EU INCO-dev contract no. ICA-CT-2001-10055

Second Annual Scientific Report
(period: 1 Dec. 2002 to 30 Nov. 2003)

Systems Research for Integrated Resource Management and Land Use Analysis in E and SE Asia

compiled by
R.P. Roetter
IRMLA Project Co-ordinator

Alterra, Wageningen UR, The Netherlands
IRMLA Project Report 4

IRMLA
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http://www.irmla.alterra.nl

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Preface

In September 2000 the project proposal 'IRMLA: Systems Research for Integrated Resource Management and Land Use Analysis in E and SE Asia' was submitted to EU-INCO development programme. The proposal was approved in January 2001 and resulted in the contract ICA-CT-2001-10055. The 4 years project officially started on 1 December 2001 and will last till 30 November 2005.

This second project report of the 'Systems Research for **I**ntegrated **R**esource **M**anagement and **L**and Use **A**nalysis' (IRMLA) presents the scientific accomplishments of the second project year.

During year 2, the project progress has been according to plan. Main accomplishments during this year are the finalization and documentation of the technical coefficient generator, the training and support of the local teams in model development and application,, the development of a prototype farm household model and an analysis of environmental risks.

This report comprises four major parts. In the first part an overview is given of progress made during the second year with respect to each workpackage and the various deliverables. In addition, an outlook is given on activities to be carried out during year 3. Part 2 of this report deals with the progress in methodology development. Part 3 describes the progress in the case studies. Part 4 deals with managements aspects, accomplishments, bottle-necks, and possible improvements. In part 5, the individual partner annual progress reports are presented, and part 6, finally, comprises a number of annexes illustrating some of the accomplishments.

For more information, the reader is referred to the IRMLA website (www.irmla.alterra.nl)

I would like to take the opportunity to thank all project partners for the timely delivery of their input to this report.

Wageningen, 15 December 2003

Reimund P. Roetter
IRMLA Project Co-ordinator

Contract number : ICA4-CT 2001-10055 (IRMLA) **Year** : 2003

Data sheet
for annual report

(to be completed by the co-ordinator at 12-monthly intervals from start of contract. Figures to be up-dated cumulatively throughout project lifetime)

1. Dissemination activities

	Totals (cumulative)
Number of communications in conferences (published)	3
Number of communications in other media (internet, video, …)	5
Number of publications in refereed journals (published)	5
Number of articles/books (published)	2
Number of other publications	6

2. Training

Number of PhDs	3
Number of MScs	3
Number of visiting scientists	12
Number of exchanges of scientists (stays longer than 3 months)	0

3. Achieved results

Number of patent applications	0
Number of patents granted	0
Number of companies created	0
Number of new prototypes/products developed	0
Number of new tests/methods developed	1
Number of new norms/standards developed	0
Number of new softwares/codes developed	2
Number of production processes	0

4. Industrial aspects

	yes		No	
Industrial contacts	yes	☐	No	X
Financial contribution by industry	yes	☐	No	X
Industrial partners : - Large	yes	☐	No	X
- SME[1]	yes	☐	No	X

5. Comments

[1] Less than 500 employees.

Major partners of IRMLA project – Systems Research for Integrated Resource Management and Land Use Analysis in E and SE Asia

Coordinator:

1. ALTERRA
Soil Science Centre
P.O. Box 47
6700 AA Wageningen
The Netherlands

Dr. Reimund Roetter
Email Reimund.Roetter@wur.nl
Phone 31-317-474229
Fax 31-317-419000

Contractors:

2. Zhejiang university (ZU)
Department of Natural Resource Science
Huajiachi
Hangzhou 310029, Zhejiang
P.R. China

Prof. Wang Guanghuo
Email ghwang@mail.hz.zj.cn
Phone: 86-571-86971957
Fax 86-571-6049815

3. National Institute for Soils and Fertilisers (NISF)
Chem, Tu Liem
Hanoi
Vietnam

Dr. TT Son
Email tsonnisfacvn@hn.vnn.vn
Phone 84-4-8362380
Fax 84-4-8389924

4. Mariano Marcos State University (MMSU)
Batac, Ilocos Norte
Philippines

Dr. Epifania Agustin
Email rddirectorate@hotmail.com
Phone 63-77-792-3131/ 2547
Fax 63-77-792- 3191 /3447

5. Cuu Long Delta Rice Research Institute (CLRRI)
Agrotechnology Transfer Center
O Mon, Can Tho
Vietnam

Dr. NX Lai
Email attc@hcm.vnn.vn
Phone 84-71-861392
Fax 84-71-861457

6. Institute for Meteorology and Climate Research.
Atmospheric Environmental Research Forschungs-zentrum Karlsruhe GMBH (IMK-FZK)
Kreuzeckbahnstr. 19
D-82467 Garmisch-Partenkirchen
Germany

Dr. Reiner Wassmann
Email reiner.wassmann@imk.fzk.de
Phone 49-8821-183-139
Fax 49-8821-183-294

7. Wageningen University — Dr. Ir. Martin Van Ittersum
Group Plant Production Systems, Department of Plant Sciences (PPS.DPW.WU)
PO Box 430 — Email Martin.vanIttersum@wur.nl
Haarweg 333 — Phone 31-317-482382
6700 AK Wageningen — Fax 31-317-484892
The Netherlands

8. Plant Research International (PRI) — Prof. Dr. Ir. Herman Van Keulen
Agrosystems department — Email herman.vankeulen@wur.nl
PO Box 16 — Phone 31-317- 475955
Bornsesteeg 65 — Fax 31-317-423110
6700 AA Wageningen
The Netherlands

1 Summary of project and accomplishments

1.1 General

The project in a nutshell

Currently, in many of the highly productive lowland areas of E and SE Asia a trend to further intensification and diversification of (agricultural) land use can be observed. The gains in productivity and the associated environmental impacts of these developments are unknown. Effective land use planning and resource use analysis at different scales can help to make the issues transparent. This also includes design and analysis of resource-use efficient systems that can serve a broad range of development objectives. Both are key to identification of the scope for technical and policy change and its feasibility.

The current study will consider three relevant technology levels: (I) current farmers' practice; (II) available knowledge-intensive production technology, i.e. in the research and development (R&D) pipeline; and (III) future production technology, i.e. considered a feasible (R) target. Moreover, two policy scenarios will be considered in the analysis: expected changes in 2000-2005 and 2010-15.

Four case study regions have been pre-selected, all located in important agricultural areas, characterized by increasingly intensive rice-based systems, with varying degrees of diversification:

1) Pujiang county, Zhejiang province, China (rice-rice)
2) Batac and Dingras municipalities, Ilocos Norte Province, Philippines (rice-dry season crops)
3) Tam Dao (Tam Duong district), Red River Delta, Vietnam (double rice-winter crop)
4) Omon district, Mekong Delta, Vietnam (double or triple rice)

To identify options for <u>sustainable</u> land use (farm to region), existing methodology for strategic land use analysis and policy formulation at regional scale has to be broadened:

- in width (incorporation of environmental impacts)
- in length (incorporation of long-term effects)
- in depth (incorporation of farmers' decisions)

During year 1 of the project, workplans and budgets and mode of operation will be refined (kick-off workshop in February 2002); land use options and resource use conflicts for current production systems will be studied at the regional level; design and start of farm surveys.

During year 2, technical coefficients (TC) describing input–output relations of innovative, future production technologies (years 2005, 2015) will be generated; adaptation strategies to climate-induced risks will be taken into account; farm household models (FHMs) will be developed to analyse effects of policy measures on resource allocation; farm survey results will be analyzed to gain insight in farmers' decision behavior and develop farm household stratifications; training on TC generation and FHM at Wageningen.

During year 3, the farm household models will be finalized and operationalized; test results will be presented and discussed with local stakeholders (in-country workshops, February – April 2004); technical documentations.

During year 4, the link of farm household and regional land use modelling will be established and applied to analyse the response of farm households to different policy measures and examine whether and to what extent implementation of such policies would lead to realisation of policy objectives (rural development goals) at the regional level; on this basis feasible options for sustainable land use will be presented to policy makers; impact symposium (first half of 2005) and finalize publications.

The work is divided into six workpackages (see, Section 1.3 and www.irmla.alterra.nl).

Establishing the missing link between farm and regional analysis

The IRMLA project was able to build on the foundations laid by two previous projects operating in E, S and SE Asia and co-ordinated by IRRI and Wageningen UR (both co-funded by the Dutch government). The first one was the Simulation and Systems Analysis for Rice Production (SARP) project (1989 - 1995) with focus on research capacity building in simulation modelling of rice systems and applications at plot/field level. The second one was the SysNet Project (1996-2000) with focus on developing scientific-technical methodology and systems research tools for exploring land use options in four different Asian regions at the provincial/state level.

IRMLA is breaking new ground by moving beyond the limitations of its predecessors. SARP introduced systems approach and simulation modelling at field and farm level, while SysNet project changed the way regional land use is analysed and planned. IRMLA combines participatory research and different bio-economic modelling approaches to come up with a multi-scale modelling framework for analysing sustainable land use options at farm, district and provincial level.

1.2 Objectives and methodology

1. to develop scientific-technical approaches that support development of sustainable land use systems through informed decision-making on resource use at various hierarchical levels, and interactive policy design
2. to develop operational tools integrated in a decision support system for multi-scale analysis of land use systems and appropriate policy interventions
3. to design innovative production systems that produce sufficient food and that are resource-use efficient and tailored to sustainable land use

To bridge the gap between the current state-of-the-art of scientific support to natural resource management in E and SE Asia (design of resource-use efficient production systems, and systems methodology development for land use explorations for provinces and states) and the demands for practical applications, the work programme concentrates on effective farm level integration of recent results from field level research on natural resource management (NRM) and regional policy analysis. Starting point of the procedure are results from exploratory land use scenario analyses, generated by applying the LUPAS regional modelling system. Steps in the proposed project approach are given below.

1.3 Major activities / working packages

1) Examine the broad scope for technology and policy changes and identify technically feasible, short (2001-2005) and long term (2010-15) development scenarios for (four) selected regions in E and SE Asia (Work Packages 1&2)
2) Assess productivity and major environmental risks and impacts of prevailing rice-based systems under current farmers' management practices and resource constraints (WP 2&3)
3) Identify improved production technologies and resource management strategies, assess their potential for adoption by farmers, and quantify effects of anticipated changes in management practices on productivity, resource use efficiency and resource quality at farm level (WP2 to 4)
4) Analyse possible effects of policy interventions on the adoption of improved (knowledge-intensive) management practices for different farm-household types and identify their contribution to regional development goals in close collaboration with stakeholders (WP4&5)
5) Integrate farm household modelling approaches with a regional modelling framework (such as LUPAS) and initiate testing (prototyping) of sustainable farming systems (WP5)
6) Project co-ordination and management

1.4 Overall outputs of year 2003

Year 2003 was very productive related to almost all work packages. Most substantial progress was made with respect to the deliverables of WP2 (environmental risk assessment), WP3 (technical coefficient generation) and WP 4 (farm household modelling), in detail :

1) WP 2: Procedure to assess yield gaps and environmetal risk was elaborated and documented.
2) WP 3: A tool for generating coefficients quantifying input – output relations for crop production activities (TechnoGIN-3 model) has been completed and evaluated through intensive collaboration among the various Asian and EU partners.
3) WP 3 & 4: Comprehensive databases on farm households in each of the 4 study regions
4) WP1 & WP4 :Two prototype regional multiple goal analysis models (MGLP), and two prototype farm household models (FHM) have been elaborated through (i) intensive dialogue and consultations among Asian teams and local stakeholders and (ii) fruitful collaboration between EU and Asian scientists, and key stakeholders, during a series of four case study specific workshops and one joint workshop attended by all teams on integration of data and models
5) WP1: The dialogue between key stakeholders and the four Asian research teams has been fully established and is being maintained through staunch support from local governments.
6) WP 6: Research topics and scientists participating in IRMLA appear to be attractive among students and have again generated specific research topics to be studied by two new PhD

students and 1 MSc student. On-the-job training on certain techniques and a 1 week specific workhop on integration of data and models were provided to IRMLA team members by Wageningen scientists. Moreover, in 2003, several conference presentations were given (3) and a number of scientific publications (1 published; 5 submitted; 2 in preparation) were generated by IRMLA scientists.

1.5 Activities planned for 2004

Activities will comprise documentation of outputs from workpackages 1, 2, 3 and 4 for the various case studies as well as further development of tools for identification of improved production technologies and management strategies, analysis of farmers behaviour (workpackages 1, 3 and 4) and preliminary analysis of effects of policy interventions for different farm-household types (workpackage 4).
In detail:

- Completion analysis and evaluation of all farm household survey data collected
- Design GIS applications for illustrating model inputs and outputs r (linkage of GIS to TCG and (GAMS) MGLP - and elaboration of application for one case study
- Completion of climate-induced risks for Dingras and Omon case studies
- Conducting multi-stakeholder workshops in each study region to report on progress and receive feed-back from stakeholder platforms
- Expansion of databases for regional land use optimisation models (Tam Duong and Pujiang)
- Development of technical coefficient generators/algorithms for animal production systems (evaluation for Pujiang and Tam Duong case studies)
- Elaboration of farmhousehold models for Batac and/or Dingras and Omon case studies
- Elaboration of prototype MGLPs for regional application (Tam Duong and Pujiang)
- Conducting 4 in-country workshops in Asia for establishing interaction between models and stakeholders (actors)
- Producing publications on IRMLA multi-scale approach, technical coefficient generator and FHM approach applied
- Publication of report on resource use conflicts in the various case studies
- Continue consultations with stakeholders on policy views and development goals and involve key stakeholders in formulating ‘what-if questions and jointly interpreting model results (workshops to be held in each study region)
- Databases on farm survey results documented
- Input-output tables for current and future crop production activities generated
- Algorithms and calculation rules for animal production activities developed, tested and documented
- Technical Coefficient generators elaborated for all study regions
- Further topics for formal training (MSc, PhD) of students from EU and Asian partners formulated
- Preparations made for presenting interim project findings to a wider audience (in international conferences and workshops) and via scientific and popular publications.

1.6 Communication of research results

Invited presentations/papers for International Conferences

- Ecoregional Fund Conference, Potchefstroom, S Africa (17-20 February 2003) : "Impact of Systems Research Network on eco-regional methodology advancement and research capacity building in S and SE Asia" (R P Roetter)
- Durban, South Africa (16-22 August 2003) Paper presentation at 25th International Conference of IAAE (Marrit van den Berg) on the use of production functions in bio-economic models
- Nanjing, China (23-25 October 2003) Paper presentation at at international seminar on Economic Transition and Sustainable Agricultural Development in East Asia, Nanjing, P.R. of China, 20-22 October 2003. by M van den Berg: Decreasing the use of agrochemicals in rural China: setting priorities for research and policy in Zhejiang province.

Scientific papers submitted/published in 2003

Papers in preparation

Writing-up of 2 papers has started :

(i) paper for the International workshop on Multiple Objective Decision Support Systems (MODSS 2004), 17-21 June 2004, Osnabrueck, Germany entitled: *A multiple-scale approach to integrated resource management and land use systems analysis in East and South-east Asia: Challenges and potential solutions.*

ii) paper on the generation of technical coefficients for cropping systems in E and SE Asia – TechnoGIN-3

Submitted

(1) Roetter, R.P., C.T. Hoanh, A.G. Laborte, H. Van Keulen, M.K. Van Ittersum, C. Dreiser, C.A. Van Diepen, N. De Ridder and H.H. van Laar, 2003. Integration of systems network tools for regional land use scenario analysis in Asia. Submitted to Environmental Modelling and Software.

(2) Van Ittersum, M.K., R.P. Roetter, H. van Keulen, N. de Ridder, C.T. Hoanh, A.G. Laborte, P.K. Aggarwal, A.B. Ismail, A. Tawang, 2003. A systems network (SysNet) approach for interactively evaluating strategic land use options at sub-national scale in South and South-east Asia. Submitted to Land Use Policy.

(3) De Ridder, N., Van Keulen, H., Roetter, R., Van Ittersum, M.K., Hoanh, C.T., Aggarwal, P.K., Ismail, A.B., Lansigan, F.P., Francisco, S.R., Lai, N.X., Laborte, A.G., 2004. A generic methodology for strategic land use analysis applied to four sub-national regions in South and Southeast Asia. Submitted to Agriculture, Ecosystems and Environment.

Published

(i) Ittersum, M.K. van, P.A. Leffelaar, H. van Keulen, M.J. Kropff, L. Bastiaans & J. Goudriaan, 2003. On approaches and applications of the Wageningen crop models. European Journal of Agronomy 18: 201-234.

(ii) Lu, C.H., M.K. van Ittersum and R. Rabbinge, 2003. Quantitative assessment of resource-use efficient cropping systems: a case study for Ansai in the Loess Plateau of China. European Journal of Agronomy: in press.

(iii) Hengsdijk, H. & M.K. van Ittersum, 2003. Formalizing agro-ecological engineering for future-oriented land use studies. European Journal of Agronomy 19: 549-562.

(iv) Hengsdijk, H. & M.K. van Ittersum, 2003. Dynamics in input and output coefficients for land use studies: a case study for nitrogen in crop rotations. Nutrient cycling in Agroecosystems 66: 209-220.

(v) Ven, G.W.J. van de, Ridder, N., de, Keulen, H. van, Ittersum, M.K. van, 2003. Concepts in production ecology for analysis and design of animal and plant-animal production systems. Agricultural Systems 76: 507-525.

2 Methodology development – highlights in 2003

2.1 Introduction

The recent main developments in methodologies to be applied within the project, are described in the following.

First, a technical coefficient generator , TechnoGIN3, has been finalized and documented. TechnoGIN3 has been developed for the purpose of explorative land use analysis under multiple goals. It is applied for quantifying inputs and outputs of main current and future-oriented production activities (i.e. cropping systems) in East and South-east Asia.

Second, a prototype of a farm household model (FHM) for Omon has been developed. Most decisions about land use are ultimately made by farm households. Hence, for the analysis of decision making on land use, the FHM approach is applied. Suitability of various current and future-oriented farming systems can be compared and the impact of feasible changes in policy can be analysed

Third, the impact of environmental risks on agricultural production systems is analysed. These risk assessments address the climate-induced threats for rice production in the four IRMLA study regions. Climate-induced risks include present extreme weather events such as typhoons, as well as the direct and indirect consequences of global warming. Apart from possible heat stress for rice grown in tropical/ sub-tropical climates, higher temperatures cause far-reaching hydrological changes due to sea level rise and changes in rainfall patterns.

2.2 TechnoGIN3: a generic tool for analysing cropping systems in E and SE Asia

A new version of the Technical Coefficient Generator (TCG) for cropping systems in East and South-east Asia has been released for distribution in November 2003. The model is available on CD-ROM. This CD contains also a number of data sets for the different case study areas of the IRMLA project, a user's manual and a complete technical documentation (Ponsioen et al., 2003).

2.2.1 Background

Agricultural research in East and Southeast Asia is increasingly challenged by the search for land use options that best match multiple development objectives of rural societies (i.e. increased income, employment, improved natural resource use efficiency, food security, reduced environmental pollution). This calls, among others, for effective tools for resource use analysis at different integration levels. Since the 1980s, the method of interactive multiple goal linear programming (IMGLP) has been proposed for an integrated analysis of resource use at regional or farm level (De Wit et al., 1988). This method has been applied in various land use studies (Rabbinge & Van Latesteijn, 1998; Bouman et al., 1999). Key components in frameworks using this approach are: (1) databases on biophysical and socio-economic resources and development targets; (2) description of inputs and outputs of all promising production activities and technologies; (3) multiple criteria decision method (optimisation); and (4) sets of goal variables (representing specific objectives and constraints).

Within the IRMLA-project , TechnoGIN-3 has been developed for quantifying inputs and outputs (see component 2 above) of main current and future-oriented production activities (i.e. cropping systems) in Ilocos Norte province, Philippines, Zhejiang province, China, Red River Delta, North Vietnam, and Mekong Delta, South Vietnam. TechnoGIN stands for Technical coefficient generator for Ilocos Norte province, Philippines, as it was originally developed for this province. TechnoGIN is a technical coefficient generator (TCG) and is comparable to tools that have been developed for the purpose of explorative land use analysis under multiple goals in Costa Rica and Vietnam (Hengsdijk et al., 1996; 1998; Bouman et al., 1998; Jansen, 2000).

2.2.2 Methodology

TechnoGIN applies a target-oriented approach. This means: a fine-tuning of inputs to realize a specified yield level under certain environmental and management conditions (Van Ittersum & Rabbinge, 1997). This approach enables us to quantify the required amount of various inputs such as labour, water, fertiliser, and their monetary values to attain yield levels in various land use systems. In addition to these yields and the related amounts of crop residues, also side effects of the production process on the resource base (such as soil nutrient depletion) and pollution of the environment (e.g. nitrate leaching, biocide exposure) can be calculated for the different land use systems. Such side effects are often expressed in sustainability indicators.

