinery, but some have their children working in Manila who send remittances so that they can buy machinery.

The *very poor* are laborers who have no land to farm. The very poor people don't even own their residential lots where they could grow root crops or vegetables. They might have one pig and two chickens but definitely no carabao. Some of them are helpers on the land of bigger landowners. They are laborers who have occasional jobs. It is hard for them to find a job because they have no official qualifications and low educational attainment. To earn money, they catch and gather everything that is free: fish and snails from the river and wild plants which they then sell on the market. They come from families where the parents were already very poor.

Appendix 7
Rationale for items included in the IPM and ALM scale

Appendix 7.1 The IPM scale.
Items were selected to cover the three dimensions of practices, attitude and knowledge as stated in the main text. They represent key topics of IPM and can thus serve as a profile of the overall awareness of IPM among farmers.

Practice:
Use of insecticides/herbicides/molluscicides:

The reduction of pesticide use is a central objective of IPM (see Chapter 4).

Insecticide application during the first 30 days of the cropping cycle:

Crop damage during the first 30 days of the cropping cycle is dominantly caused by leaf-feeding insects. Rice plants can usually recover from leaf damages that occur at the tillering stage (from 22 to 40 days after seeding) without showing any yield loss (Heong et al. 1992). Thus, insecticide applications at this time may not only be wasted, but may also put the crop at risk to secondary brown planthopper problems at a later stage.

Use of rice straw:

Integrated nutrient management is a concept closely related to the IPM principle of growing a healthy crop. Rice straw is a valuable source of nutrients which, if burned, is lost to the soil. In addition, burning the rice straw on the field is a considerable source of air pollution. Thus, the burning of rice straw is considered to contradict good IPM practice.

Use of organic fertilizer (other than rice straw):

Long-term soil fertility is often enhanced by the use of organic fertilizers, even though they release nutrients (mainly nitrogen) more slowly than mineral fertilizers (Thurston 1992). Organic fertilizers provide a way to recycle on-farm substances (manure, compost) and reduce the danger of soil acidity. It has been recommended that organic sources of nitrogen should remain as an important supplemental source of nutrients for rice in tropical Asia (De Datta 1981).

Use of `old'rice varieties (before IR-60) vs. use of `new' rice varieties (after and including IR-60):

While the `first generation' HYVs released in the 1960s were susceptible to a broad range of pests, plant breeders have subsequently generated varieties which are resistant to major insects and diseases in Asia. The number of insect pests against which rice varieties are resistant or moderately resistant has increased from almost zero in the 1960s to 6 in the late 1980s (Rola and Pingali 1993). Unfortunately, resistance can only be retained by constantly breeding (and using) new varieties. Farmers who use modern varieties are more likely to capture the latest resistance effect than farmers using older varieties.

Attitude:
These items asked for farmer's attitudes (agree/disagree/no opinion/it depends) towards the following statements:

`The use of chemical pesticides will increase rice yields'

Unlike fertilizers, insecticides generally exhibit diminishing marginal returns (IRRI 1989, as cited in Heong et al. 1992). In addition, frequent insecticide use increases the danger of pest outbreaks. Kenmore (1991) reports that in one outbreak-afflicted province of Thailand, the greater the number of insecticide applications, the lower the yield, regardless of variety. Thus, IPM farmers are expected to disagree with this statement.

`If the leaves are damaged early in the cropping season it is important to spray'

This item corresponds closely to the practice of early season insecticide spraying described above. However, while early season insecticide applications are most probably wasted, the practice does not fully explain the mechanism or attitude behind this behavior. This item tries to capture farmers'awareness of the ability of rice plants to recover from leaf damage, especially early in the cropping season.

`There are enough natural enemies in the field to control the rice pests'

Natural control of rice pests by natural enemies is a key concept in IPM (see Kenmore et al. 1995). If not disrupted by pesticide applications, natural enemy populations are normally strong enough to keep pests in check. Thus, IPM-farmers are expected to agree with this statement.

`Expected yield loss if no insecticides are used'

Farmers were asked how much yield loss they expected to suffer if they would not use any insecticides on their rice. Several studies from Indonesia, Vietnam and the Philippines have shown that yields from untreated fields are often equal to or even higher than yields from insecticide-treated fields (e.g. Kenmore 1991; Medrano et al. 1993; van de Fliert 1993). IPM-farmers are expected to trust in the power of natural enemies (see previous item) and not fear any yield losses.

Knowledge:
Farmer correctly identifies insects/spiders presented to him/her as harmful or beneficial:

It is not only important to know that there are both harmful and beneficial insects and spiders in the rice field, but knowing which ones are the good and the bad ones (without necessarily knowing their names) is essential for an assessment of the ecological balance in the field.

Farmer correctly describes the damage symptoms of the identified insect pests:

Knowing the damage symptoms of major insect pests in rice is another important precondition for informed decision-making with regard to control measures.

Farmer states `resistance to pests' as a reason for choosing a rice variety:

Varietal resistance is an important concept in IPM. Farmers who select resistant rice varieties demonstrate their knowledge of this fact and their intention to utilize it as part of their strategies against pests.