TechnoGIN has initially been developed on the basis of concepts from earlier TCGs such as LUCTOR (Hengsdijk et al., 1998) and Agrotec (Jansen, 2000). The new version TechnoGIN-3 has thoroughly been re-designed and tested to become a more generic and flexible tool, applicable to an extended range of cropping systems and agro-ecological conditions in East and Southeast Asia. In addition, the QUEFTS model (Witt et al., 1999) was incorporated to calculate the crop's nutrient uptake.

TechnoGIN-3 was programmed in Microsoft Excel with macro programming in Microsoft Visual Basic for Applications. To make the TCG and databases better manageable and accessible, TechnoGIN-3 consists of a model file and separate data base files for the different case study areas. In the model file, calculations are executed, the model interface (buttons and user forms) is integrated and model output is stored (which can be exported to a separate file for feeding the IMGLP model). TechnoGIN-3 has a user-friendly interface (Figure 2.2.1). You may select a production activity (top button of Figure 2.2.1), such as a crop rotation (i.e. LUT or land use type) on a Land Management Unit (LMU) with the yield levels that are expected for a present or future production technology. For these 'target' yield levels, TechnoGIN calculates the technical coefficients (i.e. required inputs, environmental pollution). TechnoGIN may be applied for comparing resource use efficiency, labour demand, cost/benefit ratios and environmental pollution from different crop rotations and production technologies.

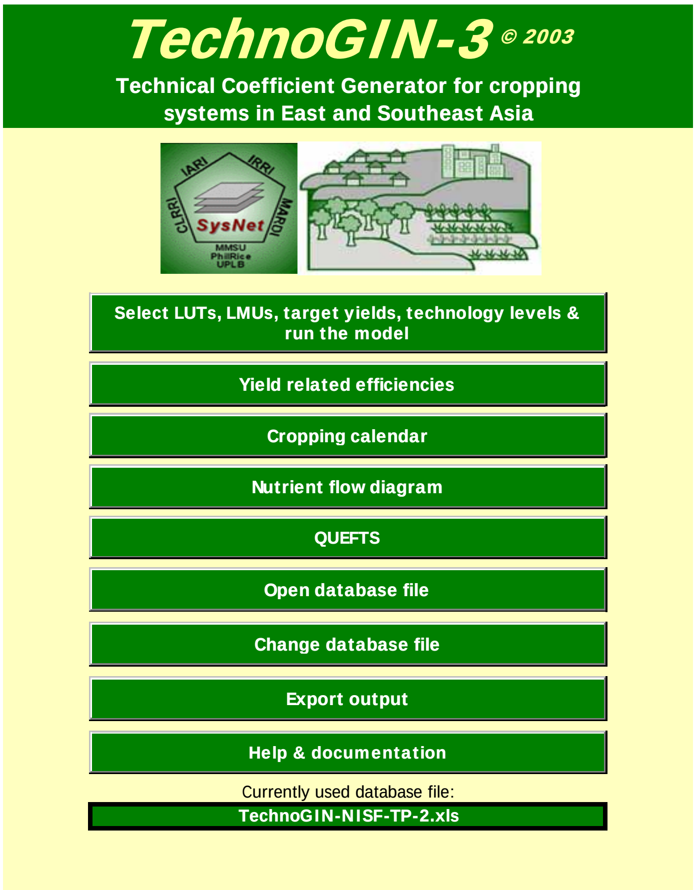


Figure 2.2.1 Main selection form of TechnoGIN-3

For each case study area of IRMLA, a database file is produced. This file contains data bases organised in separate worksheets for respectively crops, land use types (i.e. crop rotations), land (management) units, production techniques, fertilisers, biocides, etc in that area. A simplified representation of the structure of TechnoGIN and its data bases is shown in Figure 2.2.2. An overview of the output of TechnoGIN, i.e. the technical coefficients, is also given in this figure.

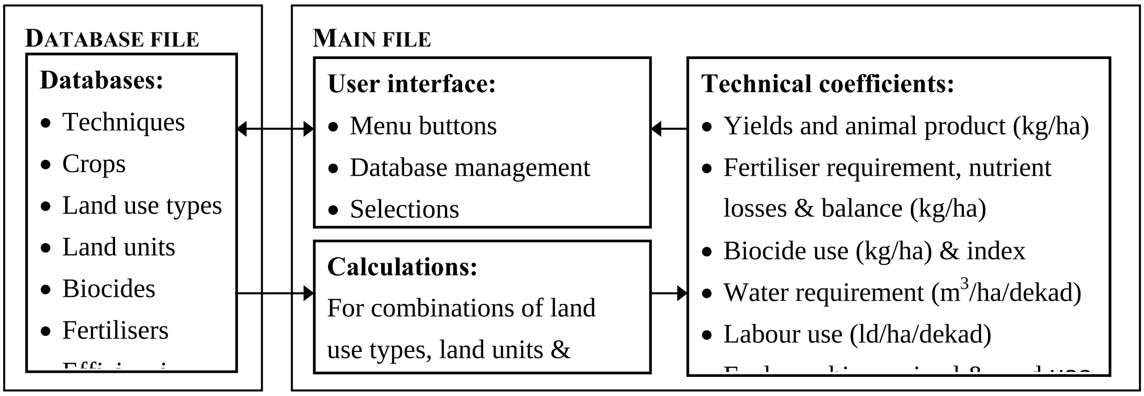


Figure 2.2.2 Simplified representation of the structure of TechnoGIN (Source: Ponsioen et al., 2003); the arrows represent flows of data

2.2.3 Application and Results

The outputs of TechnoGIN are the technical coefficients that describe the input – output relations of crop production systems. The technical coefficients consist of:

a. evapo-transpiration and irrigation water requirements
b. N,P,K fertilizer requirements and emissions
c. labour demand
d. costs and use of different types of fertilisers
e. cost and use of different pesticides, herbicides and fungicides
f. costs and use of other inputs (machinery, animals, investments)
g. economic indicators
h. environmental impacts

Evapo-transpiration and required irrigation water

TechnoGIN calculates from the potential evapo-transpiration over the year for the specified crop rotation and the annual rainfall distribution the required amount of irrigation water (Figure 2.2.3). This shows that in the case study area in North Vietnam, the irrigation water requirements are high in spring when the amount of rainfall is limited.

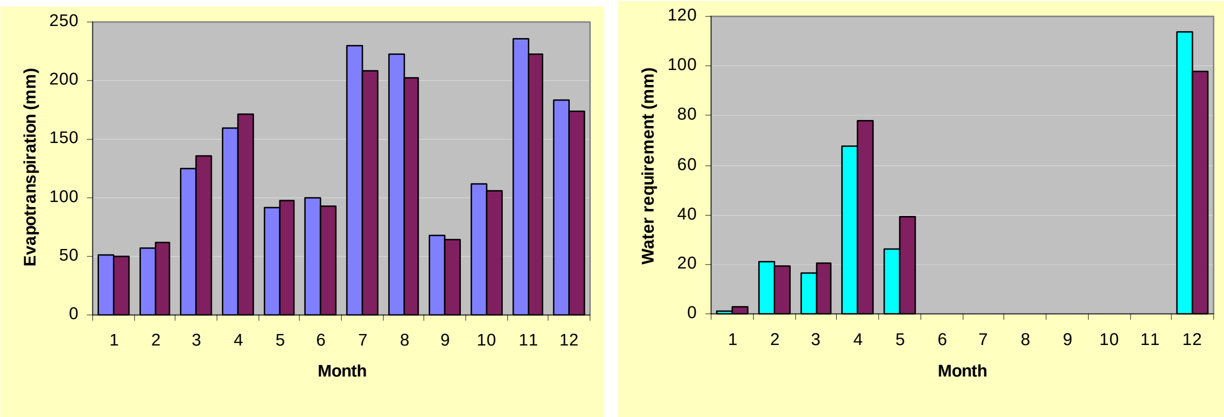


Figure 2.2.3. Evatranspiration and required amount of irrigation water for two cropping system in North Vietnam from TechnoGIN calculation

NPK fertiliser requirements and emissions

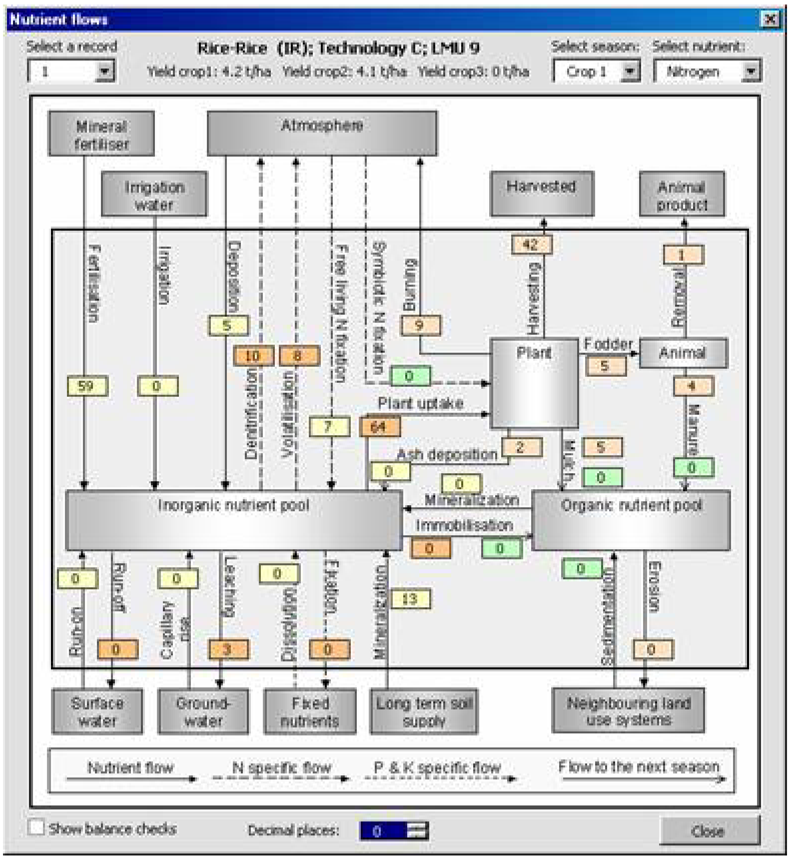


Figure 2.2.4 Diagram of nutrient pools and flows for the specified crop production system (e.g. rice-rice rotation on LMU=9 and Technology C and indicated target yields) from TechnoGIN calculation

For the specified crop production system (e.g. rice-rice) the flows of nitrogen, phosphorus and potassium over one year are calculated (Figure 2.2.4). For the specified target yield level, the crop's nutrient uptake is calculated with the QUEFTS approach (Witt et al., 1999). For each Land Management Unit the natural soil nutrient supply can be specified. From this soil supply and the crop's nutrient uptake, the required amount of fertiliser nutrient application and the nutrient emissions by leaching, denitrification and volatilization are calculated.

Labour demand

For each crop type the amount of labour that is required for land preparation, crop establishment (sowing or planting), crop management (fertiliser application, crop protection, etc.) and harvesting, is specified. For the specified crop rotation the labour demand over the year can be calculated (Figure 2.2.5) with TechnoGIN-3, based on these input data.

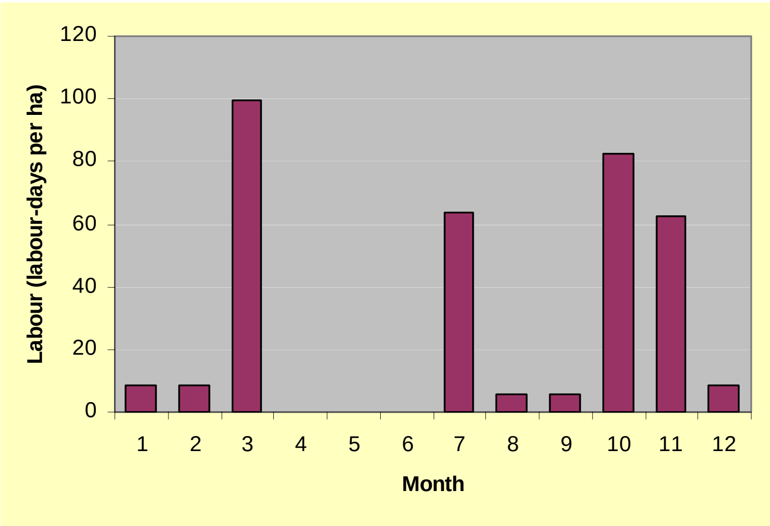
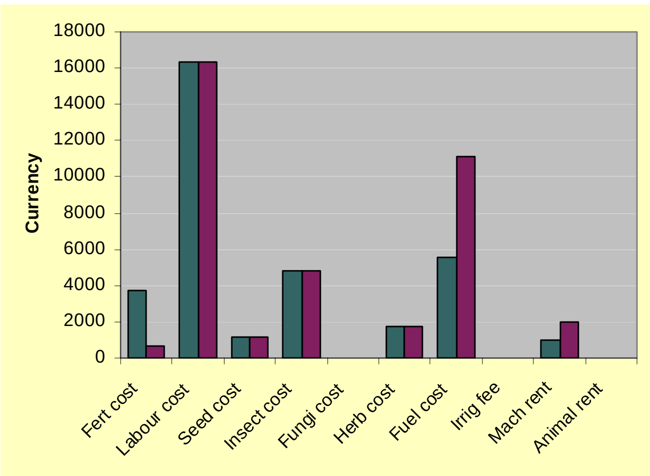


Figure 2.2.5 Labour demand over the year for a double cropping rotation from TechnoGIN calculation

Costs of inputs and economic indicators



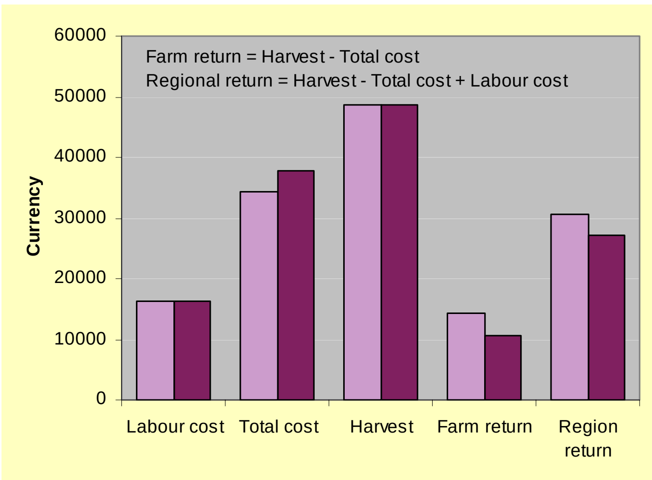


Figure 2.2.6 Costs of inputs for double rice cropping in the Philippines (left) and the benefits (=harvest), farm return and region return (right) from TechnoGIN calculation

For the different inputs such as labour, machinery and animal use, the different types of fertilisers and the different types of biocides, the prices are specified in the input data files. From these prices and the calculated input use, the costs for the specified crop rotation can be calculated (Figure 2.2.6 left). For each crop product, the price is specified in the input file. The crop yields times these prices give the benefits from the specified crop rotation. These benefits minus the total costs (inclusive costs for labour) give the farm return and the benefits minus the total non-labour costs give the region return (Figure 2.2.6 right).

Environmental impacts

Nutrient losses by leaching to the groundwater and nitrogen emissions to the air by denitrification and volatilization can be calculated by TechnoGIN-3, as shown above in the nutrient flow diagram (Figure 2.2.4). Based on the applied biocides in a crop rotation, the total biocide residue index is calculated. This index is a rough estimate for the environmental impacts of the total biocide use, and depends on total biocide use, the persistence of these biocides in the soil and their toxicity.

2.2.4 Conclusions

The first applications of TechnoGIN-3 show that it can be a very useful tool for comparing actual and possible future land use systems and different crop production technologies. In such a comparison, the differences between production systems can be shown and analysed in terms of water use, labour demand, fertiliser nutrient requirements, economic aspects and environmental impacts.

TechnoGIN-3 is a userfriendly tool for producing technical coefficients (i.e. inputs and outputs) for the often large number of main crop production activities (i.e. LUT-LMU-technology combinations) in a region. The number of technical coefficients that TechnoGIN-3 can produce for each production activity, is large. They can easily be managed and interpreted using graphs, statistics, geographic information systems (GIS) and optimisation models.

The quality of the TechnoGIN-3 output is always determined by the quality of the input data. Hence to ensure the quality of the TechnoGIN output, input data should be checked on local information (e.g. farm surveys, field trials) and output need to be carefully evaluated on the basis of the applied assumptions on the agricultural production system.

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2.3 Farm household model for Omon

The overall goal of IRMLA project is to contribute to sustainable agricultural development in selected areas of East and Southeast Asia through novel techniques of resource use analysis and land use planning connecting various decision levels and actors. Most decisions about land use are ultimately made by farm households. For the analysis of decision making at this level, the IRMLA team uses the farm-household modelling approach.

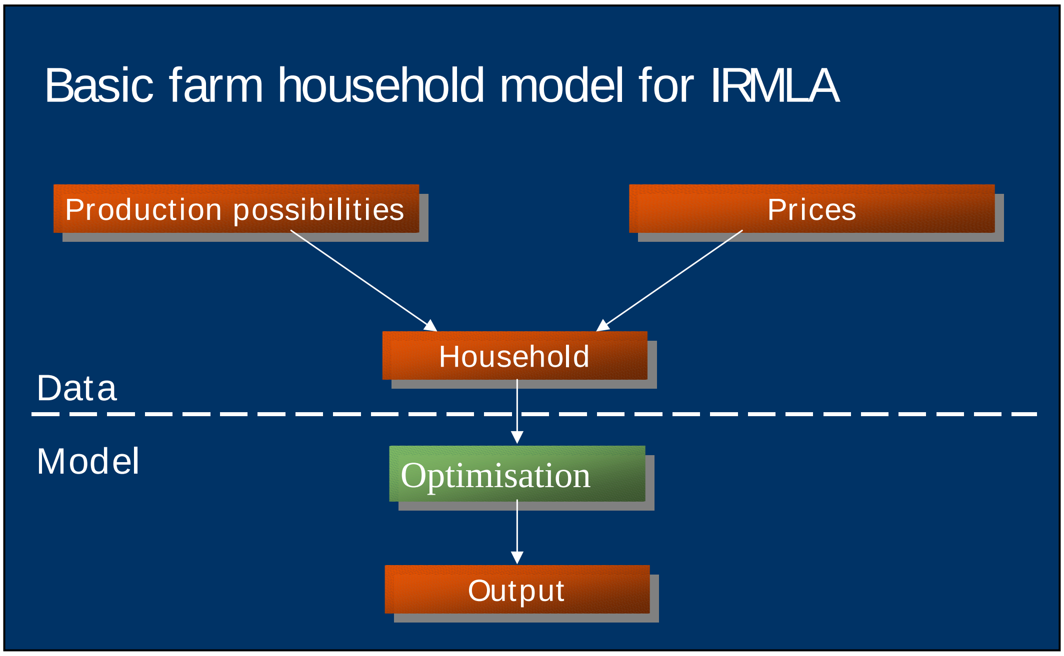
Farm-household models are developed for two reasons:

1. to analyze the suitability of various current and future-oriented farming systems for the specific setting of the farmers in the case study area; and
2. To simulate the impact of feasible changes in policy on technology choice and farmer objectives.

The farm-household modeling approach can be summarized as follows. Farmers are classified into various relatively homogeneous groups. For each farm group, a linear program is made, in which utility (or usually a derived objective like income) is maximized subject to resource and market constraints. To account for market interactions (demand for products, supply and demand of labor) these models can be linked through market equilibria in the most important markets.

2.3.1 Development of a prototype model

The first step in the development of farm household models for IRMLA was the development of a prototype model by the PPS-DPW-WU team. The model maximizes either total income (returns to family land, labor and management) or discretionary income (total income above basic consumption requirements). The constraints involve: ownership of different types of land, family labor, seasonal credit for working capital, investment capital, monthly availability of off-farm and non-farm employment, and minimum consumption of rice. The model is structured as such, that in each run results are generated for four different types of household.



Adjustment to the local situation

During the in country workshop, the team of CLRRI and a member of the PPS-DPW-WU team discussed requirement for adapting the prototype model to the situation of farmers in O Mon. The results of this discussion are presented below. The final model including the required changes is presently under development.