Farmer knows that pesticide applications are harmful to beneficial organisms:

Preserving the beneficial organisms in the field is the key to natural or biological control which is the core of IPM (Kenmore et al. 1995). If farmers are aware that the natural pest-predator balance will be disrupted by the application of pesticides, they are less likely to use pesticides indiscriminately.

Appendix 7.2 The ALM scale.

Items were selected to cover the three dimensions of knowledge, attitude and practices as stated in the main text. They represent key topics of ALM and can thus serve as a profile of the overall awareness of ALM among farmers.

Practice:

Farmer has a pond or trench in his/her field…

A pond or a trench in the field is an indication for the fact that the farmer takes actions towards the management of aquatic organisms in the ricefield.

Farmer stocks/feeds aquatic organisms in his/her field…

The deliberate stocking and/or feeding of aquatic organisms are fairly advanced levels of management. In an initial version of the scale, it was considered to rank practices like utilizing–stocking–feeding in an ascending order according to the management skills required. However, it soon turned out that only few farmers actually implement these practices and that the construction of a meaningful sequence is not possible with other manifestations of ALM. Therefore, a simple additive index was chosen in which each indicator has an equal weight.

Farmer utilizes aquatic organisms for food, animal feed or as pest control agents…

This item evaluates farmers' awareness of the value of aquatic organisms in the field. No difference was made between the various ways in which the organisms are utilized, assuming that as soon as the farmer associates a positive value with these organisms, he or she will try to preserve them.

Attitude:

Reasons for non-use of aquatic organisms (not using aquatic organisms because of pesticide use/not using aquatic organisms for reasons other than pesticide use):

As described earlier, ALM stands for the environmentally friendly management of aquatic organisms in the field. A farmer who does not utilize these organisms because he or she fears that they are contaminated by pesticides implies that a change in pest management practices is needed for rice-aquaculture to become feasible. This farmer is more likely to practice ALM than a farmer who shows no interest in aquatic organisms regardless of pesticide use.

Farmer names aquatic organisms when asked for organisms living in the ricefield:

This item shows a general awareness of the aquatic fauna of the ricefield, a first step towards ALM.

Knowledge:

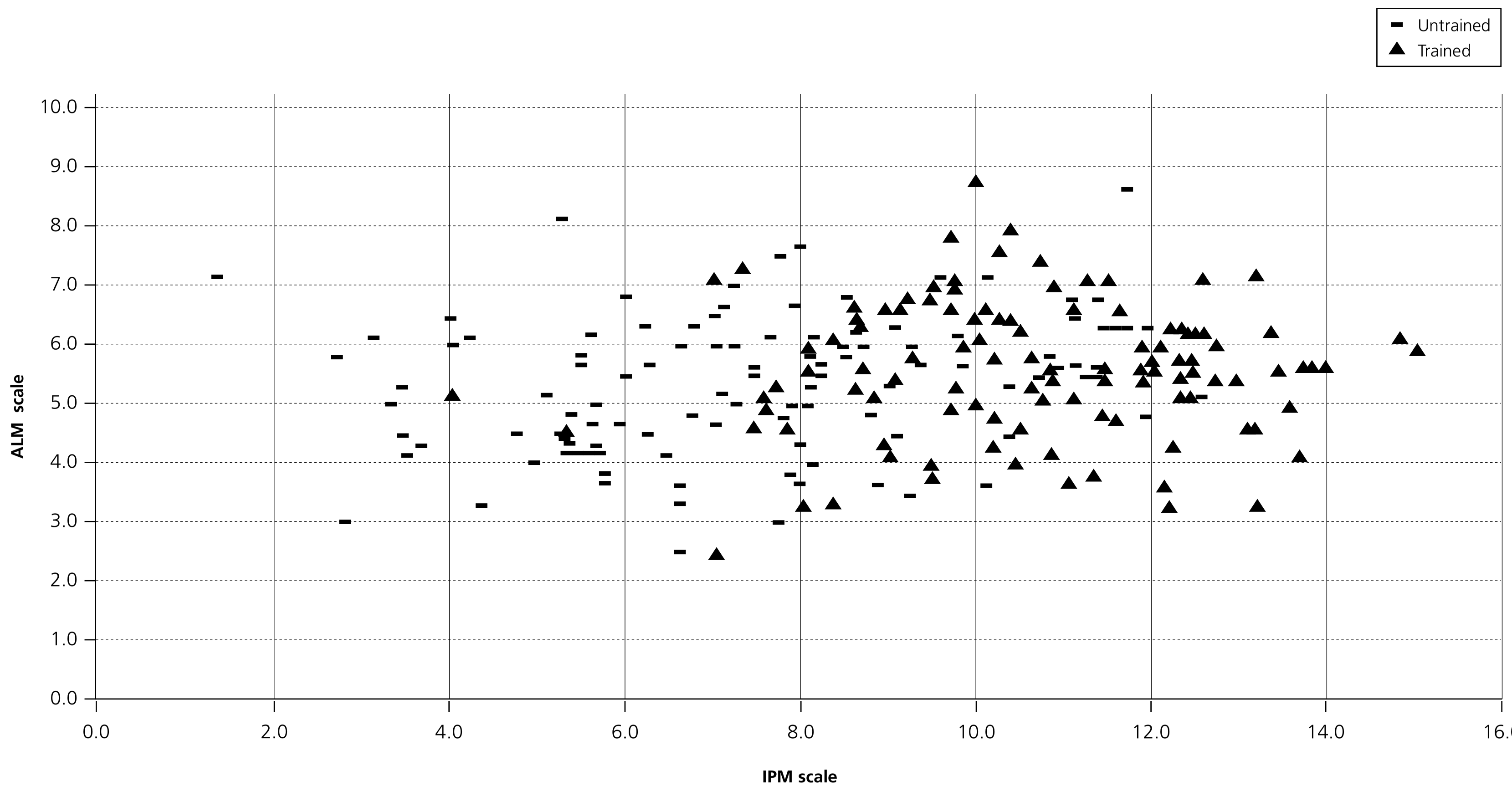
Farmer correctly describes the habitat/diet of 5 key aquatic ricefield organisms:

Knowledge of the feeding habit and preferred living environment of aquatic organisms is a precondition to their successful management. Five key organisms were identified from informal interviews with farmers in Antique, namely edible frogs, a common species of edible snails, the Golden Apple snail, ricefield crabs, and shrimps. Fish, one of the most commonly utilized organisms, was excluded from these items because the pre-test revealed that a) there was no variation in answers relating to the habitat (all respondents stated that fish live 'in places where there is sufficient water') and b) the diet of fish varies according to species, environment and growth stage, which is difficult to evaluate.

Farmer knows that tadpoles are the babies of frogs:

This fairly specific item tests for farmers' knowledge of biology and ecosystem linkages. Tadpoles are visible and they occur in most irrigated ricefields. If farmers are not aware that they will turn into frogs, they will take no steps to preserve them.

Appendix 8
Scatterplot of scale values for IPM and ALM, trained and untrained farmers



Appendix 9
Chapter 9 Tables

Table A9.1. Labor requirements of rice production, seasonality and division of labor as used in the LP-model.

Activity	Month	Performed by	Wage rate	Days/ha	Source	Notes
Fixing the dikes	1st month of each cropping season (June, October)	family labor (men, children); hired labor	PhP50/person/day	2.5 persondays	own data (Antique rice labor survey)	
Plowing the sides of the field with a carabao (water buffalo)	1st month of each cropping season (June, October)	hired labor; family labor (men)	PhP100/team of person and carabao/day	1 person-animal-day + 0.5 days of FL for supervision	own data (Antique rice labor survey)	This task is performed by a team of person and carabao; mostly hired, if no own carabao is available. One team can manage at least 1 hectare in 1 day.
Plowing/ harrowing the whole field with a hand tractor	1st month of each cropping season (June, October)	hired labor; family labor (men)	PhP1 200/ha or PhP360/ha if farmer owns a handtractor	not applicable; 0.5 days of FL for supervision	own data (Antique rice labor survey)	Plowing and harrowing is normally done under a contractual arrangement (per hectare, not per day). PhP1 200/ha are paid for the hiring of operator and tractor. If the farmer owns a handtractor, the payment is reduced to PhP360 for the labor of the operator.
Leveling the field with a carabao	1st month of each cropping season (June, October)	hired labor; family labor (men)	PhP100/ team of person and carabao/ day	1 person-animal-day + 0.5 days of FL for supervision	own data (Antique rice labor survey)	This task is performed by a team of person and carabao; mostly hired, if no own carabao is available. One team can manage at least 1 hectare in 1 day.
Applying molluscicides	1st month of each cropping season (June, October)	family labor (men); hired labor	PhP50/person/day	1 person-animal-day		Molluscicides are applied after the final land preparation, before broadcasting the seeds. No molluscicides are applied in the third cropping because water is scarce and not many snails occur, so snail control is not needed.
Making canals and broadcasting seeds	1st month of each cropping season (June, October)	family labor (men); hired labor	PhP50/person/day	3 persondays		In some cases, the wage rate is PhP60/person/day plus food; this applies when the field is far away from the house and the hired person has to haul the sacks of seeds to the field.

Table A9.1, continued

Activity	Month	Performed by	Wage rate	Days/ha	Source	Notes
Applying herbicides	1st month of each cropping season (June, October)	family labor (men); hired labor	PhP50/person/day	1 personday		Herbicides are applied during the first week after seeding.
Replanting empty spots	2nd month of each cropping season (July, November)	family labor (men, women, children); hired labor	PhP50/person/day	20 persondays		Empty spots are mainly caused by snail damage. Seedlings are taken from more densely planted areas of the field. In the third cropping season, no extra labor is required for the replanting of empty spots since snail damage is negligible. If replanting is necessary, it is assumed to be included in general crop care activities.
Applying fertilizer	2nd month of each cropping season (July, November)	family labor (men); hired labor	PhP50/person/ day	2 persondays (for 2 applications)		Fertilizer is normally applied twice per cropping season; first application: 3 weeks (20 days) after seeding (= 2nd month of each cropping season); second application: 5-7 weeks (35-45 days) after seeding (= 3rd month of each cropping Season). If the hired person has to haul the sacks of fertilizer to the field, an additional PhP10/ person/day are paid.
Applying insecticides	2nd and 3rd month of each cropping season (July/August, November/ December)	family labor (men); hired labor	PhP50/person/ day	1 personday per application (= 2 per cropping)		Two applications of insecticides, one in the second and one in the third month after seeding (after fertilizer application).
Other crop care activities (weeding, water management, field monitoring)	2nd, 3rd and 4th month of each cropping season	family labor (men, women, children), hired labor	PhP50/ person/day	2nd and 3rd month: 12 persondays 4th month: 9 persondays		Assumed: 3 persondays/ha/week for general crop care activities. In the 4th month, crop care activities include preparations for harvest.
Harvesting rice	4th month of each cropping season (September, January)	hired labor	Contractual arrangement (16.67% of gross yield)	not applicable; 7 days of FL for supervision		Family labor (adult men only) is needed for supervising the harvesters and threshers, to store and sell the harvested rice.