Photo 2.3.1 Vietnamese scientist working on farm household model at the Wageningen workshop

Objectives

Farmers in O Mon strive for a high income that is protected from large fluctuations due to price variability. They want to achieve this high income with as little effort as possible. Production of rice for home consumption does not appear to be an important objective. Not all farmers grow rice and 30%-50% of those who do so sell their entire produce and purchase rice in the market. Moreover, farmers store no or very little rice during the rainy season, as this leads to a decline in quality. Most farmers do not care about the health or environmental effects of the use of agrochemicals.
This combination of objectives implies that we need to develop an objective function that includes at least the level and variability of income and possibly also leisure.

Photo 2.3.2 Rice cultivation in Omon

Additional constraints

Farmers in O Mon face more constraints than those included in the prototype model. Firstly, they have only limited education and knowledge of new technologies. In the model this translates in the availability of technologies for the different farm types, and no additional constraints are required. Secondly, the market is a major limitation. Farmers find it difficult to sell large amounts of non-rice crops and infrastructure does not allow sale of some crops for farmers in remote areas. In the model this translates in maximum sales levels and low or zero prices. Finally, there is a limit on the amount of labor that farmers can hire during peak seasons, especially during harvesting in the wet season. In the model this translates in upper boundaries for hiring in certain months.

Photo 2.3.3 Fruit tree production in Omon

Remarks

The following points have come up that are kept in mind during the farm household modeling work:

- farmers consider last-year prices when making decisions
- most important changes: different rice varieties
- few fruit plantations, conditions not favorable, limited skills
- renting in land: 10%, renting out land 10%?. *Depending on the outcome of the survey, we either consider actual land cultivated or land ownership and the possibility to rent in/out land.*
- Good quality rice (for export) is more expensive to produce and the farm-gate price is only somewhat higher. So it is currently not profitable for the farmer.
- No tax on agricultural production and land
- Around 10% of the households get remittances from family members in city or abroad. *Currently, the model includes exogenous working capital. This is assumed not to be used for consumption, but to be saved as working capital for next year. Remittances are an exogenous source of income that can also be used for consumption. So we should include this in the model as a separate parameter.*

- low prices are a problem for many farmers
- village leader can encourage farmers to do some things by giving information, e.g. grow upland crops. *You can mimic this in your model by increasing the set of available technologies*.

Examples of possible simulations

The models can be used to simulate the potential adoption of new technologies. Technologies that seem promising at the research station may run into constraints at the farm level. These constraints can involve for example limited investment capital, uncertainty, or high labor requirements at peak seasons. Through modeling farmer objectives and constraints, it is possible to adjust research and extension more closely to the local situation.

Photo 2.3.4 Family work at farm in Omon

Moreover, it is for example possible to assess the effectiveness of government programs *ex ante*. For example, will an increase in the availability of credit lead to an increase farmer income and/or environmental sustainability? And will increased market integration, through higher output prices, *ceteris paribus* lead to more or less pollution of the environment?

Photo 2.3.5 Scenery with canals in Omon

2.4 Environmental risks

These risk assessments address the climate-induced threats for rice production in the four IRMLA study regions. Climate-induced risks include extreme weather events occurring under present climates, namely typhoons, as well as the direct and indirect consequences of global warming. Apart from possible heat stress for rice grown in tropical/ sub-tropical climates, higher temperatures cause far-reaching hydrological changes, e.g. in form of sea level rise.

The four IRMLA case studies show different degrees of vulnerability to these climate-induced risks. Sea level rise and typhoons only pose threats to Cantho (**Assessment 1**) and Ilocos Norte (**Assessment 2**), respectively, and are therefore discussed in the following section for these cases only. While temperature rise will affect all four regions, the following discussion addresses the consequences of higher temperatures for the regions of Hangzhou and Hanoi (**Assessment 3**).

2.4.1 Assessment 1: Risks stemming from Sea Level Rise (Cantho)

Nature of the risk

Sea level rise (SLR) is one of the most ascertained consequences of global climate change and can already be observed along many shorelines. Along the Vietnamese coastline, the available records indicate sea level rise of 1.75 to 2.56 mm/year. In this study, we have derived 2 SLR scenarios from the first report by the Intergovernmental Panel on Climate Change that projected SLR of Δ8-29 cm by 2030 and Δ21-71 cm by 2070. We have rounded up the 'best estimates' of these projections to Δ20 cm and Δ45 cm sea level rise which were used as medium-term and long-term scenarios in this study.

The bulk of the land in the Vietnamese Mekong Delta (VMD) is only slightly (< 2 m) above mean sea level. Approximately 1 mio ha are affected by tidal flooding and 1.7 mio ha by salt water intrusion. No other crop than rice that can be grown under these adverse conditions of unstable flooding. In several years, however, flooding in the VMD has exceeded the tolerable level for rice production leading to huge economic losses in the agricultural sector. Most farmers in flood-prone rice areas are very poor, with limited options to divert to other sources of income and it will become absolutely vital for these farmers to adjust to a changing environment.

Reliable assessments of possible changes have to be based on profound knowledge of the hydrological conditions in the VMD. Tide and river discharge variations over time are creating very complex and highly dynamic flow systems. In this study, we used a hydraulic model of the Mekong Delta to link the hydrologic information with land use data (Figure 2.4.1). The model uses the sea water level as boundary condition so that the model could be run under virtual conditions of higher sea level.

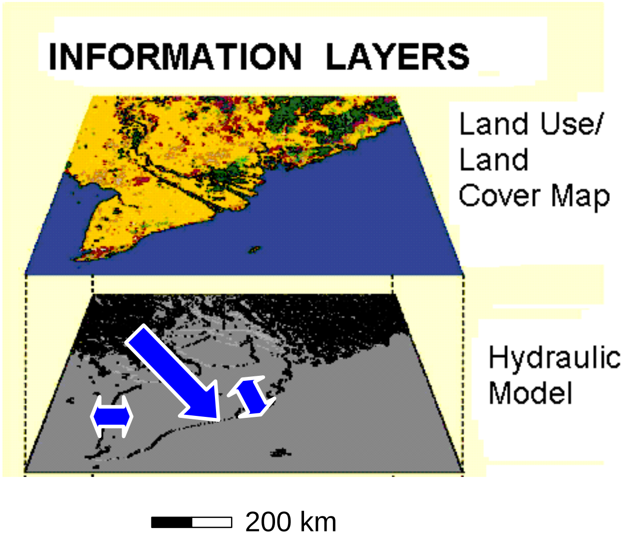


Figure 2.4.1 Schematic presentation of different information layers for risk assessment of VMD to sea level rise

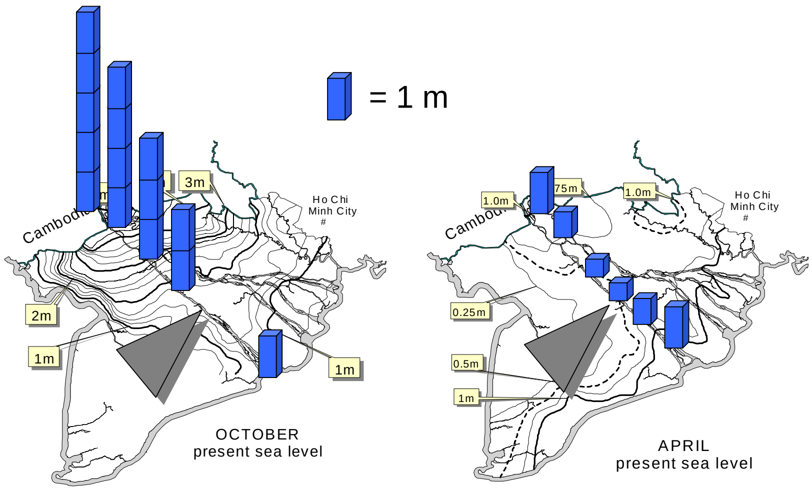


Figure 2.4.2a,b Spatial patterns observed water levels (m asml) in flood season (October) and dry season (April); arrows indicate location of Cantho

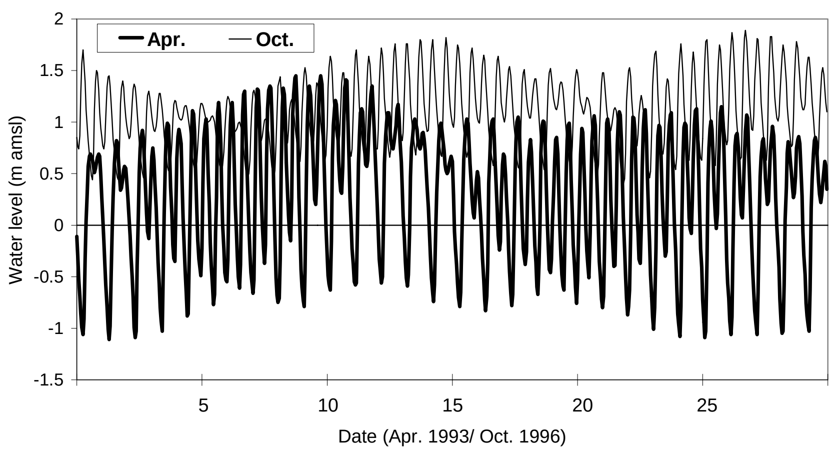


Figure 2.4.3 Comparison of observed water levels (m asml) in dry season (April) and flood season (October) at Can Tho

Impacts of SLR in the flood and dry season

Simulated data on water levels were transferred into a GIS data base to display the contours of water levels at different seasons. In the wet season, the water levels correspond to a distinct slope from ca. 5 m amsl (above mean sea level) at the Cambodian border to ca. 1 m amsl at the mouth of the Mekong river (Figure 2.4.2a). At the peak of the flood season in October, tidal fluctuations account for ca. 1 m amplitude in Cantho Province (Figure 2.4.3) and water levels range between 1.5 and 1.75 m amsl in this part of the Delta. In the dry season (April), water levels are <1 m amsl in Cantho Province; only the upper part of the VMD has a distinct gradient in water level with approximately 3 m amsl at the Vietnamese-Cambodian border (Figure 2.4.2b). The entire VMD is affected by tidal waves which have an amplitude of ca. 2m at Cantho (Figure 2.4.3).

For this analysis, we have generated a series of maps displaying water contour lines under Δ20 SLR and Δ45 SLR and have compared these data with present conditions. To limit space for this presentation, however, we focus our figures here on the impact of Δ45 SLR scenario in the months of August (onset of the flood season), October (peak of the flood season) and April (dry season).

In August, the 1 m contour line cuts through Cantho province under present conditions, but is shifted by 40 - 50 km towards the sea under Δ45 SLR scenario (Figure 2.4.4a,b). In the Δ20 SLR (not shown), the 1 m contour line was shifted by 15 - 25 km in August. During this early period of the flood season, water levels in Cantho Province will be elevated by >16 cm and >25 cm under Δ20 SLR and Δ45 SLR, respectively.

At the peak of the flood season in October, the impact of SLR is buffered by high water discharge from the river and high background water levels, so that the shifts in contour lines are generally smaller (Figure 2.4.5a,b). However, Δ20 SLR will still elevate water levels in Cantho Province by >12 cm (not shown) and Δ45 SLR SLR by > 32 cm (Figure 2.4.5a,b).

In April, the discharge of the Mekong river branches at the Vietnamese-Cambodian is less than 10 % of the discharge in October. Subsequently, water levels are generally low and tidal waves can propagate throughout the Delta. These hydrologic conditions also imply that even small increments in the sea level will affect large areas of the VMD including Cantho Province. On the other hand, water cover in the dry season is basically restricted in the rivers/canals. Hence, higher water level will probably not cause significant impacts on rice production. In fact, a large part of the VMD is suffering from limited water availability during dry season which may be ameliorated by higher water level as a consequence of SLR.

For the dry season, our risk assessment focused on possible aggravation of salinity intrusion. Under present conditions, the area affected by salinity intrusion in the VMD is about 1.7 mio ha, comprising a broad strip along the coastal area as well as the Ca Mau peninsular (Figure 2.4.6a). Surprisingly, our simulation results showed that SLR will only slightly increase the saline area of the VMD. An increase of 45 cm will shift salinity gradients about 6 km inward as compared to the present situation (Figure 2.4.6b) – well before having any possible effect in Cantho Province.

The movement of salt is a relatively slow process requiring a mass transport through tidal movement or along concentration gradients. In contrast, changes in water level immediately affect the gravitation flow in the upstream segments. This fundamental difference limits the further encroachment of salinity into the Mekong delta whereas almost the entire delta will experience higher water levels.

Figure 2.4.4a,b Water level contours (m amsl) in August under (a) present sea level and (b) Δ45 SLR scenario; arrows indicate location of Cantho.

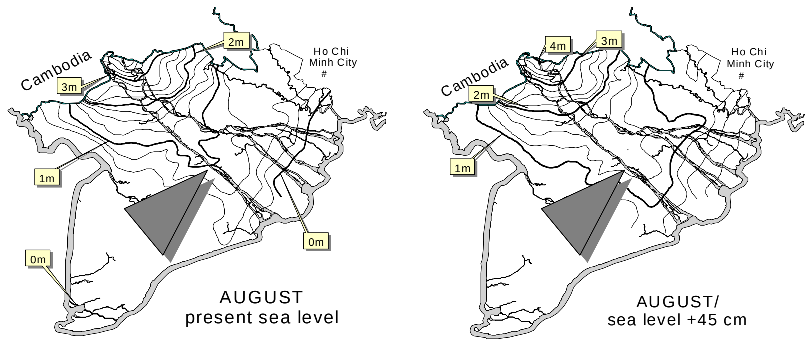


Figure 2.4.5a,b Water level contours (m amsl) in October under (a) present sea level and (b) Δ45 SLR scenario; arrows indicate location of Cantho.

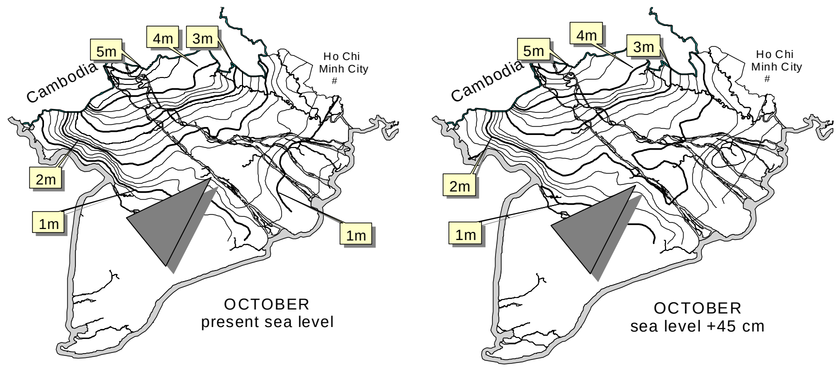
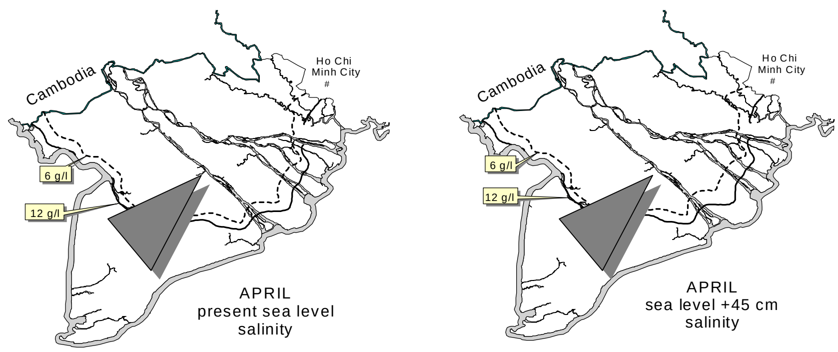


Figure 2.4.6a,b Salinity contours (g/ l) in April under (a) present sea level and (b) Δ45 SLR scenario; arrows indicate location of Cantho.



Possible implications of SLR on rice production

Rice can be grown in the VMD in three different crops (Table 1), i.e. Dong Xuan (winter-spring crop), Mua (rainfed crop) and He Thu (summer-autumn crop). Farmers can also grow a spring-summer crop, but this is only applied in a limited area with good irrigation system and therefore not included in this assessment. The three main rice crops appear in different combinations in the VMD:

- as single crop: Mua
- as double crop: either Dong Xuan + He Thu or He Thu + Mua
- as triple crop: short duration varieties in Dong Xuan + He Thu + Mua

Table 2.4.1 Cropping calendar and hydrological characterization of major rice crops in the VMD (ir = irrigated; rf = rainfed); SLR impact phases denote excessively high water level (A), prolonged inundation period (B), and improved water supply (C)

Month	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Febr.	March
Summer -autumn crop			**HE**	**THU**	(ir/rf)							
Flood season crop						**MUA**	(rf)					
Winter-spring crop									**DONG**	**XUAN**	(ir)	
Water level	**Min. ::> Max. ::>**											
Rainy season		|===|										
SLR impact phase		├ C_1 ┤			├─ B_1 ─┤	├── A ──┤		├─ B_2 ─┤				├ C_2 ┤

The seasonal impacts of SLR can be characterized as follows (Table 3):

- Phase A: Excessively high water level
  At the peak of the flood season, water level in the fields often reaches the physiological limits of the rice plant. Additional increase in the flooding depth could severely hamper the performance of the Mua crop. The timing and the location makes this crop especially vulnerable to rising water level. It is typically planted with traditional rice cultivars with a long growing period that inevitably stretches over the peak of the flood season.

- Phase B: Prolonged inundation period
  Another effect of SLR is the prolonging of field inundation that may cause excessively moist condition during the harvesting of the He Thu (Phase B_1) and a delay in planting of the Dong Xuan crop (Phase B_2). For both crops, a certain shift towards the dry season may technically be feasible, but would unavoidably lead to higher water demand during the dry months. It is not clear, if this increment could be compensated by improved water supply associated with higher sea level.
  At the same time, potential yield of He Thu crop would decline when planting date is earlier. Crop simulation using the WOFOST model and weather data (1983-1995) from the central part of the VMD indicated a 8 % decrease in potential yield of the He Thu crop planted in mid-March (i.e. approximately one month earlier than the usual date). Early planting increases yield risk of the He Thu crop since losses can be as high as 18 %.
- Phase C: Improved water supply in the dry season
  During the low water level period from March to May accessibility will generally be improved and less fuel will be required for pumping. Such positive impact may affect the early stage of He Thu (Phase C_1) and late stage of Dong Xuan (Phase C_2) crops.

2.4.2 Assessment 2: Risks stemming from typhoons (Ilocos Norte)

The Northern Philippines are located along one of the most common track pathways of tropical cyclones in South-East Asia. While this region was hit by more than 200 typhoons in the period from 1945 to 1998, the corresponding number of typhoons in the other IRMLA case studies was <60 in Hangzhou and Hanoi and <20 in Cantho.

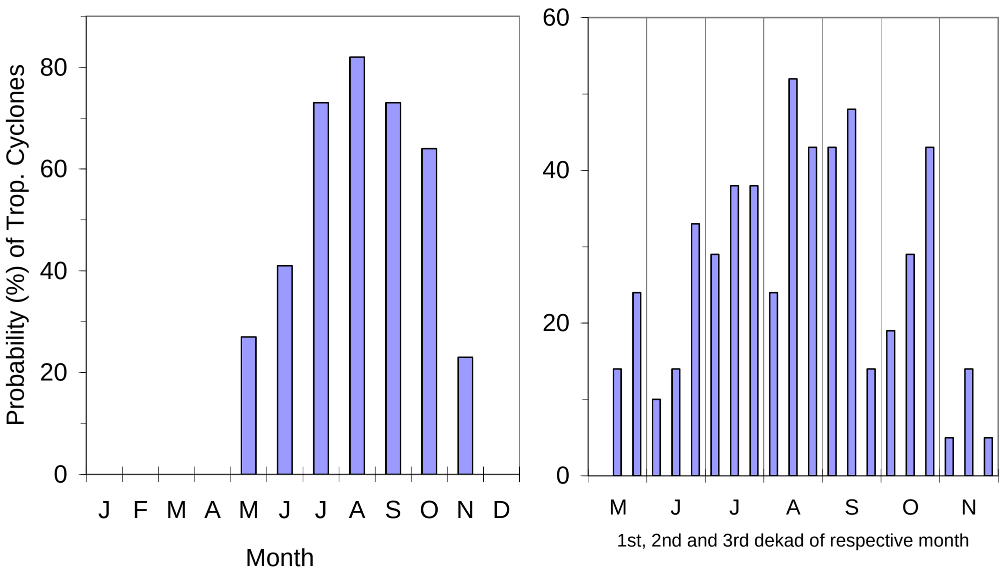


Figure 2.4.7a,b Probability of tropical cyclones in Ilocos Norte at different months (a) and dekads of typhoon-prone months (b)

In Ilocos Norte Province, farmers prefer to grow vegetables during the dry season limiting the rice crop to the wet season only. Thus, the rice crop (July to Nov.) falls into the typhoon season that stretches from May to November. The probability distribution of typhoons shows a mono-modal shape with a peak (ca. 80 % probability) in August (Figure 2.4.7a). A higher resolved probability distribution based on dekads (i.e. 10d-intervals), however, reveals several disruptions of the mono-modal shape with individual dekads in June and October that have > 30 % probability of tropical cyclones (Figure 2.4.7b).