Source: Own computations.

Table A9.2. Material input prices (in Philippine pesos) used in the model formulation, crop year 1993/94.

Rice seeds (certified)	PhP8/kg
Fertilizers[8]	
Urea	PhP235/50 kg
Compound fertilizer	PhP287.50/50 kg
Ammonium phosphate	PhP270/50 kg
Ammonium sulfate	PhP166/50 kg
Muriate of potash	PhP235/50 kg
Pesticides[9]	
Thiodan (Endosulfan; insecticide)	PhP284/l
Fosferno (Methyl-parathion, insecticide)	PhP275/l
Sofit (Pretilachlor, herbicide)	PhP560/l
Tilapia fingerlings[10]	PhP0.24/piece
Rice bran[11]	PhP1.80/kilo
Piglet	PhP600 each

Table A9.3. Monthly farm gate and retail prices (in Philippine pesos) for rice used in the model formulation.

	Rough rice (PhP/kg)[12]	Milled rice (PhP/kg)[13]
June	6	10.25
July	6	11.50
August	6	11.50
September	5.75	12
October	4.75	10.75
November	5	10
December	5	10
January	5.50	10.50
February	6	11
March	6	11
April	6.25	11.25
May	6.25	11.50

8 Fertilizer prices for Antique were obtained from the weekly cereal and fertilizer price monitoring of the An tique office of the Bureau of Agricultural Statistics. Values are averaged for the years 1993 and 1994.

9 Pesticide prices for both Antique and Nueva Acija were obtained from a price survey of various agricultural supply dealers in both provinces in 1993.

10 Prices for tilapia fingerlings (improved breeds) were obtained from unpublished data collected by ICLARM.

11 Prices for rice bran were estimated based on data privided by Israel et al. (1994) for Nueva Ecija and key in formant interviews in Antique.

12 Source: Weekly cereal and fertilizer price monitoring of the Bureau of Agricultural Statistics, Antique Office, San Jose, Antique. Monthly averages for the model period (own computations).

13 Source: Weekly cereal and fertilizer price monitoring of the Bureau of Agricultural Statistics, Antique Office, San Jose, Antique. Monthly averages for the model period (own computations).

Table A9.4. Retail prices (in Philippine pesos) and farm gate prices[14] for food commodities used in the model formulation.

Food commodity	Retail (market) price (Pesos/kg)	Farm gate price (Pesos/kg)
Tilapia	34	30
Round scad	26	
Yaito tuna	20	
Milkfish	60	
Sardine	29	
Fermented fish paste	20	
Dried anchovies	67.50	
Dressed chicken	64	
Beef	91	
Pork	61.50	
Chicken eggs	2.40*	2*
Mungbeans	22	
Peanuts	31	
Taro	9.50	
Sweet potato	8.60	
Chinese cabbage	9.90	
Water spinach	2.70	
Squash	9.80	
Stringbeans	9.40	
Eggplant	12.30	
Bitter gourd	13.50	
Papaya	18.60	
Guava	23.50	
Mango	33.50	
Banana	11.60	
Finished pig		2 100*
Live chicken	60*	55*
Tilapia fingerlings		0.20*

Source: Bureau of Agricultural Statistics, San Jose, Antique, Philippines
*= price per piece

Table A9.5. Recommended dietary allowances (RDAs), maximum and minimum consumption requirements for the model family.

Food group	RDA (kg/family/month)	Maximum consumption level (RDA + 20%)	Minimum consumption level (RDA – 10%)
Cereals (rice)	71.68	86.01	64.51
Roots and tubers	18.30	21.96	16.47
Fish/meat/poultry	32.33	38.80	29.10
Eggs	3.66	4.39	3.29
Dried beans/ nuts/ seeds	3.66	4.39	3.29
Leafy green/yellow vegetables	18.30	1.96	16.47
Vitamin C-rich fruit	15.55	18.66	14.00
Other fruits/vegetables	27.45	32.94	24.71

Source: Own computations based on de Guzman et al. (1988).

[14] Farm gate prices are listed only for those food commodities which are produced for sale in the model farm.

Table A9.6. Recommended dietary allowances (RDAs), maximum and minimum consumption requirements of various nutrients for the model family.

Nutrient	RDA (kg/family/month)	Maximum consumption level (RDA + 20%)	Minimum consumption (RDA – 10%)
Energy (kcals/month)	415 105	498 126	373 594.50
Protein (g/month)	10 187	12 224.40	9 168.30
Calcium (g/month)	112.85	135.42	101.57
Iron (mg/month)	2 684	3 220.8	2 415.60
Vitamin A (RE, mcg/month)	103 700	124 440	93 330
Vitamin C (mg/month)	13 572.50	16 287	12 215.25

Source: Own computations based on de Guzman et al. (1988).