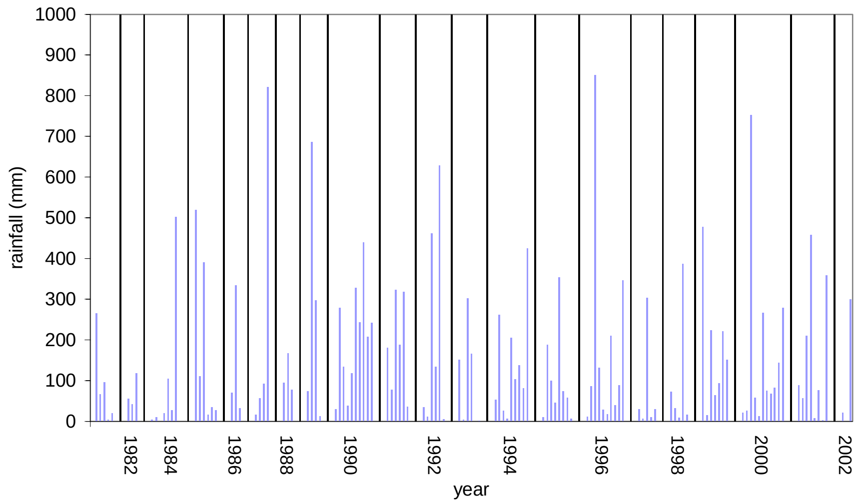


Figure 2.4.8 Rainfall of individual tropical cyclones in Ilocos Norte from 1981 to 2002

For individual years the number of tropical cyclones over the last two decades varied from 3 (in 2002) to 10 (in 1990). Likewise, the amount of rainfall brought by these typhoons showed substantial variation from effectively zero to up to 850 mm. However, neither typhoon frequency nor events of heavy rainfall were reflected in the yield development (Figure 2.4.9). More specific information on the damaging capacity of typhoons is expected from household surveys in Ilocos Norte which included specific questions about yield losses due to climatic variation.

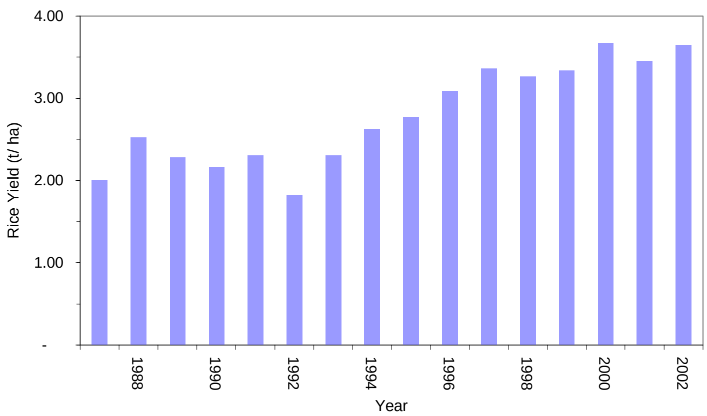


Figure 2.4.9: Rice yields of the wet season crop in Ilocos Norte from 1987 to 2002

2.4.3 Assessment 3: Risks stemming from temperature increase (Hangzhou and Hanoi)

Global mean temperatures have risen by 0.7 °C over the last century and are expected to rise further as a consequence of the anthropogenic greenhouse effect. The available models for predicting the regional impacts of global climate change indicate that temperature rise in Eastern Asia will even be slightly above global average. Although the projections of temperature increase differ in a wide range from 1 to 4 °C pending on the emission scenario used, it can be assumed that agriculture will have to adjust to these conditions for maintaining or increasing current yield levels.

Higher temperatures will also affect intensity and seasonality of rainfall, but the regional patterns of these changes are highly uncertain. Therefore a site-specific assessment of possible impacts of global warming and possible adjustment strategies can at present only consider temperature effects. In this analysis, we have selected climate records of years with relatively regular weather patterns in Hangzhou and Hanoi. Then, we have modified temperature records by adding 1 °C for the short-term scenario and 4 °C for the long-term scenario. In the next step, we have used the WOFOST model to assess yield responses.

Hangzhou

In Zheijiang Province, farmers typically grow an early (March to July) and a late rice crop (July to Nov.) per year. Temperature increase will not cause problems for early rice; yields may even slightly increase due to higher temperatures in springtime (Figure 2.4.10). For late rice, however, rising temperature leads to a gradual decrease in yields. Therefore, we have tested a possible delay in sowing dates to avoid temperature stress for early plant stages (Figure 2.4.11). Under +4 °C scenarios, yields can reach the same level as under present conditions as long as cropping dates are delayed by 50 d.

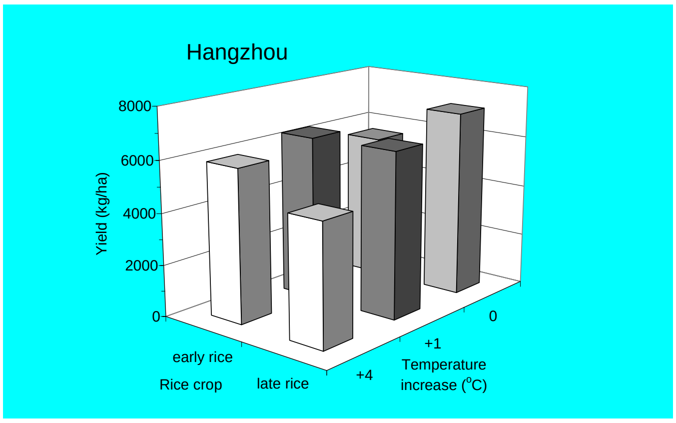


Figure 2.4.10
Yield response to temperature increase of 1 and 4 °C in early and late rice crop in Hangzhou

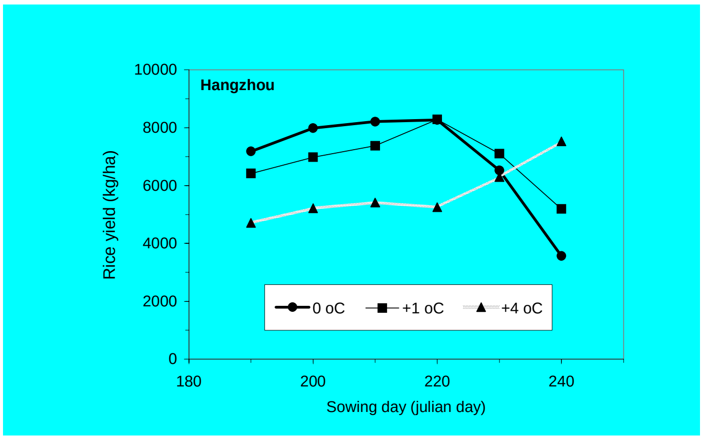
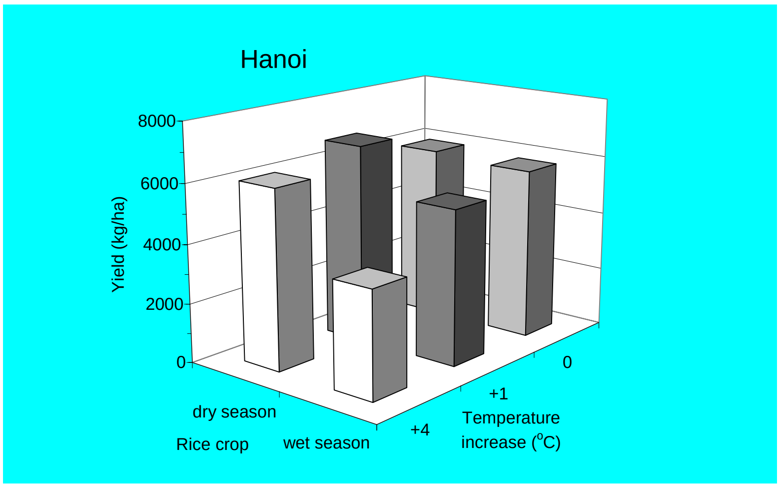


Figure 2.4.11:
Yield response to shifting of early and late rice crop in Hangzhou under temperature increase of 1 and 4 °C

Hanoi

The typical cropping pattern in the Hanoi region encompasses a dry season (Jan. to May) and a wet season (July to Nov.) rice crop. Yield simulation showed that dry season crop is only marginally affected by higher temperatures whereas the wet season crop is rather vulnerable (Figure 2.4.12). Yields in the wet season decrease by more than 30 % under +4 ^{o}C temperature scenario. Given a higher background level of temperatures as in Hangzhou, however, it can be assumed that the potential losses in Hanoi can also be compensated by adjustment of cropping dates to avert unfavorable temperatures for sensitive plant stages.

Figure 2.4.12
Yield response to temperature increase of 1 and 4 ^{o}C in early and late rice crop in Hanoi



2.4.4 Conclusion

In the four IRMLA case studies, climatic variations do not appear as a major driver for yield trends under present conditions. The case of typhoons in Ilocos Norte may present to some extent an exception from this assessment, but actual yield losses are not correlated to frequency or intensity of typhoons in a given season. Instead the damage capacity of typhoons seem to depend on specific attributes (timing, wind speeds?) of these events that require further in depth analysis to assess probability of yield damage under different cropping dates.

Rice production has to adjust to direct and indirect consequences of global climate change to maintain or increase current yield levels. While some effects of climate change cannot be forecasted on regional scale, e.g. changes in rainfall and storm intensities, other effects such as higher temperatures and rising sea levels can be predicted with a reasonable accuracy to explore adaptation strategies.

In the four IRMLA case studies, temperature increase will have to be taken into account for cropping dates to prevent yield losses. Rising sea levels represent a potential threat for rice production in Cantho, but the exposure to higher water levels will – apart from the actual sea level rise – depend on future development of the river/ canal system and possible infrastructure for flood prevention.

The outcome of this tentative analysis yielded cautionary as well as optimistic aspects: higher temperatures and sea level will impact rice production, but the adverse changes brought by global climate change can – at least to some extent – be averted or minimized by site-specific adjustment of cropping dates. More information on these adjustment strategies under the specific settings of each case study is expected in the remaining course of the IRMLA project.

3 Case study development

3.1 Securing Asia's future harvest - system-wide challenge illustrated by four different case studies

Rice-based ecosystems in East and Southeast Asia are heading for trouble. Food production must rise by 50% by 2025 to keep pace with rising populations and incomes. But crop yields have reached a plateau or are falling, while much of the best agricultural land is disappearing as the cities of the alluvial plains and river deltas expand. Each time a new factory or home connects to the urban water supply, it tightens the squeeze on irrigation, still a profligate user of the increasingly scarce resource. Soil fertility and structure are in decline as years of mono-cropping take their toll. And as crop diversification increases, pesticide pollution is getting more rampant, with dire effects on aquatic life forms as well as human health.

These alarming trends have long been known to scientists and policy makers. And so too have the answers, at least in theory. The grand strategy for lifting the region's agriculture out of trouble is to intensify still further, achieving higher yields from equal or lower levels of input. This will, among others, help to conserve forests and free up land for diversification out of rice and into more profitable and less 'thirsty'crops, thereby stimulating farmers to stay in business and saving water. At the same time, farmers must be persuaded to adopt cleaner production practices, that, for instance, substitute IPM practices for the excessive use of pesticides.

But there are two major difficulties in putting this strategy into practice. First, its generic prescriptions have to be broken down into solutions that are right for each location. This takes research – lots of it -- conducted locally in and with farming communities, to diagnose local problems and opportunities and to test the innovations that look most suitable. Second, once identified, these local solutions need to be extrapolated to the regional level, to find out where else they can be used and to identify the policy and institutional measures needed to support their transfer and adaptation. In other words, the region's decision makers face the classic challenge of scaling up and out: how to generate and disseminate the detailed knowledge needed to enable millions of small-scale producers to change their farming practices for the better.

In September 2000, Alterra Green World Research of Wageningen UR submitted a project proposal to EU-INCO-dev , 5th framework programme on behalf of four European and four Asian pratners that would address sustainable resource use and design of innovative innovative land use systems at different scales (farm to region). The project, entitled >> Systems Research for Integrated Resource management and Land Use Analysis in East and South-east Asia (IRMLA) << would use a combination of modelling approaches such as farm household modelling and regional mulitple goal linear programming, and a range of component models/tools (such as crop simulation models, expert systems and GIS) to evaluate land use in contrasting environments, propose new options,

analyse feasibility of new technologies and promising policy interventions and engage in a dialogue with policy makers, farmers and other stakholders.
Besides its research goals, the project has an implicit institutional goal: to get its analytical methods widely adopted and/or further tailored to local conditions by national institutions. The means to this end is a networking arrangement that ensure the exchange of knowlegde between EU and Asian scientists and local stakeholders. Coordinated by Alterra, Wageningen UR, the network would link four national research institutes – in China, Philippines and (two) in Vietnam-- that had already demonstrated their commitment to the use of a systems approach and quantitative tools to the analysis of land use and resource management.

3.2 Case study development for Pujiang, Zhejiang province

3.2.1 Introduction

The IRMLA approach has been applied to Pujiang county in Zhejiang province, P.R. China. The main accomplishments during the last year are highlighted. These are:

a. identification and delineation of homogeneous land units that have similar land qualities and suitability for specific land use types, and determination of the areas of suitable lands for different land use types in the whole county;
b. farm household survey
c. training workshops at Zhejiang university
d. training workshop at Wageningen university
e. first results of MGLP land use analysis
f. stakeholder’s consultations

First, the land unit delineation for Pujiang is described. This delineation of land units has been based on available digital maps using GIS technology (ARCVIEW) for Pujiang County.

3.2.2 Definition of land use types

Definition and identification of land use types is based on three criteria, i.e. crop rotation, yield levels and production technologies. The land use definition for Pujiang county has taken into account the current agricultural practices, present land use problems and regional development objectives. Table 3.2.1 gives the land use types (i.e. crop rotations) that are representative and currently practiced in Pujiang. In total, 13 types of crop rotations were selected for Pujiang, for producing food grains and vegetables and for generating income. Most of the crop rotations are practiced under irrigated conditions. Rainfed cropping is limited to the hilly and mountainous areas, comprising mainly non-rice crops. Based on current practices and biophysical conditions of Pujiang, three production technologies were distinguished (Table 3.2.1). These technologies differ with respect to the degree of mechanization. Tree crop, livestock and fishery productions are promoted by the local government, to increase income of rural population. Table 3.2.2 presents the major types of tree crop, livestock and fishery production systems that are currently practiced or are to be introduced in the near future (e.g. cows) in Pujiang county.

Table 3.2.1 Selected crop rotations and production technologies for Pujiang county

Code	Crop/rotation types	Irrigated	Rainfed	Tech1 [1)]	Tech2	Tech3
OR	Oil seed – single rice	y [2)]	n [3)]	y	y	y
RR	Early rice – late rice	y	n	y	y	y
sR	Single rice	y	y	y	y	y
VR	Vegetables – single rice	y	n	y	y	y
MR	Watermelon – late rice	y	n	y	y	y
WMR	Wheat – watermelon – late rice [4)]	y	n	n	y	y
BP	Soybean – sweet potato	n	y	n	y	y
cVR	Chinese vetch – single rice	y	n	y	y	y
oV	Outskirt Vegetables	y	n	n	n	y
BCV	Soybean/sweet corn – vegetables [5)]	y	y	n	n	y
mV	Mountain vegetables (Radish, eggplant, kidney beans）	y	y	n	n	y
SS	Sorghum – sorghum	n	y	n	n	y
PC	Potato – sweet corn	n	y	n	n	y

[1)] Tech1: land preparation (plowing) and harvesting by machinery without use of draught animals; Tech2: all farming operations by hand except for land preparation (by machinery); and Tech3: manually without use of machinery and land preparation by draught animals

[2)] y = suitable/considered

[3)] n = not suitable/not considered

[4)] Wheat is just for producing residues used for the following watermelon

[5)] Soybean and sweet corn are intercropped.

Table 3.2.2 Tree crop, livestock and fishery production systems for Pujiang county

Fruit trees	Livestock	Fishery
Grape, Orange, Tea, Sweet pear, Chinese plum, Ornamental trees, Bamboo, Jujube, Chinese nut, Citron, Gingkgo	Pigs, Goats, Chicken, Duck, cow, Rabbit	Fish, Shrimp, Turtle, Pearl

3.2.3 Suitable land units

Six land units were identified with their degree of suitability for different land use types (Table 3.2.3), based on four criteria, i.e. land accessibility, irrigation water availability, surface relief (slope and elevation), and soil properties. For all suitable land units, it was assumed that the distance to villages should be less than 1 km. Lands under forests were excluded, because of their high conversion costs for growing food or tree crops, the potential risk of soil degradation by such land use conversion, and the resulting conflict with the current national policy.

Table 3.2.3 Land units in Pujiang county and their suitability for the identified land use types

Code	Land unit	Brief description	Suitability
APC	Alluvial plains, clay paddy soils	Elevation < 150 m, flat lands, deep and clay soils; irrigation systems available	Suitable for all land use types except for tea
APL	Alluvial plains, loamy paddy	Elevation < 150 m, flat lands, deep and loam soils; irrigation available; high	Suitable for all land use types except for tea

	soils	groundwater table	
AFL	Alluvial flats, loamy paddy soils	Elevation generally below 300 m in river valleys; deep and loam soils, irrigation systems available	Suitable for all land use types except for tea
HPC	Hillocks & piedmont, clay red soils	Altitude < 150 m, flat to gently sloping (slope < 6 degree); no irrigation systems available	Suitable for all rainfed cropping systems and all tree crops
GSL	Gentle slope lands, sandy red soils	Altitude generally between 150 and 600 m; sand loamy soils, flat to gently sloping (slope generally < 6 degree)	Suitable for rainfed cropping systems and all tree crops
SSL	Steep slope lands, sandy red soils	Hillside slopes, slope gradient generally between 15 and 25 degree and altitude between 150 and 600 m	Only suitable for tree crops, not suitable for annual crops and grapes due to erosion risks
USL	Unsuitable lands	Lands under forests, shallow soils, steep land (slope > 25 degree), lands with an altitude of above 600 m or the distance to residence areas exceeding 1 km Also, water surfaces, built-up areas and roads	Not suitable for all the identified land use types

Three basic digital maps were used to delineate the suitable land units, i.e. land use, soil and topographic maps. These maps have the same scale of 1: 50 000, and have been converted into GRID format with the cell size of 20 m * 20 m. The delineation of land units comprises the following steps:

Step 1: Identification of potentially suitable lands based on current land use (i.e. land use map for year 2000).

The land use map of Pujiang differentiated between 33 land use types, including farmlands (5 types) and tree crop lands (6 types), forest/shrub lands, grasslands, water surface, built-up and transportation land, etc. These land use types were grouped into three categories (Table 3.2.4, Figure 3.2.1). Category 1 comprises all farmlands with irrigation available. Category 2 includes uplands currently used for growing annual and tree crops, and lands under shrubs and grasses. The remaining land use types are grouped into Category 3, including forest lands, built-up lands, water surface, etc., which are considered unsuitable for agricultural use.

Table 3.2.4 Land use categories in Pujiang county

Code	Inclusions	Comments
1	Farmlands with irrigation available, including lowland rice field, irrigated non-rice cropland and vegetable lands	Flat lands, distributed in plains and valleys
2	Farmland without irrigations; lands under tree crops; shrub lands and grasslands	Uplands, flat to steeply sloping. No irrigation available
3	Other lands including forest lands, water surfaces, built-up and transportation lands	Excluded for agricultural use

Step 2. Classification of slope and altitude

For slope and altitude, respectively, four classes were distinguished (Table 3.2.5), based on the digital elevation map (DEM) generated using the topographic map. Figure 3.2.2 and Figure 3.2.4 present the maps of Pujiang with the classification results for slope and altitude, respectively.

Table 3.2.5 Classes of altitude and steepness in Pujiang county

Code	Altitude zones (m)	Slope (degree)
1	< 150	< 6
2	150 – 300	6 – 15
3	300 – 600	15 – 25
4	> 600	> 25

Step 3. Calculation of distance zones to villages/towns

The distance to villages/towns was used to roughly indicate land accessibility. The distance was calculated with the following steps using ARCVIEW:

- Firstly, villages and towns were extracted from the land use map using Map Query command
- Secondly, the distance zones were calculated using the BUFFER command. In this case, a distance of 500 m for each zone was used
- The distance zones were converted into GRID format using the command CONVERT TO GRID. The grid map was reclassified into three zones using the RECLASSIFY command: < 500 m, 500 – 1000 m and > 1000 m (Figure 3.2.7).

Step 4. Determination of suitable land units and area

Suitable land units are feasible combinations of the above factor maps, and are calculated using the Map Calculator command of ARCVIEW with following steps:

- Overlay the land use map (Figure 3.2.1) and the slope map (Figure 3.2.2) to add slope characteristics to each of the three land use categories, using Map Calculator of ARCVIEW. The combinations that are not suitable (e.g. combinations of land use category 3 with different slope classes), were grouped into one type (coded as 99) using RECLASSIFY command (Figure 3.2.3).
- Overlay the newly generated map (Figure 3.2.3) with the altitude zone-map (Figure 3.2.4). Next, reclassify the new land use-slope-altitude map, and obtain a new map (Figure 3.2.5).
- Following the same procedure, soil (Figure 3.2.6) and distance zone (Figure 3.2.7) information was added, resulting in Figure 3.2.8. For the flat areas (Figure 3.2.2), the generated units in Figure 3.2.5 were subdivided into loamy soils and clay soils, whereas for the mountainous areas no further division was done (soil properties can be visually derived from soil map). Overlaying of distance zones is to exclude the land areas with a distance in excess of 1 km from villages/towns.
- The finally generated map (Figure 3.2.8) was reclassified into 7 types (Figure 3.2.9). Based on this last map and the township map, land unit areas for each township were obtained (Table 3.2.6) with command Tabulate Areas of ARCVIEW.

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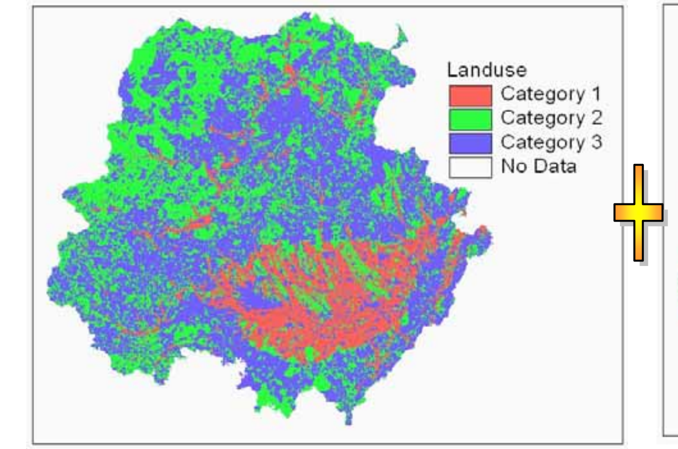


Figure 3.2.1 Land use map for Pujiang county

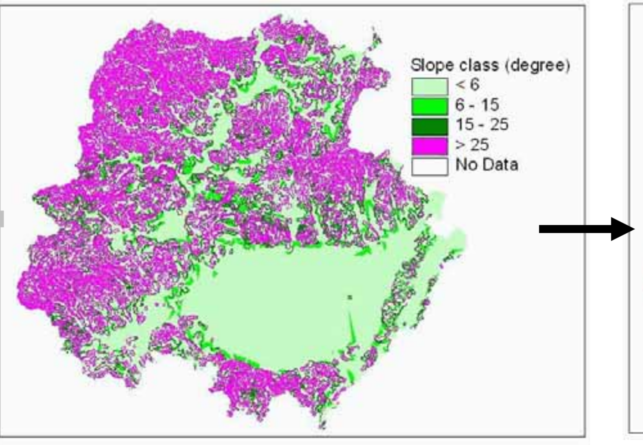


Figure 3.2.2 Slope map for Pujiang county

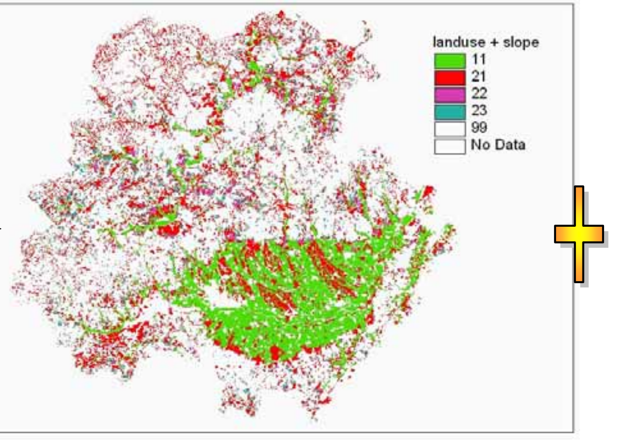


Figure 3.2.3 Combinations of land use and slope

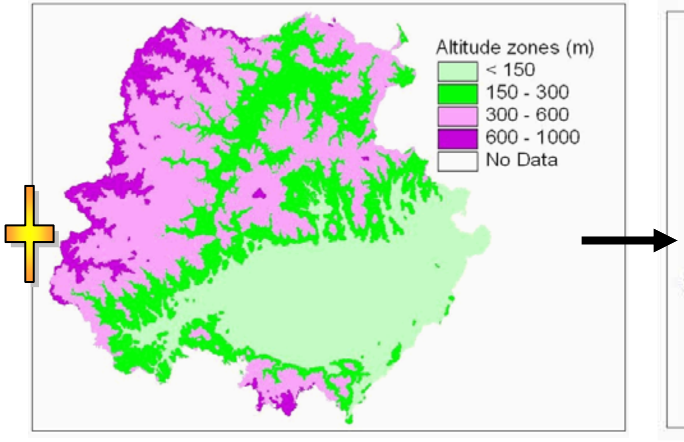


Figure 3.2.4 Altitude zones for Pujiang county

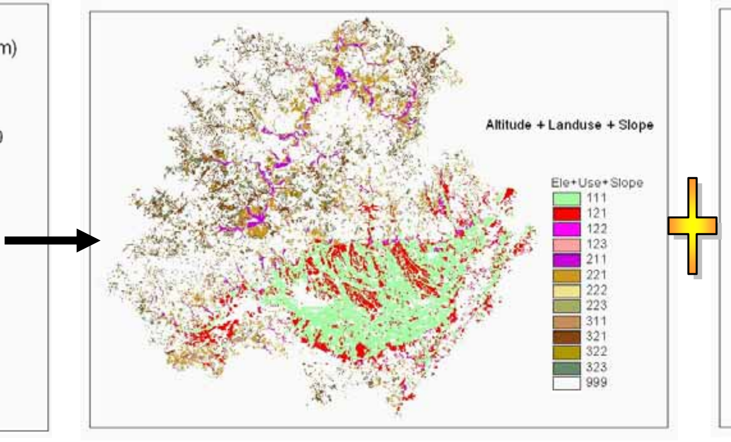


Figure 3.2.5 Combinations of altitude, land use and slope

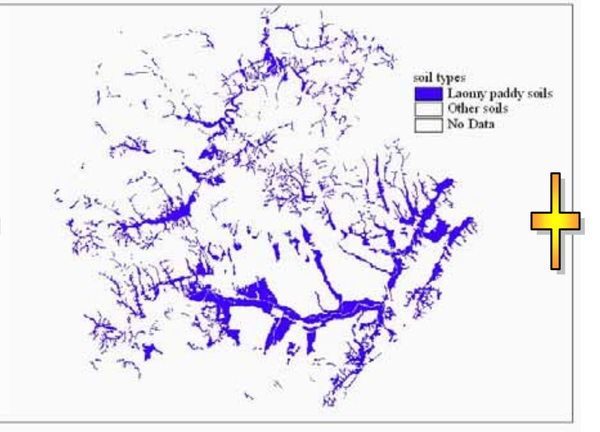


Figure 3.2.6 Paddy soils with loamy texture extracted from the soil map

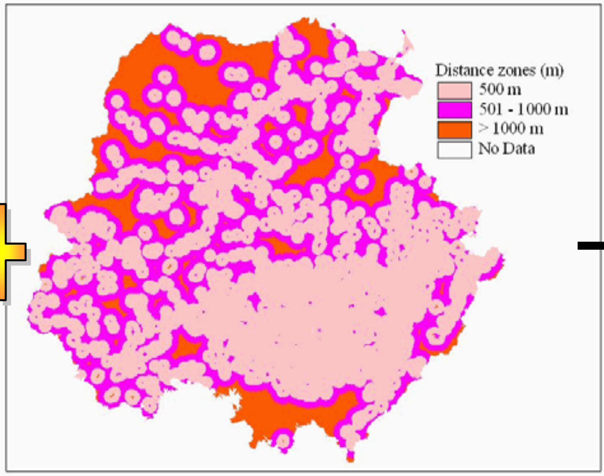


Figure 3.2.7 Distance zones to villages

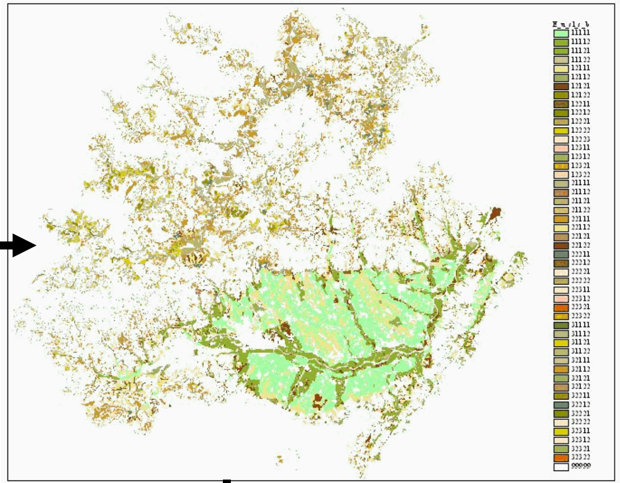


Figure 3.2.8 Combinations of altitude, land use, slope, soil and distance zones to village for Pujiang county

Reclassification and editing

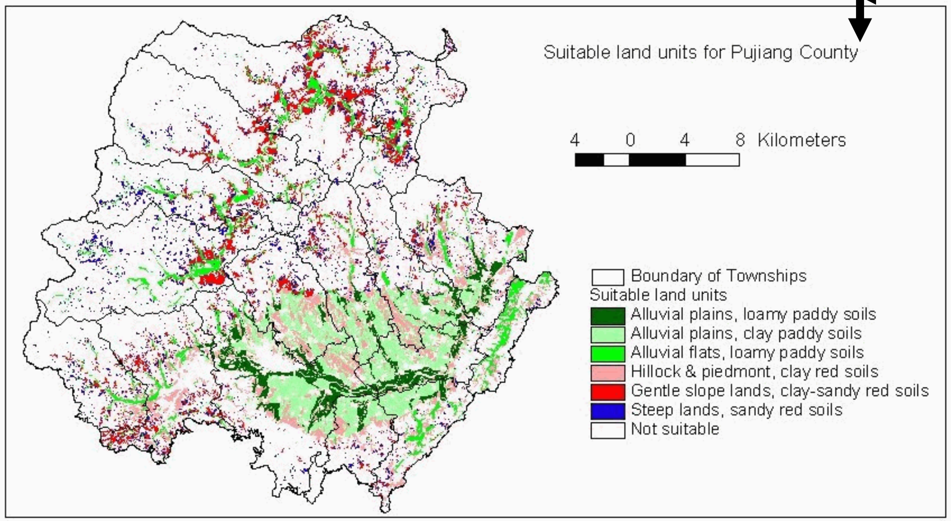


Figure 3.2.9 Final land unit map for Pujiang county

Table 3.2.6 Area (ha) of land units per township in Pujiang county

Townships	Alluvial plains, clay soils	Alluvial plains, loam soils	Alluvi-al flats	Hillocks & pied-monts	Gentle slope lands	Steep lands	Unsuited lands	Total land
TANGXI	0	0	472	0	1503	811	8033	10819
ZHENGZHAI	716	222	76	515	135	137	2363	4164
HANGPING	0	0	530	0	1423	797	6425	9177
ZHONGYU	0	0	208	0	794	397	2805	4204
DAFANG	0	0	229	0	982	386	7133	8730
QILI	890	147	49	598	334	251	2164	4433
HUAQIAO	0	0	160	150	372	186	3430	4297
YUZHAI	0	0	278	0	704	534	3831	5347
BAIMA	219	304	280	698	230	239	3965	5935
PUYANG	1635	1279	105	975	136	169	4949	9247
YANTOU	793	159	115	562	296	256	2745	4927
QIANWU	19	37	297	486	665	272	4449	6226
HUANGZHAI	1068	560	11	416	0	22	1059	3135
PANZHAI	499	134	7	297	25	74	1615	2652
ZHENGJIAWU	0	0	460	318	0	33	1341	2152
ZHIPING	478	133	247	421	58	93	1719	3147
Pujiang county, total	**6316**	**2975**	**3524**	**5436**	**7659**	**4656**	**58027**	**88593**

3.2.4 Farm household survey

Based on the land use map of Pujiang (Figure 3.2.1), we conducted a farm household survey from November 2002 to February 2003 to improve the understanding of the current land use, resource use efficiencies, farmer's economic situation, and the impacts of current agricultural systems on future development possibilities and sustainability. We organized three survey groups composed of one research team member, one staff of the Agricultural Bureau of the county, and one technician of the relevant township. A total of 106 farmer households representative for the main cropping systems, technology levels and social economic status, were selected for the survey. These households were distributed quite evenly over the 16 townships of Pujiang. Detailed information of each farmer household was collected on the basis of the "Farmer household survey form" provided by Dr. Marrit van den Berg, Wageningen University.

The data obtained from the farmer household survey were checked and re-checked with the farmers surveyed and with local experts. First impressions from the survey were that the pure rice farmers can only get a very low annual income and that the farmers are generally in bad need for more knowledge, such as how to select more profitable agricultural systems, and how to improve the current technology of crop production. They usually complained about the low price for agricultural goods and the lack of capital to initiate new cropping systems. The farm survey database was established and subsequently used as a source for input data for the TechnoGIN analysis. TechnoGIN-3 (Section 2.2) is applied for producing input-output relationships for the main cropping systems on the different land units in Pujiang county (Figure 3.2.9).

3.2.5 Training workshop at Zhejiang University

The workshop was held from March 29 to April 4, 2003. Besides the research team members of the IRMLA project, the Deputy county magistrate Mr. Wu Guocheng, Director of Agricultural Bureau of Pujiang County, Mr. Huang Ting, Deputy Director of Agricultural Bureau of Zhejiang Province, Professor Xiao Dongsun, and the Deputy Dean and land management expert of College of Environmental and Resource Science, Prof. Wu Cifang, participated in the workshop. Prof. Xiao gave an introduction on the current agricultural production situation and the main development goals in the next 10 years, and emphasized the agricultural laws and policies of Zhejiang province. Mr. Huang Ting gave detailed information about the current land use, cropping systems and main agricultural products of Pujiang. He gave a clear description of the coming 5 and 10 years' development plan for the county.

The farmer household survey data were checked again and statistical analysis of the data was performed. We identified 24 cropping systems as the key systems in Pujiang. Under the supervision of WUR scientists, team members learnt to apply the TechnoGIN model and used it to analyse the input-output relationships of the main cropping systems in Pujiang. With the help of Dr. Lu Changhe, the regional coordinator of IRMLA project, we learned to use the MGLP model and started to build a first model for Pujiang and to define relevant scenarios. For more detailed information on this workshop, see Annex 6.

3.2.6 Training workshop at Wageningen University

This workshop was from September 29 to October 4, 2003. Three team members took part in the workshop, i.e. Prof. Wang Guanghuo, Dr. Wang Jiandi, and Mr. Fang Bin. The team members went through the TechnoGIN model and MGLP model, and produced technical coefficients for the main cropping systems in Pujiang county. The first results from TechnoGIN model calculations for the main cropping systems showed that the order of profitability was as follows (from high to low) : Vegetables >= Woody ornamentals > Fruits > Cash crop + Rice > Rice (Table 3.2.7). However, the most profitable cropping systems require high capital investment and improved production technology, and have more market risks, too.

The results from TechnoGIN model calculations were entered into the MGLP model and used to build a prototype MGLP for Pujiang. A MGLP run was done for maximizing profit and with constraints on the available land area, labor population, food (rice production), and other crop production. A sensitive analysis was done with the MGLP model, assuming different scenarios with different targets for development of Pujiang.

3.2.7 Stakeholder consultations

The first scenario analysis results were presented to the Agricultural Bureau of Pujiang and discussed. Discussions between scientists and officers from Pujiang indicated the required improvement of the scenarios. Zhejiang Province recently issued an official document to encourage every district to produce its own development plans. This means that agricultural areas that are particularly suitable according to their agro-ecological conditions and have potential advantages in market competition, are given special priority for their development.

During the visit of Prof. Herman van Keulen to Zhejiang University (October 27 to November 1), he met Mr. Wu Wenyi from Pujiang. Mr. Wu is responsible for drafting of a development plan for Pujiang. This resulted in good discussions on the Pujiang development plan for period 2003 to 2007. In the Pujiang plan, the main emphasis is on expansion of five agricultural systems: mountain vegetables, ornamentals, fruits, tea, and animal husbandry. For more information, see Annex 6. These five systems are all highly profitable according to the TechnoGIN analysis (Table 3.2.7). We evaluated this 5-year plan based on its suitability for Pujiang and provided GIS maps to the county. We emphasized that 50% to 100% self-sufficiency in food (rice) production in Pujiang should be taken into account, and also rice field conservation, market risks, and environmental impacts.

3.2.8 Subsequent steps in IRMLA research

1. Because animal production yields about 25% of the total agricultural GDP value in Pujiang, we need to conduct a more detailed farm survey on livestock systems before the next in-country training workshop in March 2004 and produce technical coefficients for livestock systems;
2. The area of woody ornamentals is increasing rapidly, and not only in Pujiang but also in the whole Zhejiang province. To collect more information on its input-output relationships, market risks, contribution to soil conservation, and its consequences for rice production sustainability, we will conduct a farm survey especially for woody ornamentals in Pujiang.This activity will be supported by PPO, Netherlands;
3. We will expand the databases for the MGLP model for Pujiang. The model will be refined and relevant future scenarios will be defined. This scenario development will take place with sufficient feed-back from the stakeholders.

Table 3.2.7 Profit (in Chinese yuan) from the main cropping systems in Pujiang county as calculated with TechnoGIN model

No	LUT	returns	profit	region return
1	Outskirt vegetables	125900	112326	118326
2	Woody ornamentals	118800	102666	113466
3	Sugarcane	110250	98628	106128
4	Mountain vegetables	109280	95392	101392
5	Pear	58500	52463	55163
6	Grape	52800	43838	49738
7	Vegetable-Single rice	43144	30937	38101
8	Jujube	31680	29358	30738
9	Tea	31920	17163	30663
10	Orange	30000	23594	28494
11	Chinese plum	28800	26570	28190
12	Wheat-Sweet Potato	23640	14134	21194
13	Potato-Corn	20820	13785	17735
14	Watermelon-Late rice	21327	9718	16296
15	Sorghum-Sorghum	17640	10762	14482
16	Wheat-Soybean	15270	8576	13386
17	Early rice-Sorghum	14519	7565	11325
18	Sweet corn-Late rice	13677	4356	9974
19	Oilseed-Single rice	11689	1107	9165
20	Early rice-Late rice	12625	2664	9130
21	Single rice-Pasture	12044	4450	9114
22	Soybean-Sweet potato	9450	3685	8055
23	Single rice	8044	2202	6066
24	Single rice-Green manure	8188	1615	5845

3.3 Case study development for Tam Duong, Vinh Phuc province

3.3.1 Stakeholder discussions

Discussions with stake-holders have been organized. The main problems and development objectives for the Tam Duong district have been discussed which resulted in the following lists.

Main problems in district:
1. Poor soils
2. Limited irrigation systems
3. Poverty
4. Low education
5. Marketing
6. Land/labour ratio very low (500m^2 per capita)
7. Post harvest
8. Policy
9. Bad quality of vegetables

Main objectives for development of district:
1. Improved irrigation systems
2. Improvement of quality of product so that it can be exported
3. promote marketing cooperatives
4. training especially for INM & IPM
5. reduction of environmental pollution
6. diversification / specialization of agricultural production
7. increase in livestock production
8. increase in income

This leads to a number of planned changes in the agricultural system, as shown in Table 3.3.1:

Table 3.3.1 Objectives for structural changes in agricultural production

	Year 2001	Year 2005
Crop production (%)	64	48
Livestock (%)	25.6	35-38
Fishery (%)	2.9	7-8
Forestry (%)	7-8	15
Cash (US/ha)	280	350-400?