Table A9.7. Nutrient composition of food items included in the model diet (per kg "as purchased").

portion	% edible (kcals)	Energy (g)	Protein (mg)	Calcium (mg)	Iron (RE)	Vitamin A (mg)	Vitamin C
Rice (milled)	100	3 650	74	270	10	—	—
Tilapia	39	437	68	300	0.39	809	—
Round scad	41	381	77	308	3.69	277	—
Yaito tuna	63	800	154	328	102.69	320	—
Milkfish	68	904	125	326	6.80	827	—
Sardine	52	572	95	468	8.84	247	—
Fermented fish paste	100	610	103	5 350	109.00	3 600	—
Dried anchovies	100	3 210	602	21 840	130.00	4 208	—
Chicken	70	812	144	602	10.50	140	—
Beef	100	1 360	229	960	32.00	1 858	—
Pork	100	3 330	143	280	9.00	1 150	—
Chicken eggs	87	1 427	108	644	24.36	2 632	8.70
Mungbeans	100	3 370	244	1 420	57.00	133	100
Peanuts	100	5 670	258	670	27.00	—	—
Taro	77	739	18	300	6.93	39	69
Sweet potato	88	1 162	10	484	6.16	792	308
Chinese cabbage	84	151	17	1 411	31.08	1 792	454
Water spinach	58	151	20	534	26.68	2 489	174
Squash	71	249	10	433	4.97	1 041	142
Stringbeans	93	335	29	567	8.37	388	205
Eggplant	91	200	9	319	5.46	121	46
Bitter gourd	82	148	7	344	6.56	273	328
Mango	67	409	4	67	4.02	1 301	308
Papaya	64	288	3	218	6.40	480	474
Guava	99	743	9	337	5.94	107	1 564
Banana	69	759	10	145	5.52	414	173
Frog	31	295	65	143	5.58	—	—
Crab	45	567	62	9 500	4.50	—	—
Snail	41	340	50	6 765	35.67	2 047	—
Mudfish	62	546	127	484	8.68	124	—

Source: Own computations based on FNRI (1990).

Table A9.8. Seasonal calendar for the production of fruits and vegetables in the backyard garden, Antique.

	January	February	March	April	May	June	July	August	September	October	November	December
Mungbeans	X	X	X	X								X
Sweet potato					X	X	X	X				
Chinese cabbage	X	X	X	X								
Eggplant	X	X	X	X	X	X						
Bitter gourd	X	X	X	X								
Squash	X	X	X	X	X							X
Water spinach					X	X	X	X	X	X	X	X
Stringbeans	X	X	X	X				X	X	X	X	X
Mango	X	X	X	X	X						X	x

Source: Survey of 16 key informants in Antique, June 1995.
No seasonality could be detected for peanuts, banana, papaya, and guava. They were thus assumed to be available year-round in constant quantities.
The selected food items are assumed to be available in the market one month before and one month after the season indicated above, reflecting some regional trade in food items from places with slightly different seasons.

Table A9.9. Estimated backyard garden production of food items included in the model.

Food item	RDA (kg/family/ month)	% adequate	Total production (kg/year)	Total productive months	Production per food item (kg/productive month)
Root crops (taro, sweet potato)	18.30	10	21.96	16	1.37
Beans, nuts, seeds (mungbeans, peanuts)	3.66	42.26	18.60	17	1.09
Green leafy / yellow vegetables (squash, water spinach, Chinese cabbage)	18.30	43.33	95.16	18	5.29
Vitamin C-rich fruit (papaya, mango, guava)	15.55	29.20	54.48	31	1.76
Other fruit and vegetables (bitter gourd, stringbeans, eggplant, banana)	27.45	69.50	228.96	31	7.39

Source: Own computations.
Total production per food group was estimated from the identified RDAs for each food group for the model family (see Table A9.5) and the percentage adequacy of actual food consumption for this food group as reported in Chapter 7. The resulting amount was divided by the total number of productive months for all food items in the respective group, based on the seasonal calendar presented in Table A9.8, thus providing production estimates for each food item per productive month.

Table A9.10. Fish weight (kg/ha) at different stocking densities and different times during the 90-day culture period.

Stocking densities (fish/ha)	5,000	10,000	15,000	20,000
initial	1.91	3.82	5.73	7.64
15 days AS	12.25	22.24	30.92	38.61
45 days AS	70.15	120.93	161.09	193.66
75 days AS	160.44	271.77	356.72	423.14
90 days AS	182.96	308.36	403.03	476.23
first harvest[15] (25%)	45.74	77.09	100.76	119.06
second harvest (75%)	137.22	231.27	302.27	357.17

Source: Own computations based on Prein (1993).
AS = after stocking
Loss in each period is computed as 12.5% of the original number of fish (= 50% over the whole culture period).

[15] The computation of first and second harvest quantities is based on the total yield after 90 days, even though 25% of the fish is harvested earlier. It was assumed that these fish reach their final weight faster (because of higher stocking weights or other parameters) and can thus be harvested first.

Table A9.11. Computed feeding rates for rice bran (kg/month/ha) corresponding to 5% of fish body weight/day.

	Stocking densities (fish/ha)			
	5 000	10 000	15 000	20 000
15 days AS	9.34	16.96	23.58	29.44
45 days AS	106.97	184.42	245.67	295.33
75 days AS	244.67	414.45	544.00	645.28
90 days AS	139.05	235.12	307.32	363.13
total	500.94	850.95	1 120.55	1 333.17

Source: Own computations.
AS = after stocking
For the first (15 days AS) and last (90 days AS) period, feeding rates were computed for 0.5 months only.

[16] Only 50% of these rates were used in the model formulation, see text in chapter 8.

Table A9.12. Balanced minimum cost diet for the model family, base model (in pesos).

	January	February	March	April	May	June	July	August	September	October	November	December
Rice	83.87	81.49	81.49	82.49	80.93	80.07	80.37	80.55	80.55	80.83	82.26	82.09
Yaito tuna	7.93	10.02	10.02	9.64	10.80	10.57	10.11	9.81	9.81	9.10	8.72	9.03
Round scad	19.31	—	—	17.57	16.35	16.38	16.88	17.20	17.20	17.92	18.37	18.09
Tilapia	—	16.92	16.92	—	—	—	—	—	—	—	—	—
Dried anchovies	1.61	1.91	1.91	1.64	1.71	1.90	1.85	1.83	1.83	1.83	1.76	1.73
Fermented fish paste	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Eggs (pieces)	65.80	87.80	87.80	65.80	65.80	65.80	65.80	65.80	65.80	65.80	65.80	65.80
Taro	16.47	16.47	16.47	12.24	9.96	8.42	13.91	14.12	14.12	16.47	16.47	16.47
Sweet potato	—	—	—	4.23	6.51	8.05	2.56	2.35	2.35	—	—	—
Mungbeans	2.20	1.09	1.09	1.09	—	—	—	—	—	—	2.20	2.20
Peanuts	1.09	2.20	2.20	2.20	3.29	3.29	3.29	3.29	3.29	3.29	1.09	1.09
Bitter gourd	2.54	2.54	2.54	2.54	—	—	—	—	—	—	—	—
Stringbeans	7.39	7.39	7.39	7.39	7.71	—	6.48	7.39	7.39	7.39	7.39	7.39
Eggplant	7.39	7.39	7.39	7.39	7.39	7.39	—	—	—	—	—	—
Squash	1.30	11.31	11.31	3.74	5.26	—	—	—	—	—	—	3.50
Water spinach	20.66	—	—	18.22	16.70	18.63	19.57	19.68	19.68	20.47	19.91	18.46
Chinese cabbage	—	10.65	10.65	—	—	—	—	—	—	—	—	—
Papaya	11.49	1.76	1.76	12.24	12.24	14.00	14.00	14.00	14.00	13.61	11.70	11.92
Banana	7.39	7.39	7.39	7.39	9.61	17.32	18.23	17.32	17.32	17.32	17.32	17.32
Mango	1.76	12.24	12.24	1.76	1.76	—	—	—	—	—	1.76	1.76
Guava	0.75	—	—	—	—	—	—	—	—	0.39	0.54	0.32
Total	259.20	278.82	278.82	257.82	256.27	251.57	253.30	253.59	253.59	254.28	255.54	257.42

Table A9.13. Change in key parameters under different price scenarios (in Philippine pesos) for tilapia, without IPM.

% price reduction	Objective value	Household gross margin	Farm cash expenses	Food expenses	Area under rice-fish culture		Area under rice monoculture		Consumption of own tilapia	Purchase of tilapia	Total tilapia consumption
	(PhP/farm/ year)	(PhP/farm/ year)	(PhP/farm/ year)	(PhP/farm/ year)	Season 1 (ha)	Season 2 (ha)	Season 1 (ha)	Season 2 (ha)	(kg/family year)	(kg/family year)	(kg/family year)
0%	42 020.14	61 947.77	45 564.45	19 155.81	1.7	1.7	0	0	0	33.84	33.84
-10%	37 174.19	55 030.62	43 453.92	17 107.25	1.7	1.7	0	0	63.77	34.19	97.95
-0%	32 360.06	49 920.68	41 773.25	16 862.19	1.7	1.7	0	0	65.62	133.08	198.70
-30%	27 829.39	44 771.86	40 093.05	16 170.66	1.7	1.7	0	0	69.69	149.76	219.45
-40%	23 369.31	39 282.39	38 414.24	15 141.26	1.7	1.7	0	0	95.65	150.09	245.74
-45%	21 194.42	36 800.66	37 573.30	14 834.43	1.7	1.7	0	0	95.65	191.47	287.12
-50%	19 235.37	30 257.44	28 576.14	14 631.21	0.32	1.7	1.38	0	95.65	191.47	287.12
-52.5%	18 736.60	24 488.29	20 331.78	14 479.56	0.20	0.20	1.50	1.50	95.65	191.47	287.12
-55%	18 893.62	24 134.95	18 924.14	14 816.95	0.07	0.07	1.63	1.63	63.79	223.33	287.12
-60%	19 278.93	24 195.32	18 807.85	14 543.66	0.06	0.06	1.64	1.64	56.03	231.09	287.12
-70%	20 105.34	24 443.50	18 449.35	14 338.16	0	0	1.7	1.70	0	290.50	290.50
-80%	21 149.67	24 459.43	18 433.21	13 309.76	0	0	1.7	1.7	0	306.56	306.56
-90%	22 210.65	24 474.26	18 416.91	12 263.61	0	0	1.7	1.7	0	308.62	308.62
-100%	23 443.84	24 533.94	18 398.35	11 090.10	0	0	1.7	1.7	0	415.61	415.61

Source: Own computations

Table A9.14. Change in key parameters under different price scenarios for tilapia, with IPM.