In more detail, the future objectives are:
- decrease in crop production but increase in livestock production
- 6 main commodities (rice, maize, mulberries, vegetables, fruit trees, flowers)
- to produce 400,000 t grain food per year (i.e. mean yield level of 5.3 t/ha for rice and 4.1 t/ha for maize)
- 3000 ha of mulberries in total (increase from current 2000 ha)
- 500 ha with flowers and bonsai

- 60-100 ha with environment-friendly produced (organic) vegetables
- 1000 ha tree cultivation (forestry)
- 1500- 2000 ha for fish and shrimp with 20,000 t total annual production
- 10,000 cows and 10,000 pigs in 2020
- 2313 billion VND income value per year from agriculture and fishery after 2005
- change from 64% of relative income from crop production to 48 - 50% after 2005

3.3.2 Background information on present and future situation in Tam Duong

An overview of the present land use and the planned changes in land use in Tam Duong are given in Table 3.3.2.

Table 3.3.2 Current situation and plans for future land use (in ha) in Tam Duong district

Index	2001	2010	2020
Natural land	19,799.99	19,799.99	19,799.99
I. Agricultural land	8,035.91	8,124.46	8,024.46
a. Annual crop cultivation land	6,137.60	5,780.76	5,940,76
1. Rice + Rice and upland crop		5,419.39	5,374.34
- 3 crop land		1,467.05	1,467.05
- 2 crop land		3,898.08	3,848.08
- seedbed land		54.26	54.26
2. Perennial plant cultivation land		561.37	
- Multiple plant garden	1,055.59	179.69	174.69
- Perennial tree cultivation land	636.28	2,333.50	2,173.50
II. Forest land	6,844.07	7,454.44	7,445.44
III. Land for special purpose	2,511.64	2,782.31	2,882.31
IV. Resident land	861.16	927.28	1,047.28
V. Unused land	1,627.71	400.5	400.5

[1] the change in land use at present is given in Table C-16.

More detailed information on arable cropping areas and food production in Tam Duong is given in Table 3.3.3.

Table 3.3.3 Arable cropping areas and food production in Tam Duong district

	Area / production
Total cultivated area	15401 ha
Food crop area	13246 ha
Rice crop area	9483 ha
Maize crop area	2239 ha
Rice yield	4.65 t/ha
Maize yield	3.32.t/ha
Foodstuff crop area	1143 ha
Production	10500 t
Short duration industrial crop	1200 ha
Total production of grain food crop	50000 t

Quantity of grain food / capita	400 kg
Income per ha of arable land	22.5 million VND

The targets for the future agricultural production and resulting income are given in Table 3.3.4. The present socio-economic characteristics of Tam Duong are given in Table 3.3.5.

Table 3.3.4 Targets for future agricultural production in Tam Duong district

Year / Index	2005	2010	2020
Agricultural growth rate (%/year)	5-6	4.5-5	4
Agricultural income per total income (%)	47	44	40
Production of grain food (t)	58000	68000	80000
Income per capita (USD/year)	280-300	350-400	550-600
Income per ha arable land (million VND)	28-30	35-40	50-60
Coverage by forest (%)		35	40

Table 3.3.5 Socio-economic characteristics at present in Tam Duong district

No. of village	16
Small town	1
Population	123 670
Population density	625 persons / km^2
No. of ethnc groups	10
Kinh and San Diu ethnic groups	99.4 %
Population growth rate	1.98 %
Poor households	13.5 %
Malnutrition of children	29.7 %
Working labor per total labor rate	88.7 %

3.3.3 Land use types

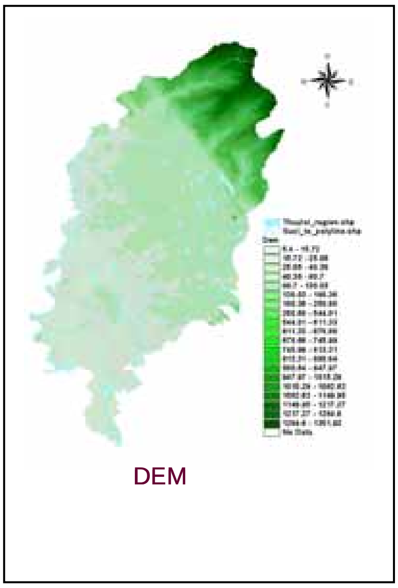
The main land use types (or crop rotations) in Tam Duong district are given in Table 3.3.6. For each of these land use types the input-output relationships are calculated for the suitable land units (see Section 3.3.4). The inputs are the amounts of labour, machinery, capital, fertiliser nutrients, biocides and water that are required to attain a current or future target yield level on a specified land unit. Outputs are this yield level but also environmental pollution and other consequences of this production activity. These input-output relationships have been calculated with TechnoGIN (see Section 2.2) for Tam Duong, but are not shown here.

Table 3.3.6 Main land use types in Tam Duong district

TT	Land use types
1	Rice - Rice - WMaize
2	Rice - Rice - WSoybean
3	Rice - Rice - WVegetable
4	Rice - Rice - WGroundnut
5	Rice - Rice - Rice
6	Peanut - Rice - WMaize
7	Peanut - Rice - WVegetable
8	Peanut - Rice - WPeanut
9	Peanut - Rice - WSoybean
10	Vegetable - Rice - WVegetable
11	Vegetable - Vegetable - WVegetable
12	Maize - Maize
13	Maize - WSoybean
14	Rice - Fish
15	Fruit tree (longan, litchi, mango, pineapple)

3.3.4 Land units in Tam Duong

Basic maps (soil, climate, DEM) were generated for land resource evaluation for Tam Duong district (Figures 3.3.1 and3.3.2). These map were combined to produce a digitized land unit map for Tam Duong district (Figure 3.3.3). This map comprises the main natural characteristics that determine the suitability and limitations for crop production.



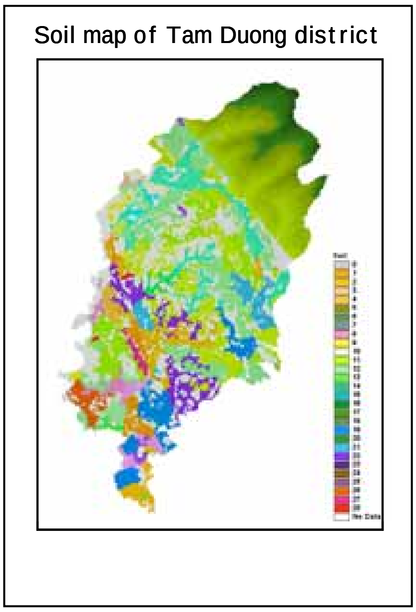


Figure 3.3.1 Maps for Tam Duong district: a) Digital elevation model (DEM), b) Soil Map

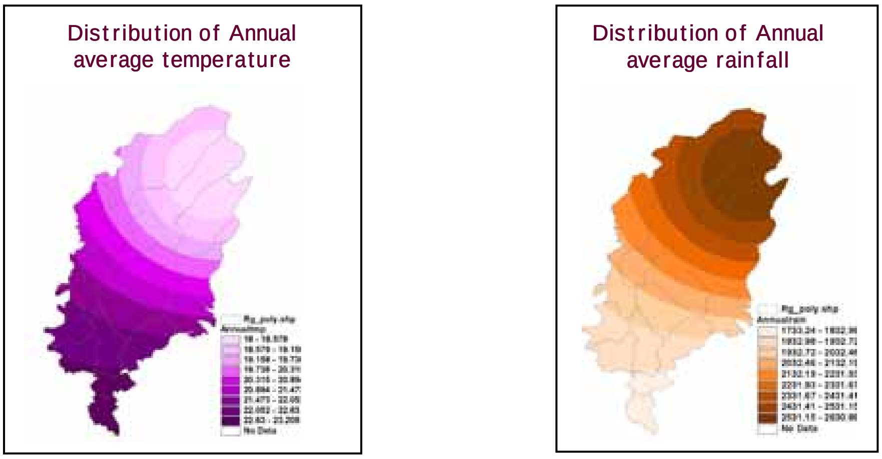


Figure 3.3.2 Maps for Tam Duong district: a) Annual mean temperature map, b) Annual mean rainfall map.

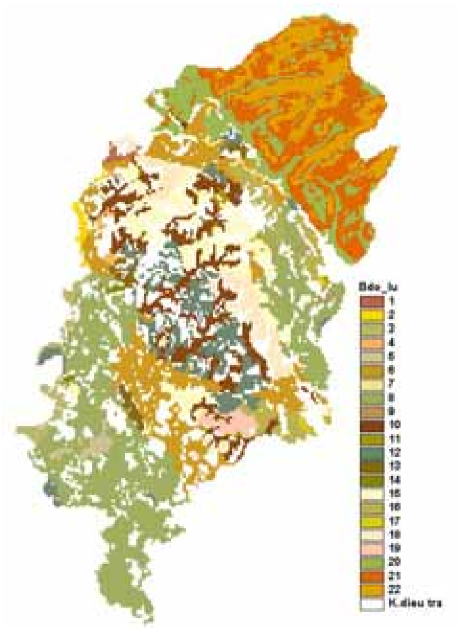


Figure 3.3.3 Land unit map for Tam Duong district

3.3.5 MGLP model for Tam Duong district

To analyse the possible decisions on land use and agricultural production activities and their consequences for food production, income, environmental pollution and labour demand in Tam Duong district, an MGLP model has been developed. The included production activities are characterized by their input-output relationships (Section 3.3.3).

The problems and regional objectives as identified by stakeholders in earlier consultations were the following:

Overall strategy	Direct objectives	Comments
- Develop sustainable agricultural system - Industrialization/modernization - Diversification/specialization within the region	- Increase income (farmers'and regional) - Increase production and quality of products - Improve quality of natural resources - Reduce poverty	- Economic growth - Food self-sufficiency - Environmentally sound cultivation practices - Environmental protection - Poverty eradication

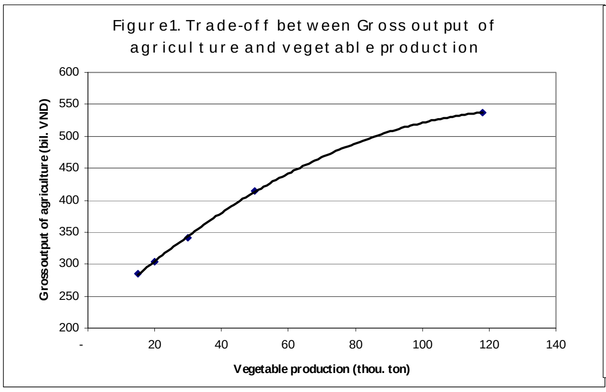
Results from a first MGLP analysis

In this analysis, increasing food production and income generation were assumed to be the major future objectives, whereas limitations were set on the maximum availability of water, labor and capital. The first results are shown in Table 3.3.7. Maximizing income results in a strong increase in the vegetable production area.

Table 3.3.7 Consequences for land use in Tam Duong district of maximizing income from agriculture (with actual production targets for 2001 imposed as goal restrictions) in comparison to the actual land use in year 2001 in the district.

No	Item	Unit	2001 (actual)	Model
1	Spring rice	ha	4.243	3.474
2	Summer rice	ha	4.960	5.434
3	Corn	ha	2.015	1.572
4	Cassava	ha	300	231
5	Groundnut	ha	390	290
6	Soybean	ha	503	382
7	Greenbean	ha	10	6
8	Fruit (litchi, longan,mango, pinneapple)	ha	1.233	600
9	Tea	ha	28	11
10	Potato	ha	3	2
11	S. Potato	ha	1.386	586
12	Taro	ha	14	12
13	Vegetables	ha	823	9.566
14	Sugarcane	ha	121	103
15	Meat (pork)	ha	-	-

The consequences of increasing applications of fertilisers nutrients and of changes in land use (i.e. more vegetable cropping area) on the gross output of agriculture are presented in Figure 3.3.4.



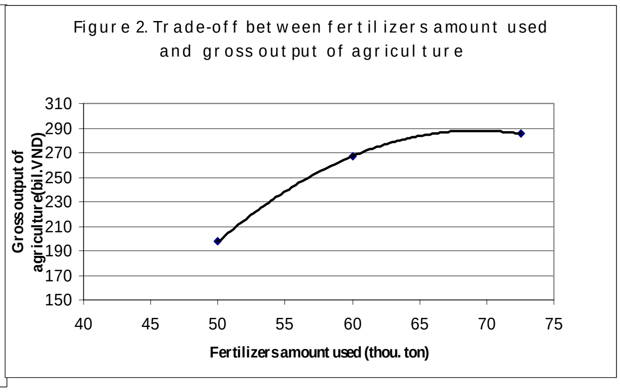


Figure 3.3.4 Trade-offs between gross output from total agriculture and vegetable crop production (left) and applied amount of fertilisers (right).

3.4 Case study development for Dingras/Batac, Ilocos Norte province

3.4.1 Introduction

It is common knowledge that the Asian regional currency crisis has seriously slowed down economic growth in the Philippines resulting in decreased foreign investments, increased inflation rate, drop in the stock market, closure of certain business and created unemployment problems. Nevertheless, such crisis also opened opportunities for potential agro-industrial growth.

Going into the food security business is one of the opportunities and answers of the leadership in the province of Ilocos Norte to mitigate the adverse effects of the economic recession. However, hand in hand with industrialization is increased demand for alternative land uses such as recreation parks and tourism areas.

In view of the above, the agricultural sector now faces conflict/competition for scarce natural resources particularly land and water. This is evident in the provincial development plan, which include conversion of some areas into tourism areas and expansion as primary and secondary urban centers. At present, land conversion is still within the allowable annual rate of 10% in Batac and 5% Dingras. However, the conversion does not spare the identified strategic agriculture and fisheries development zones (SAFDZ).

This accomplishment report highlights the farm household model that was developed for optimizing resource use of representative agricultural households in Dingras, Ilocos Norte. It also highlights the processes/procedures that were undertaken such as household survey, farm typology/classification as well as stakeholder's consultation meetings.

3.4.2 Locale of the Project

The province of Ilocos Norte, Philippines is geographically located between 17°48' and 18°29' north latitude and 120°5' and 120°58' east longitude occupying the coastal plain in the northwestern corner of the island of Luzon. It has a total land area of 0.34 million ha, more than one-third of which (129,650 ha) can be classified as agricultural land. The climate is classified as Type 1 characterized by a distinct dry and wet season, i.e., predominantly dry from November to April and wet season from May to October with a mean annual rainfall of about 2000 mm. The province experiences frequent strong typhoons and interspersed dry spells during the wet season.

Ilocos Norte is a second class province consisting of one city and 22 municipalities among which are the municipalities of Dingras and Batac. The present agricultural system can be characterized as highly diversified and intensified. Both municipalities are mainly agricultural and located within the Central lowlands of Ilocos Norte.

Batac has a total land area of 16,100 while Dingras has 17,362, more than 50% of which are classified as agricultural land (Table 3.4.1). In terms of population, Batac has 47,682 which is increasing annually at the rate 0.94% (Table 3.4.2). Total number of households is 9,601 majority (7,108) of which are classified as rural. On the other hand, Dingras has 33,310 with an annual growth rate of 1.93%. Total household is 6,921 with the majority also classified as rural. Available manpower per household for both municipalities is 4.

Table 3.4.1 Land and Water Resources of Batac and Dingras, April 2003.

Land Resources[1]	Towns	
	Batac	*Dingras*
Total area (ha)	16,100	17,362
Agricultural	8,313	9,549
Firewood & Pastures	5,100	-
Forest & Forest Reserve	2,036	-
Water Resources[1]		
SWIPs	4 locations	-
Lakes	4 locations	-
Dams	7 locations	-
Diversion Dams	29 locations	-
SFRs	737 locations	-
Fishwater Ponds		
SFRs (ha)[2]		14

[1] Source: as reported by MAO during the workshop
[2] Collectively but in different locations

Table 3.4.2. Population Characteristics of Batac and Dingras.

Population Characteristics	Batac	Dingras
Total Population	47,682	33,310
Urban	11,408	6,353
Rural	36,274	26,957
Population Growth (%)	0.94	1.93
Number of Households	9,601	6,921
Urban	2,493	1,302
Rural	7,108	5,619
Available Manpower (person/household)	4.0	4.0

Source: Provincial of Ilocos Norte Development Plan

3.4.3 Stakeholder's Consultation Workshop

The workshop was conducted in Mariano Marcos State University (MMSU) Batac, Ilocos Norte, Philippines last April 7-11,2003. The workshop was participated by MMSU officials and researchers, IRMLA collaborators (from Wageningen University, IRRI, UP Diliman), Provincial Planning and Agricultural Officers, MAO officers, agricultural technicians, farm leaders and NGO representatives.

The workshop objectives were presented by IRMLA collaborator (H. van Keulen) from WUR. These are as follows:

- To consult with the stakeholders on land use and resources management issues, with particular attention to regional development goals, priorities of different stakeholders, policy views and measures, future scenarios, objectives and constraints;

- To present capabilities of the methodology and data requirements and discuss the procedure of exchanging data and results;\
- To foster collaboration between the Philippine and European IRMLA teams by working together in the design and integration of the components of a decision support system for multiscale land use planning

The Provincial Planning Officer (PPO) presented the various land uses in the province as well as the alternative spatial strategies that were developed. These include:

1. 2003 trend or “Do Nothing”
2. Alternative 1 – Agri-industrialization
3. Alternative 2 – Eco-cultural tourism
4. Alternative 3 – Agroforestry

According to the PPO, a combination of Alternatives 1, 2 and 3 is preferred. It is hoped that this will augment employment opportunities in the province.

Among the issues raised was agricultural land conversion. The PPO mentioned that existing conversion rate is minimal along the roadside and not much in the interior. Nevertheless, prohibition is the conversion of SAFDZ to other uses is not yet fully implemented.

For land use issues specific to Batac and Dingras sites, these were presented by the respective Municipal Agricultural Officer (MAO). These are summarized in Table 3.4.3.

Table 3.4.3. Land use issues and development goals in Batac and Dingras, Ilocos Norte.

Site	Land Use Issues	Development Goals
Batac	Crop diversification both in the dry and wet seasons High use of agricultural chemicals and groundwater in the dry season Water pollution by nitrates and pesticide residue Agricultural land conversion to urban use Establishment of and integration of fish culture in SWIP, dams and SFR	Agro-industrialization through crop and market zonification and putting up of agri-based industries and scouting of market outlets of farm produce Reduce risk due to drought by establishment of SWIPs, dams and SFR Adoption of environmentally-friendly technologies such as balanced fertilization and IPM Increase farmers income
Dingras	Crop diversification in the dry season and farm mechanization Agricultural land conversion to urban use Agricultural land conversion to fish ponds due to promotion of fish culture	Agro-industrialization Sustain status as an exporter of rice Increase farm income Reduce production inputs through IPM, labor saving technologies and use of BT corn

3.4.4 Farm Typology

A farm survey was carried out in 15 villages. In total, 146 households were interviewed. The interviews included the following topics:

1. Household characteristics (composition, age, educational level, occupation)
2. Land use and agricultural production
3. Land utilization
4. Input-output
5. Livestock production
6. Disposal of production (consumption, paid for loans, sold, given away)
7. Marketing
8. Employment and income
9. Assets other land
10. Expenditures
11. General assessment of the economic status of the household

Dingras

The household were grouped into relatively homogenous groups (farm typology using cluster analysis). The variables used in the cluster analysis were:

a. total hectares of farm land
b. proportion of farm area with surface irrigation throughout the year
c. proportion of farm area with good drainage
d. total farm assets in monetary terms (pesos)
e. number of economically active household members

Based on the cluster analysis, there were four farm types (FTA, FTB, FTC, and FTD) identified, the characteristics of which are summarized in Table 3.4.4.

Table 3.4.4 Characteristics of representative farm households, Dingras, Ilocos Norte, Philippines.

Parameter	**Farm type**			
	FTA	**FTB**	**FTC**	**FTD**
Total farm area (ha)	0.92	1.07	1.63	0.83
Own farm (ha)	0.24	0.22	0.23	0.05
Share cropped (ha)	0.68	0.85	1.4	0.78
Surface irrigation				
Availability (% of total area)				
Surface irrigation throughout	14.88	62.65	84.93	99.03
Surface irrigation wet season only, groundwater during the dry season	21.85	13.27	8.73	0.97
Rainfed-groundwater used as supplemental irrigation both in the	63.27	24.08	6.34	0

wet and dry seasons				
Well-drained area (% of total area)	93.76	17.56	97.12	97.56
Worker (no. of economically active members)	3.6	3.6	5.0	2.5
Farm Assets (000 pesos)	53.71	63.84	99.19	62.90
Number of samples	39	28	39	40
% of total samples	27	19	27	27

All the households are renting the bulk (74-97%) of their farm area. There is a provision for surface irrigation throughout the year but the proportion of farm area having such provision varies from as low as 14.88% (FTA) to as high as 99.03% (FTD). Most of their farms are well-drained except FTB with only 17.56% of its farm classified as well-drained.