% price reduction	Objective value	Household gross margin	Farm cash expenses	Food expenses	Area under rice-fish culture		Area under rice monoculture		Consumption of own tilapia	Purchase of tilapia	Total tilapia consumption
	(PhP/farm/ year)	(PhP/farm/ year)	(PhP/farm/ year)	(PhP/farm/ year)	Season 1 (ha)	Season 2 (ha)	Season 1 (ha)	Season 2 (ha)	(kg/family/ year)	(kg/family/ year)	(kg/family/ year)
0%	45 233.11	64 366.89	44 624.65	18 361.97	1.7	1.7	0	0	0.00	33.84	33.84
-10%	40 210.44	57 140.08	42 958.97	16 180.48	1.7	1.7	0	0	63.77	34.19	97.95
-20%	35 383.51	52 137.21	41 284.73	16 055.27	1.7	1.7	0	0	65.62	133.08	198.70
-30%	30 853.63	46 961.83	39 605.19	15 336.38	1.7	1.7	0	0	69.69	149.76	219.45
-40%	26 393.79	41 463.35	37 926.53	14 297.74	1.7	1.7	0	0	95.65	150.14	245.79
-45%	24 219.27	38 969.89	37 085.96	13 978.80	1.7	1.7	0	0	95.65	191.47	287.12
-50%	22 467.63	31 589.86	27 378.78	13 077.30	0.21	1.7	0	1.49	95.65	191.47	287.12
-52.5%	22 133.80	26 154.13	18 976.65	13 171.39	0.07	0.20	1.50	1.63	79.75	207.37	287.12
-55%	22 305.70	25 969.32	18 296.68	13 239.23	0.07	0.07	1.63	1.63	63.79	223.33	287.12
-60%	22 692.73	26 030.64	18 179.97	12 965.18	0.06	0.06	1.64	1.64	56.03	231.09	287.12
-70%	23 531.58	26 285.67	17 818.44	12 754.09	0	0	1.7	1.7	0.00	290.50	90.50
-80%	24 575.95	26 301.60	17 802.29	11 725.65	0	0	1.7	1.7	0.00	306.56	306.56
-90%	25 638.82	26 316.60	17 785.82	10 677.78	0	0	1.7	1.7	0.00	308.62	308.62
-100%	26 867.53	26 375.88	17 767.66	9 508.34	0	0	1.7	1.7	0.00	415.61	415.61

Source: Own computations.

Table A9.15. Changes in land allocation due to increasing wage rates, Nueva Ecija, conventional pest management only (in hectares).

	Season 1			Season 2		
Original wage level	Rice	Rice-fish	Fallow	Rice	Rice-fish	Fallow
+50%	1.19	0.99	0.12	—	2.3	—
+100%	0.74	0.99	0.57	—	2.3	—
+200%	—	0.99	1.31	—	2.3	—
+300%	0.05	0.73	1.52	—	1.76	0.54
+400%	0.53	0.11	1.66	—	1.15	1.15

Source: Own computations.
*Changes in wage level concern both on-farm and off-farm wages.

Appendix 10
Simplified matrix of the LP model

Simplified structure of the linear programming model used for the economic analysis of technology options.

Period 1			Production system			Select stocking density				Other farm activities	Labor		Material inputs		Sell output	Transfer output	Gather aquatic organisms	Buy and consume food	Consume own produce	Credit		Transfer cash	Off-farm activites
			rice mono-culture	rice-fish culture	pond	5 000	10 000	15 000	20 000		hired	family	own	purchased						formal	informal		
	Objective function		0	0	-34850	0	0	0	0	0	-w	0	0	-q	+p	0	0	-p	0	$-i_f$	$-i_{if}$	0	+w
Period 1	rice and fish 1	total rice land	1	1	1																		
		rice-fish land		1	1																		
		pond area		0.1	-1																		
		stocking density				1	1	1	1														
		stock fish		1	1	-1	-1	-1	-1														
		labor tasks	l_1	l_1	l_1						-0.9	-1											
		material inputs	m_1	m_1	m_1								-1	-1									
		output	$-y_1$			$-y_1$	$-y_1$	$-y_1$	$-y_1$						1	1			1				
	other farm 1	extent								1													
		labor tasks								l_1	-0.9	-1											
		material inputs								m_1			-1	-1									
		output								$-y_1$					1	1			1				
	aquatic	labor tasks										-1					l_1						
	organisms 1	output															$-y_1$		1				
	nutrition 1	minimum consumption																c_1	c_1				
		maximum consumption																c_1	c_1				
	cash balance 1										+w			+q	-p			+p		-1	-1	1	-w
Period 2	rice and fish	total rice land																					
		rice-fish land																					
		pond area																					
		stocking density																					
		stock fish																					
		labor tasks																					
		material inputs																					
		output																					
	other farm 2	extent																					
		labor tasks																					
		material inputs																					
		output																					
	aquatic	labor tasks																					
	organisms 2	output																					
	nutrition2	minimum consumption																					
		maximum consumption																					
	cash balance 2																			$+(1+i_f)$	$+(1+i_f)$	-1	
Period 3	other farm	extent																					
	activities 3	labor tasks																					
		material inputs																					
		output																					
	nutrition3	minimum consumption																					
		maximum consumption																					
	cash balance 3																						
Monthly limits	off-farm labor																						
	credit	formal																		1			
		informal																			1		
Own fund maintenance																							