In general, FTC has the largest farm size, relatively well-drained and 84.93% of its land area is provided with surface irrigation throughout the year. Additionally, this farm type also has the highest number of economically household members and the highest farm assets.

FTB also has a large farm size of which 62.65% is provided with surface irrigation throughout the year. However, their farm assets and the number of economically household members are less than FTA and as mentioned earlier, only a small proportion of their land is well-drained. On the hand, FTD, apart from having the smallest farm size, has also the least number of economically active household members and rent most (97%) of its landholding. Nevertheless, most of its landholdings are also well-drained and almost these are irrigated throughout the year.

FTC has also a small farm size and low farm assets. Most of its landholdings are also well-drained but the majority are rainfed.

Batac

In Batac site, Pradel and Bi (2003) used the following variables in grouping the farm households:

a. total hectares of farmland
b. proportion of farm area located in lowlands
c. proportion of the farm area with good soil
d. proportion of the farm area that is irrigated
e. total farm assets
f. number of economically active household members

Based on the above criteria four farm types were identified (FTA, FTB, FTC, and FTD). The characteristics are summarized in Table 3.4.5.

Table 3.4.5 Characteristics of representative farm households, Batac, Ilocos Norte, Philippines.

Parameter	Farm type

	FTA	FTB	FTC	FTD
Own farm area (ha)	0.28	0.37	0.32	0.98
Rented farm area (ha)	0.57	0.53	0.63	1.56
Surface irrigation (% total area)	40	2	88	59
Good soil (% total area)	0	93	95	43
Lowland (% of total area)	48	47	61	41
Well-drained (% of total area)	66	82	74	72
Family size (persons)	4.9	5.0	4.9	6
Labor force (persons)	3.2	3.9	3.4	4.7
Farm assets (000 pesos)	51.9	51.8	47.1	122.2
Number of samples	44	55	39	11
% of samples	30	37	26	7

In general, FTA has a relatively small farm size with most of the land provided with surface irrigation but with no good quality soil and with relatively low level of working capital. FTB also has a relatively small farm size without provision for surface irrigation and low level of working capital but with good quality soil. FTC has also small farm size but almost all of the area are well-provided with surface irrigation and with good soil quality and the household has relatively low level of working capital. On the other hand, FTD has a relatively big farm size with mixed soil quality, land with surface irrigation and relatively high amount of working capital.

3.4.5 Farm Household Model

Resource Endowments

Farm household model (FHM) to optimize resource use of each of the farm types in Dingras site was developed. The model considered the three resource endowments of each farm type such as labor, land and capital.

Land and land use

In the model land was classified based on land use (crops planted), land unit (water regime), drainage condition's (as perceived by the respondents) and tenure. Based on these criteria, the farms are classified into 6 land units (LU), 23 land use types (LUT), 2 drainage conditions and two land ownership (0).

The six land units include:
a. Surface irrigated throughout, well-drained
b. Surface irrigated throughout, poorly-drained
c. Surface irrigated wet season (WS), well-drained
d. Surface irrigated WS, poorly-drained
e. Rainfed, well-drained
f. Rainfed, poorly-drained

Landholding per household is either owned or share cropped; and the major sharing arrangement is 65:35 (tenant:landlord). The 23 LUTs are the following:

1. Rice-fallow
2. Fallow-yellow corn
3. Fallow-garlic
4. Rice-rice
5. Rice-yellow corn
6. Rice-garlic
7. Rice-tomato
8. Rice-pepper
9. Rice-eggplant
10. Rice-mungbean
11. Rice-potato
12. Rice-tobacco
13. Rice-rice-rice
14. Rice-rice-corn
15. Rice-rice-sweet pepper
16. Rice-rice-mungbean
17. Rice-rice-tobacco
18. Rice-bittergourd
19. Yellow corn-yellow corn
20. Rice-yellow corn-rice
21. Rice-fallow-rice
22. Rice-fallow
23. Rice-yellow corn-yellow corn

The cropping calendar for the main LUTs is shown in Table 3.4.6.

Table 3.4.6 Cropping calendar according for the main land use types in Dingras, Ilocos Norte, Philippines

Land use type	Crop 1		Crop 2		Crop 3	
	Planting	**Harvesting**	**Planting**	**Harvesting**	**Planting**	**Harvesting**
1 Rice	Apr June	Aug Oct				
2 Rice	Apr	Aug	Aug	Nov		
3 Rice	Apr	Aug	Aug	Nov	Dec	Apr
R-upland crops (YC, Ga, Tc, Pp, Eg, Tb, Bg, Mu)	June	Oct	Oct-Nov	Feb-Mar		
Fallow-upland crops			Oct-Nov	Feb-Mar		
Rice-Fallow-Rice	Apr	Aug			Dec	Apr
Rice-Rice-upland crops (YC, Tb, P, T, Bg)	Apr	Aug	Aug	Nov	Nov-Dec	Apr

The area per LU of the different farm types and area distribution of owned and share cropped are shown in Table 3.4.7-3.4.9.

Table 3.4.7. Area (ha) per land unit of the different farm types in Dingras, Ilocos Norte, Philippines.

Land Unit	FTA	FTB	FTC	FTD
S. irrigated throughout, well-drained	0.137	0.118	1.344	0.810
S. irrigated throughout, poorly-drained	-	0.553	0.040	0.020
S. irrigated WS, well-drained	0.189	0.025	0.142	-
S. irrigated WS, poorly-drained	0.012	0.117	-	-
Rainfed, well-drained	0.546	0.045	0.103	-
Rainfed, poorly-drained	0.036	0.212	-	-

Table 3.4.8. Area (ha) distribution of owned land by farm type and land units.

Land Unit	FTA	FTB	FTC	FTD
S. irrigated throughout, well-drained	0.02	-	0.21	0.05
S. irrigated throughout, poorly-drained	-	0.10	-	-
S. irrigated WS, well-drained	0.02	0.02	-	-
S. irrigated WS, poorly-drained	-	0.01	-	-
Rainfed, well-drained	0.02	0.04	-	
Rainfed, poorly-drained	-	0.05	0.02	
Total	0.24	0.22	0.23	0.05

Table 3.4.9 Area (ha) distribution of rented (share cropped) by farm type and land units

Land Unit	FTA	FTB	FTC	FTD
S. irrigated throughout, well-drained	0.11	0.38	1.00	0.74
S. irrigated throughout, poorly-drained	-	0.26	0.07	0.04
S. irrigated WS, well-drained	0.15	0.06	0.24	0.01
S. irrigated WS, poorly-drained	0.02	0.01	-	-
Rainfed, well-drained	0.32	0.13	0.08	-
Rainfed, poorly-drained	0.08	0.01	-	-
Total	0.68	0.85	1.35	0.79

Labor (Human Capital)

Farm households are quite diversified. Often, non-agricultural activities contribute greatly to household income. The number of economically active members per household was calculated based on the following assumptions:

<10 years old	-	0
10-15 years old	-	0.5 manday
16-70 years old	-	1.0 manday; if student 0.5 manday

The monthly total labor which the household can allocate is the product of the number of economically active numbers and 24 days a month with 8 working hours a day. The rest is reserved for leisure/non-productive activities at the disposal of the household.

Economic Capital

Economic capital could come from farm assets such as land, machinery, farm equipment and animals, as well as savings from farm income. In the model, economic capital includes liquid farm assets (animals such as pigs, goats and chicken) as well as remittances abroad, cash generated by family income through off- and non-farm activities and income from previous cropping.

Household Consumption

Decisions regarding production and consumption are non-separable. The model integrates household decision on consumption of products that can be produced at home or that can be bought in the market.

Framework of the Model

The FHM framework consists of an objective function, which maximizes farm income and a set of equations that constrain the objectives. These constraints are both physical and socio-economic factors**.**

Structure

The main resource endowments that determine the on- and off-farm agricultural activities are: land, labor, material input and capital. These were characterized in the model in terms of quality and quantity.

Objective

The model that was developed has as its objectives the maximization of discretionary income, i.e., the income accrued by the farm for the use of his land and family labor minus consumption from own product or that bought in the market.

Constraints

The following constraints were imposed: land availability and ownership (owned and share cropped), labor availability and utilization (on-farm, off-farm and non-farm), water availability, drainage conditions, capital availability, and food consumption (based on average per capita consumption from the Bureau of Agricultural Statistics).

Data Used in the Model

The model used the following technical coefficients generated by the TechnoGIN:

1. Yield of products for each combination of LU, LUT and Technology (T)
2. Costs – total costs of fertilizers, pesticide and other costs (excluding labor) for each combination and LUT, LU and T.
3. Labor requirement – labor use for each LU, S and T
4. Nutrients – NPK use
5. N loss and biocide use as indicators of environmental sustainability.

Data on hired labor costs were not derived from TechnoGIN but are calculated based on the FHM. The model allows the households to allocate their labor supply into on-farm, off-farm and non-farm activities.

Other data inputs include wage rate and labor availability at a given month, price of products (market and farm gate) product per capita consumption, promising LUT at a given LU and land area by LU, owned and share cropped.

All of the above data were stored as prn file and imported in GAMS when the FHM in run to maximize profit or minimize N leaching/biocide use.

3.4.6 Mathematical description of FHM

The mathematical description is based on the information on the farm household model developed in GAMS software. The complete model is presented in Annex 8. The indices of the parameters in the farm household model, the coefficients in the model, the indices and dimensions of the model variables, and the descriptions of the variables in the model are summarized in respectively, Table 3.4.10, 3.4.11, 3.4.12 and 3.4.13.

Table 3.4.10 Indices of the parameters in the farm household model.

Index	**Parameter**	**Element**
P	Products	Ri1, Ri2, Ri3, Rwe, Ycl, Tc, Gar, Tb2, Pp, Tb3, Mn2, Mn3, Bg, Egg, Yc2, Yc3, Pp3
L	Land use types	RFa, FYc, FGa, 2RI, RyC, RGa, RTc, RPp, REg, RMu, RPo, RTb, 3RI, RRC, RRP, RRM, RRT, RBg, YcC, RCR, RFR, 1RI, RYY
M	Months	JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC
N	Nutrients	Ni, P, K
S	Land units	LU1IR, LU2IR, LU3IR, LU4IR, LU5IR, LU6IR
T	Technologies	TAC, TBF
E	nloss	N_lch, NGAS
C	Cost	Fert, Bio, Othr
W	Wage	H, O, N
O	Land ownership	X, Y
R	Cropping season	S1, S2, S3
H	Household type	H1, H2, H3, H4
G	Price of consumed products	G1, G2
FC	Consumption goods	Ri, Yc, Tc, Tb, Gar, Pp, Mn, Bg, Egg

X (P, FC)	Ri1.Ri, Ri2.Ri, Ri3.Ri, Rwe.Ri, Yc1.Yc, Yc2.Yc, Yc3.Yc, Tc.Tc, Tb2.Tb, Tb3.Tb; Gar.Gar, Pp.Pp, Pp3.Pp; Mn2.Mn, Mn3.Mn, Bg.Bg Egg.Egg

Table 3.4.11 Coefficients in the farm household model

Coefficient	**Description**	**Unit**
YIELD (S, L, T, P)	Yield per product of each LUS & T	kg $ha^{-1}yr^{-1}$
LABOR (S, L, T, M)	Labour use of each LUS and Technology for each month	Labordays $ha^{-1}month^{-1}$
NUTRIENTS (S, L, T, R, N)	Nutrient use	kg NPK $ha^{-1}yr^{-1}$
NLOSS (S, L, T, R, E)	Nitrate leaching & Nitrogen gas	kg N $ha^{-1}yr^{-1}$ kg ai $ha^{-1}yr^{-1}$
COST (S, L, T, C)	Costs per year	PhP Pesos $ha^{-1}yr^{-1}$
PRICE1 (P)	Product farm gate price	PhP Pesos kg^{-1}
PRICE2 (FC)	Product market price	PhP Pesos kg^{-1}
CAPITAL	Working capital per household type	
CONSRice	Minimum consumption of rice	kg (120 kg $person^{-1}$)
LAB_MAX (M)	Household labourers available per month	Mandays (120)
NONLAB_MAX (M)	Nonform labor availability in each month	Mandays
OFFLAB_MAX (M)	Off-farm labour availability in each month	Mandays
LANDOWN (S, O)	Land availability per land unit owned and share-crop	ha
WAGE (W, M)	Wage for labour in each month	PhP Pesos day^{-1}
PROMISING (S, L, T)	Promising combination of S & L	
BIOINDEX (S, L, T)	Bio index of S and L per technology	
CONSUMPTION (FC)	Annual per capita food consumption	kg
FSIZE	Average family size per household type	

Table 3.4.12 Indices and dimension of the variables included in the farm household model.

Index	**Variable**	**Unit**
VBIOindex	Bio-index per year	kg ai^{-1} yr^{-1}
VINCOME	Total income per year	PhP Pesos yr^{-1}
vLAB (W, M)	Labour in each month	Mandays $month^{-1}$
VLABOWN (M)	Household labor use for farm activities per month	Mandays $month^{-1}$
vLAND (S, L, T, O)	Area with certain land use system & technology	ha
VNlch	Nitrate leaching	kg N ha^{-1} yr^{-1}
vPRODUCT (P)	Production	kg yr^{-1}
VConsRice	Min Consumption of rice	kg $household^{-1}$ yr^{-1}
vConsumption (FC)	Household consumption	kg $household^{-1}$ yr^{-1}
vBUY (FC)	Goods bought that are not produced by the household products sold	kg
vSALES (P)	Products sold	kg
vOWNCONS (FC)	Consumption from own production	kg
vDINCOME	Discretionary income	PhP Pesos yr^{-1}

Table 3.4.13 Description of variables in the farm household model (b_balances and c_constraints).

Equation	**Description**
b_INCOME	Farm income plus wage income
b_DINCOME	Discretionary income
c_MINCONS	Minimum consumption constraint for rice
b_PROD	Product balances
b_SALES	Sold product
b_BUY	Goods purchased
b_COMMODITY	Commodity balance
c_LAND	Use of land units by LUS and technology
c_capital	Capital constraint per year
c_consumption	Annual per capita consumption
b_LABFARM	Balance of labour use per month
c_OWNLAB	Household labour availability per month
c_LABOFF	Restriction on possibility to work off-farm per month
c_LABNON	Restriction on possibility to work non-farm per month
b_N_lch	N leaching
c_N_lch	Constraint on max N leaching
b_BIOindex	Biocide index
c_BIOindex	Biocide index constraints
b_BIOuse	Biocide use
c_BIOuse	Biocide use constraint

3.5 Case study development for O Mon, Cantho province

3.5.1 Introduction

O Mon district is situated in Can Tho Province which is located in the central part of the Mekong Delta of Vietnam. The province's economy is mainly based on the agricultural sector. Total area of the province is about 0.30 million ha, of which 82.7% is under arable farming with rice-based cropping systems as the predominant land use type. The economic reform (i.e. Renovation) of Can Tho was successfully implemented between 1991 and 1996, resulting in a rapid annual economic growth rate of almost 10% during the 1990s.

Economic development of the province continues to be based on agriculture. The objectives of agricultural development are (*i*) to assure food security, (*ii*) to increase the value of agricultural production and (*iii*) to increase the total value of exports. Realization of these objectives requires more efficient use of agricultural land, with higher yields and improved quality of agricultural products. Rice production still plays a predominant role in Can Tho. The Mekong Delta, including Can Tho has to produce far above local demand and is expected to maintain its role as the major rice bowl of the country. Vietnam has decided to strictly maintain its present rice area, about 4 million ha, until at least 2010. One goal is to ensure a stable annual output of 33 million tons of unhusked rice, of which 25 million tons will be earmarked for domestic consumption and the country's food reserve, and the remaining 8 million tons for export.

Because of chronic difficulties in marketing of agricultural products, particularly rice, in recent years, policymakers have been forced to reconsider their plans for restructuring the agricultural sector. The process of restructuring agricultural production and increasing farmers' income has been too slow. The process needs to be accelerated to encourage many individuals to stay in agriculture. Therefore, a number of important 'what-if' questions needs to be considered to gain insight into promising agricultural development options. For example, what are the consequences for land use and resource quality if the policy view is changing from a scenario with priority for rice production to scenarios that favour diversification for income generation to different degrees ?

Most decisions about land use are ultimately made by farm households. For the analysis of decision making at this level, the IRMLA team uses the farm-household modelling approach.
Farm-household models are developed for two reasons:

3. to analyze the suitability of various current and future-oriented farming systems for the specific setting of the farmers in the case study area; and
4. To simulate the impact of feasible changes in policy on technology choice and farmer objectives.

For the O Mon district, first the biophysical characteristics and next the socio-economic aspects are described. This information is then used as a basis for producing technical coefficients for the main production activities in the district with the technical coefficient generator TechnoGIN (see Section 2.2). These technical coefficients are used in the farm household modelling for O Mon. See Section 2.3 for more background information about this farm house modelling work and see also papers by Hoanh et al. (2000) and Roetter et al. (2004) for more information on a comparable modelling approach at the larger (i.e. regional) scale.

3.5.2 Biophysical characteristics

Located in the center of the Mekong Delta, the area is flat and most land is situated between 1 to 3m above mean sea level. The O Mon district has a dense creek and channel system. Surface water is the main source of irrigation during the dry season. The area is flooded during about three months (September-November) with a flooding depth that varies from 30 to 90 cm over the area. The main biophysical charactetics that determine the potential and limitations for crop production, are a) weather conditions; b) soil characteristics; c) flooding.

Weather conditions

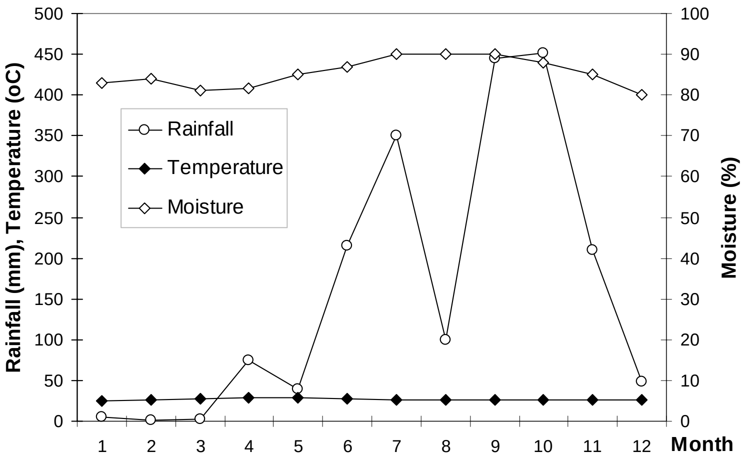


Figure 3.5.1 Precipitation (mm), temperature (^{0}C) and relative air humidity over the year in O Mon district

The main charactetics of the weather in O Mon district are shown in Figure 3.5.1. The total annual precipitation is on average 2000 mm. The wet period starts in May and ends in November, and may negatively effect the growing conditions and crop production. The rest of the year, the precipitation is practically nil and crop production is then dependent on irrigation.. The temperature is on average high over the whole year (i.e. 26.6 ^{0}C).

Soil characteristics and flooding

The main soil units in the O Mon district are shown in Figure 3.5.2.This soil map is combined with a map with depth and duration of flooding (see Table 3.5.1) and converted to the land unit map (Figure 3.5.3). This map with land units is used in the subsequent land use analysis (Section 3.5.5).

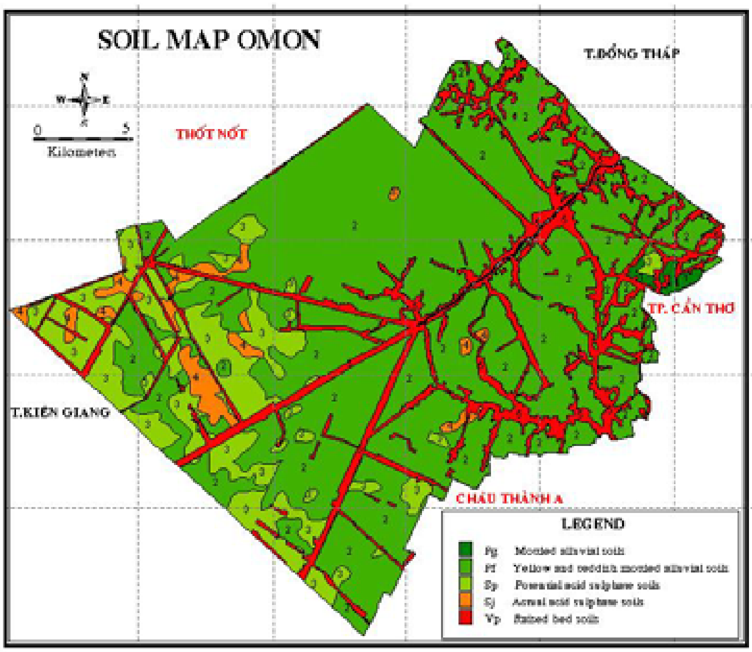


Figure 3.5.2 Soil map of O Mon district

3.5.3 Socio-economic aspects – a snapshot with observations at village level

A compilation of some socio-economic aspects of the O Mon district in Mekong delta, Vietnam is given in the following. ***This sub-section is completely based on the reporting on field work in the hamlet of Thoi Khanh by Daan Kayser,*** a PhD student of the University of Utrecht, who spent a practical period (February to June 2003) in Omon. Field work was done in close collaboration with the IRMLA team of CLRRI.