Appendix 10, continued

Period 1			Production system			Select stocking density				Other farm activities	Labor		Material inputs		Sell output	Transfer output	Gather aquatic organisms	Buy and consume food	Consume own produce	Credit		Transfer cash	Off-farm activites
			rice mono-culture	rice-fish culture	pond	5 000	10 000	15 000	20 000		hired	family	own	purchased						formal	informal		
	Objective function		0	0	-34850	0	0	0	0	0	-w	0	0	-q	+p	0	0	-p	0	$-i_f$	$-i_{if}$	0	+w
Period 1	rice and fish 1	total rice land																					
		rice-fish land																					
		pond area																					
		stocking density																					
		stock fish																					
		labor tasks																					
		material inputs																					
		output																					
	other farm 1	extent																					
		labor tasks																					
		material inputs																					
		output																					
	aquatic	labor tasks																					
	organisms 1	output																					
	nutrition 1	minimum consumption																					
		maximum consumption																					
	cash balance																						
Period 2	rice and fish 2	total rice land	1	1	1																		
		rice-fish land		1	1																		
		pond area		0.1	-1																		
		stocking density				1	1	1	1														
		stock fish		1	1	-1	-1	-1	-1														
		labor tasks	l_2	l_2	l_2						-0.9	-1											
		material inputs	m_2	m_2	m_2								-1	-1									
		output	$-y_2$			$-y_2$	$-y_2$	$-y_2$	$-y_2$						1	1			1				
	other farm 2	extent								1													
		labor tasks								l_2	-0.9	-1											
		material inputs								m_2			-1	-1									
		output								$-y_2$					1	1			1				
	aquatic	labor tasks										-1					l_2						
	organisms 2	output															$-y_2$		1				
	nutrition2	minimum consumption																c_2	c_2				
		maximum consumption																c_2	c_2				
	cash balance 2										+w			+q	-p			+p		-1	-1	1	w
Period 3	other farm	extent																					
	activities 3	labor tasks																					
		material inputs																					
		output																					
	nutrition3	minimum consumption																					
		maximum consumption																					
	cash balance 3																			$+(1+i_f)$	$+(1+i_f)$		
Monthly	off-farm labor																						
limits	credit	formal																		1			
		informal																			1		
Own fund maintenance																							

Appendix 10, continued

Period 3			Other farm activities	Labor: hired	Labor: family	Material inputs: own	Material inputs: purchased	Sell output	Transfer output	Buy and consume food	Consume own produce	Credit: formal	Credit: informal	Off-farm activites	Year end cash balance		RHS	
	Objective function		0	-w	0	0	-q	+p	0	-p	0	$-i_f$	$-i_{if}$	+w	0			max!
Period 1	rice and fish 1	total rice land														LE		1.7
		rice-fish land														LE		1.7
		pond area														LE		0
		stocking density														SOSLE		1
		stock fish														EQ		0
		labor tasks														LE		0
		material inputs														LE		0
		output														LE		0
	other farm 1	extent														EQ	x_1	
		labor tasks														LE		0
		material inputs														LE		0
		output														LE		0
	aquatic	labor tasks														LE		0
	organisms 1	output														LE		0
	nutrition 1	minimum consumption														GE	RDA-10%	
		maximum consumption														LE	RDA+20%	
	cash balance 1															LE	own funds	
Period 2	rice and fish 2	total rice land														LE		1.7
		rice-fish land														LE		1.7
		pond area														LE		0
		stocking density														SOSLE		1
		stock fish														EQ		0
		labor tasks														LE		0
		material inputs														LE		0
		output														LE		0
	other farm 2	extent														EQ	x_2	
		labor tasks														LE		0
		material inputs														LE		0
		output														LE		0
	aquatic	labor tasks														LE		0
	organisms 2	output														LE		0
	nutrition2	minimum consumption														GE	RDA-10%	
		maximum consumption														LE	RDA+20%	
	cash balance 2															LE		0
Period 3	other farm	extent	1													EQ	x_3	
	activities 3	labor tasks	l_3	-0.9	-1											LE		0
		material inputs	m_3			-1	-1									LE		0
		output	$-y_3$					1	1		1					LE		0
	nutrition3	minimum consumption								c_3	c_3					GE	RDA-10%	
		maximum consumption								c_3	c_3					LE	RDA+20%	
	cash balance 3			+w			+p	-p				-1	-1	-w	1	LE		0
Monthly	off-farm labor															LE		
limits	credit	formal										1				LE		7650
		informal											1			LE		4000
Own fund maintenance												$-(1+i_f)$	$-(1+i_{if})$		1	GE	own funds	