Rice is the main crop grown in the Mekong Delta. Besides, there are fruit gardens, upland crops aquaculture and in the coastal areas shrimp farming. In O Mon district 80% of the land was used for rice crop. Fifteen percent of the agricultural area was used for fruit trees.

Population

The population in the O Mon district in 1996 was 289.188 with an equal distribution of men and women. The population growth rate was 2.7%. This is 0.6% higher than the Vietnamese average. The high growth rate is reflected in the age distribution. Fifteen percent of the population was 50 years or older. Forty eight percent were between the age of 19-50 and thirty seven percent were younger than 18. The average household has 5.56 members of which 3.84 persons belonged to the economically active population.

Economic activities

The economic activities undertaken by the members off a household can be divided into three groups: on farm work, off-farm work and non-farm work.

On-farm work and income

The overall majority of the farmers grow rice on their fields. Since the Renovation, farmers have begun to diversify the grown crops, however, on a small scale. Some farmers have fruit gardens and grow other crops like corn and vegetables. The reason for this change is that during the collective period the government especially stimulated the production of rice. Nowadays, diversification is on the government's agenda. There are market incentives to grow other produce as well.

Rice production
In O Mon around 80 % of the agricultural land is used for rice production, although the price of rice is low compared to other produce. Since Vietnam started to export rice, the price of rice has slightly increased. There are different reasons why farmers stick to rice. One is that rice is the crop they have grown for many generations. Another reason is that it is difficult to grow other crops as everyone else grows rice. The water from the rice paddies affects the bordering land due to the lack of dikes around the fields. The financial situation of the households also plays a role. Most households don't have a financial situation that allows them to take the risks of changing to other crops. Also changing from rice to other crops requires an investment capital, which most households don't have. A final reason why families stick to rice is that it is easier to sell. The market for other crops is much less developed and requires more effort from the farmer to find a buyer.

Most farmers grow triple rice. This means they have three rice crops a year: in the dry season (from November to February), in the dry-wet season (between March to June) and in the wet season (between July and October). The average yields for triple rice are: 5.8, 4.07, 4.36 ton per hectare in respectively the dry, wet and the dry-wet season. In the wet season the yield is lowest due to the rain at harvest time. Mostly farmers grow old rice varieties, mainly because farmers are used to grow these varieties. In addition, the old rice varieties are easier to grow and the new rice varieties give higher costs due to e.g. more expensive seeds.

Other crops
Other crops that are grown include watermelon, maize, beans and other vegetables. A problem with growing these crops is the water from neighboring rice fields that can ruin the crops. To be able to grow these crops an investment into a dyke is needed. Another problem is the under-developed market and distribution systems for these crops. Many farmers though would like to grow upland and other crops as the price for these is higher. To allow this, the former mentioned problems need to be solved.

After the Renovation, the amount of fruit gardens in the village has increased. On the one hand this is because the diversification of agriculture has been stimulated by the government. On the other it is the market that makes people change to fruit, as they are highly profitable. The profit from fruit trees can be 5-6 higher than the income from rice. It is mostly the richer households that have started fruit gardens. The reason for this is that the development of a fruit garden is costly. Also the first few years no profit can be gained from the fruit, as the fruit trees are too small to give a high enough yield for sales. There are many types of fruit trees: mangos, jackfruit, pomello, leichees, ramputan and red plumb. Growing different types in one garden insures fruit harvests throughout the year and provides more security in income.

Animals

In the past most families owned oxen to plow the land. Nowadays, no oxen can be found in the hamlet. Animals are no longer kept as labor power, but for own consumption as well as for the market. Most households keep a few chickens or ducks, as they are easy to keep and don't need a special house. More and more households have started to keep pigs. Some families keep meat pigs and other keep the pigs for breeding. The meat pigs are usually sold when they weigh around 100 kg (1 dollar per kg). Those that breed the pigs sell the piglets (35 dollar per piglet) to other households or raise the piglets themselves for the market. To keep pigs a pigsty needs to be built. This requires an investment. Animals are either fed scraps or special food. This depends on the household's financial situation. Animals also require medicines and visits to the vets which are extra costs for the households.

Aquaculture

Another new activity that has developed since the Renovation is aquaculture. Like fruit gardens the fishponds require a high investment but can be highly profitable. To build a pond costs around 133 dollars. One problem with aquaculture is that the fish can be easily stolen. To keep fish you need someone who will guard the pond at night. Most ponds are small and contain around 3000 fish. The fish kept are mostly catfish and elephant ear fish. Fish are used both for own consumption and sold to the market. There is one large, purely commercial pond in the hamlet. It is owned by a businessman from Ho Chi Minh City. The pond is 1500 m^2 and contains 43.000 fish. Two men work permanently by the pond to feed and guard the fish.

Off-farm income

During the busy periods in farming the whole households helps on the land. When the work is done, the family will try to find work on the other farms. These are usually farms with a large land size and low labor availability. Such work is also done on the land of farmers who are too old to work and whose children are studying or doing other work. The average price for one labor- day is two dollars. Between friends there is a system of mutual cooperation. Friendly households will work on each others land without being paid for the work.

Non-Farm income (work outside farming)

With the growth of the labor population the need for off-farm work is increasing. There are many different non-farm activities. These can be divided into two groups. The first type are those activities in which a person rents out his labor. The second are the private businesses. Most of the labor work is in construction and in the factories in the village. Since the nineties factories have appeared in the village. They are focused on the processing of rice. At present, the hamlet counts nine factories. Some factories are owned by investors from Ho Chi Minh City and others by the army. For example, one rice processing factory has 14 permanent workers and 70 part-time carriers. A permanent worker earns 30 dollars per month and the carriers 1 dollar per day. Most farmers work in the factory a few weeks per year to increase their income. For the future there are more factories planned in the hamlet. The second type of non-farm activities are the private businesses. Since the Renovation the number of private businesses is on the increase in the hamlet. This is due to the fact that the law now allows private businesses. Also the market economy has given some households the opportunity to earn enough capital to invest in new businesses. For example, a family invested in converting their land into fruit gardens. With the capital that they have earned, they have now started a small coffee shop and hairdressers.

Land ownership

Most households get their land from their parents. Usually the land is shared equally amongst the children. As the population grows in Vietnam the land size per household decreases. This is a problem of many agrarian societies. For this problem to be solved, the non-agricultural economy must develop so that people can also earn money outside of farming. The average land owned by a household is 0.428 hectare. Land size varies between landless households and those that own more than 2 hectare. In 1998 research was done in the O Mon district on the landownership. This showed that around half of the households owned less than 0.75 ha. The amount of households that had no land was 15%. Those that had between 0.75 ha and 1.5 ha amounted to 23.7%. A group of 12 % owned more than 1.5 ha. Since the Renovation it is possible for households to buy and sell land. Under the informants there has been change in their land size. 43% of the households have lost land over the years.

3.5.4 Generation of technical coefficients

The technical coefficients for the farm household model have been calculated with TechnoGIN-3 (Ponsioen et al., 2003). See Section 2.2 for more information on the last version TechnoGIN-3. The calculation of these technical coefficients or input-output relationships has been done for the main combinations of land use type (i.e. crop rotation), land unit and technology.in the O Mon district.

Land units

The O Mon district is located in the center of the Mekong Delta. It can be considered representative for a large part of the Delta.The topography is level and the altitude varies from 1 to 3 m above mean sealevel. The soils are mainly alluvial deposits. For agricultural use the soil potential and limitations are mainly determined by the flooding duration and depth and the degree of acid sulphate formation (Table 3.5.1). The distribution of the land units over the O Mon district is presented in Figure 3.5.3.

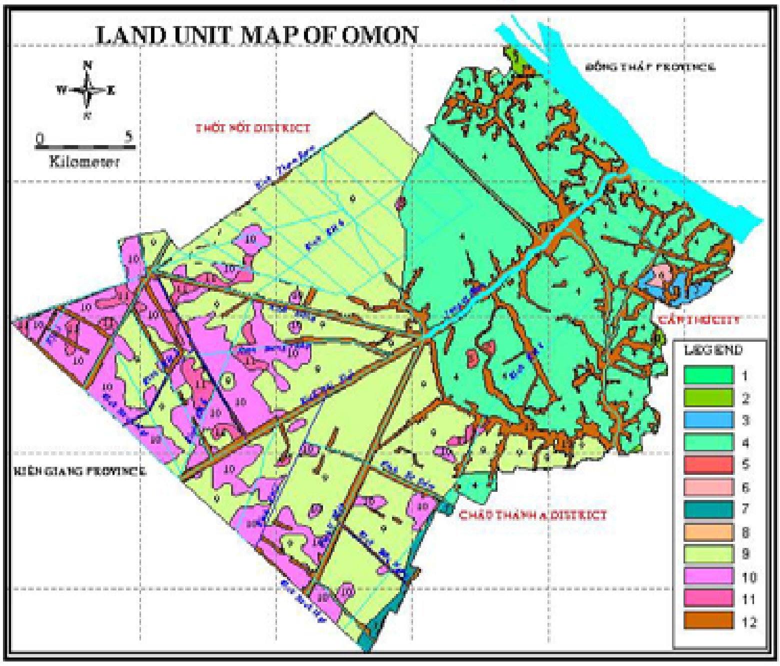


Figure 3.5.3 Land unit map for O Mon district. See Table 3.5.1 for explanation of land units

Table 3.5.1 Characteristics of land units in O Mon district

No	Soil type	Flooding depth (cm)	Flooding duration	Area (ha)
1	Yellow and reddish mottled alluvial	< 60	Sept-Nov	16,792.63
2	Yellow and reddish mottled alluvial	< 60	Sept-Oct	178.94
3	Yellow and reddish mottled alluvial	> 60	Sept-Nov	20,672.22
4	Yellow and reddish mottled alluvial	> 60	Sept-Oct	359.94
5	Mottled alluvial	< 60	Sept-Oct	7.11
6	Mottled alluvial	< 60	Sept-Nov	300.64
7	Actively acid sulphate	< 60	Sept-Nov	251.55
8	Actively acid sulphate	> 60	Sept-Nov	1,286.96
9	Potential acid sulphate	< 60	Sept-Nov	107.34
10	Potential acid sulphate	> 60	Sept-Oct	15.04
11	Potential acid sulphate	> 60	Sept-Nov	7,264.56
12	Raised bed soil			7,304.52
	Total			**54,541.44**

Land use types

The most promising land use types have been selected for the O Mon district (with WS=winter-spring, SS= spring-summer, SA= summer-autumn growth periods):

1. WS rice – SA rice
2. WS rice – SS rice – SA rice
3. WS rice – Soybean – SA rice
4. WS rice – Mungbean – SA rice
5. WS rice – Vegetable – SA rice
6. WS rice – Watermelon – SA rice
7. WS rice – Hybrid corn – SA rice
8. WS rice – SA rice + Fish/Shrimp
9. Sugarcane
10. Fruit trees

Technologies

Production technologies are first, the technologies that are presently applied and next, the possibly future technologies. Future options are a) high production agriculture with high inputs of fertiliser nutrients and biocides; b) more environment-friendly production techniques such as Integrated pest management and Integrated nutrient management.

Output

Input-output relationships for the main combinations of land use type, land unit and technology in the O Mon district have been produced with TechnoGIN. This output is to be used within the farm household model (Section 3.5.5). An overview of the output of TechnoGIN is shown in Section 2.2.

3.5.5 Mathematical description of a Farm Household Model for O Mon

To analyse the decisions on land use in the O mon district, a farm household model has been developed. Background information on this model is given in Section 2.3. The model maximizes either total income or discretionary income within a number of constraints (e.g. available land, labour and credit).

A number of ideas are collected about the main constraints for optimizing land use and agricultural development. These constraints are: 1) availability of capital; 2) knowledge about new production technologies; 3) prices of inputs and outputs; 4) market. The effects of these constraints on the possible agricultural development in the O Mon district is to be analysed with the farm household model. A first preliminary model for O Mon is described in the following:

Possible objectives:
total income: returns to family land, labour and management
discretionary income: income above basic consumption requirements.

For each production activity (i.e. production by a land use type on a certain land unit with a given production technology, see ***Sets***) the required input data are specified (see ***Input Data).***

Sets:
j: products
s: land units
l: land use types
t: technology
m:period
n: nutrients

Input Data:

Technology
Nonlabour costs per product/land use type/land unit/technology
Labour requirement per product/land use type/land unit/technology
Balance per nutrient per product/land use type/land unit/technology
Biocide use per product/land use type/land unit/technology
Yield per product per land use type/land unit/technology in kg per ha
Off-farm wage and hiring wage per period per ha.

Prices
Sales prices per kg product
Buying price per kg product for subsistence goods
Hiring wage rate per period
Off-farm wage rate per period

Household
Minimum consumption levels for subsistence goods
Available land per land unit
Family labour availablity per period
Off-farm labour availability per period
(Cash availability and maximum credit access)

Income

$$total\ income = \sum_j salesprice_j * production_j - nonlabor\cos ts - hired\ labour\ \cos ts + wage\ income$$

$$wage\ income = \sum_m off\_farmwage * off\_farmhours$$

$$cash\ income = \sum_j salesprice_j * sales_j - nonlabor\cos ts - hired\ labour\ \cos ts + wage\ income$$

$$discretionary\ income \le cash\ income - \sum_j buyprice_j * purchase_j$$

Consumption

$$consumtion_j \geq minimum\ consumption_j$$

$$consumption_j + sales_j \leq production_j + puchase_j$$

Crop production

$$production_j = \sum_{l,s,t} yield_{l,s,t,j} * ha_{l,s,t}$$

Land use

$$\sum_{l,t} ha_{s,l,t} \leq available\ ha_s$$

Nonlabour inputs

$$nonlabour\cos ts = \sum_{s,l,t} \cos tperha_{s,l,t} * ha_{s,l,t}$$

Labour

$$labour\ use_m = \sum_{s,l,t} labourrequirement_{s,l,t,m} * ha_{s,l,t} \leq onfarm\ \ family\ hours_m + hired\ labour\ hours_m$$

$$onfarm\ \ family\ hours_m + off\ \_\ farm\ \ family\ hours_m \leq available\ \ family\ hours_m$$

$$off\ \_\ farm\ \ family\ hours_m \leq \max imum\ off\ \_\ farm_m$$

$$hiredlabor\cos ts = \sum_m hiringwage * hiredhours$$

Sustainability

$$nutrient\ loss_{n,s} = -\sum_{l,t} balance_{s,l,t,n} * ha_{s,l,t}$$

$$nutrient\ loss_{n,s} \leq allowed\ loss$$

$$biocide\ use = \sum_{s,l,t} biocide_{s,l,t} * ha_{s,l,t}$$

$$biocide\ use \leq allowed\ biocide\ use$$

Cash

$$nonlabour\ \cos ts \leq cash + credit\ \max imum$$

3.5.6 References

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4 Management

4.1 Meetings, workshops and activities from December 1st 2002 to November 30th 2003

- Held (4 times) 1 or 2 bilateral stakeholder consultations in each of the four case study sites on data exchange and on workhop preparation
- Four in-country workshops held in each study site with EU, local multi-stakeholder platform and Asia IRMLA team participation (see, IRMLA Report no. 3)
- Six days' joint IRMLA workshop (29 September to 4 October) held at Wageningen UR on integration of data and models- with representatives from all teams, and research managers from different Groups of Wageningen UR.
- Annual workplans revised and documented during four in-country workshops in March and April 2003.
- IRMLA Website expanded and maintained
- Integrate input from other research groups (PPO, IRRI, DOW etc.) in the IRMLA project (example : related PhD studies ; PPO field visits to Pujiang and Tam Duong)
- Farm survey data screened and analyzed, and extended data collection initiated
- Prototype tools (WP1 – 4) developed
- Co-ordination of extended data collection and input from different partners in developing TechnoGIN, FHMs and MGLPs
- Regular meetings (monthly) on methodological aspects and innovations and organizational aspects conducted at Wageningen and documented.
- Coordinated proposal writing for follow-up project
- Compilation of 1st IRMLA annual scientific and financial report, and 3rd progress report - as requested by EU-INCO

4.2 Workshops in 2004

In-country workshops March 2004

Case study	time	EU participants
• Pujiang, Zhejiang	15-19 March	HvK, Lu Changhe
• Tam Duong	24-27 March	R Roetter, M vd Berg
• Batac/Dingras	22-25 March	HvK and MVI
• O Mon	29 Mar – 2 Apr.	R Roetter, M vd Berg

4.3 Outputs

- Reference is made to the IRMLA website: www.irmla.alterra.nl and chapter 2 and the Annexes to this report
- In addition, an IRMLA poster (for EU desk High Tech Fair, Beijing, Oct 03) and IRMLA newsletter was produced; in addition, a number of papers for publication in international journals are in preparation

- New software tool developed : TechnoGIN 3 and prototype MGLP and FHM (in GAMS)
- Several compilations (on CD-ROMs) of training materials, and documentations of research components, prototype models were produced

4.4 Impacts

The main target groups and beneficiaries of IRMLA are farmers, NARES (National Agricultural Research and Extension Systems), collaborating universities and planners/policy makers of local governments. These have (and will be) actively involved in refining objectives, developing scientific methodology & tools and analysing land use options in four selected (case study) regions in Asia.
Impacts so far include:

- Active exchange of information and views on land use and rural development issues by multi-stakeholder platforms established in Vietnam (MARD-NARES-local government authorities-farmers-Dutch Embassy), China (Provincial and district Agricultural Bureaus) and the Philippines (NARS-provincial & municipal planners and extension service- farmers)
- Involvement of key stakeholders in project workshops for each case study
- Pro-active integration of DLO-IC and INREF research on sustainable land management and related policy research (exchange of ideas / approaches through joint IRMLA-RESPONSE staff: MvdB; HvK)
- Formation of multi-lateral research links with other research work built around IRMLA case studies; linkages with: PPO, Netherlands and CGIAR institutes (IRRI, ICLARM, IWMI) and other non-EU research groups
- Development of novel ways of participatory research
- Operationalization of tools for multi-decision level analysis of technology design and adoption under alternative policy options
- Presentation of interim research findings to a wider audience of researchers and research managers within the EU and, at Wageningen UR, in particular.

4.5 Conclusions

Project progress fully in line with original plan. Current set-up of case studies and researcher-stakeholder networks provide sound basis for exploring new grounds and building missing links for participatory research and advancements in scientific-technical methodology that aims at decision support for identifying options for sustainable land management in densely populated areas of E and SE Asia.

4.6 Other management aspects

All teams fully established and operating (a result of four in-country workshops, two intensive training and planning workshops in 2002 and earlier fruitful collaboration); teams meet regularly, no major problems encountered so far

4.7 Finances

Budget spending largely in line with plan; Constraints: need for sourcing of additional funds to cover costs of required training of members of the Asian IRMLA scientists.

[Financial report will be submitted in a separate document]

5 Individual partner reports

5.1 Introduction to individual partner reports

During the second project year, 2003, a major break-through has been made in putting conceptual models and intended dialogue on policies and resource use issues between scientists and local stakeholders (farmers and planners, government officers at district & provincial level) into effect. Results are various operational models, databases and established multi-stakeholder platforms in the four case study regions:

1) A tool for generating coefficients quantifying input – output relations for crop production activities (TechnoGIN-3 model) has been completed and evaluated through intensive collaboration among the various Asian and EU partners.

2) Comprehensive databases on farm households in each of the 4 study regions.

3) Two prototype regional multiple goal analysis models (MGLP) and two prototype farm household models (FHM) have been elaborated through (i) intensive dialogue and consultations among Asian teams and local stakeholders and (ii) fruitful collaboration between EU and Asian scientists and key stakeholders during a series of four case study-specific workshops and one joint workshop attended by all teams on integration of data and models.

4) The dialogue between key stakeholders and the four Asian research teams has been fully established and is being maintained through staunch support from local governments.

5) Research topics and scientists participating in IRMLA appear to be attractive among students and have again generated specific research topics to be studied by two new PhD students and 1 MSc student.

The way in which individual partners have contributed to the success of year 2 is presented in the following sections.

5.2 Annual report of Alterra, Wageningen, The Netherlands

5.2.1 Progress over the last year

Progress in year 2 is in line with the plan.

5.2.2 Progress of project

Major activities within the project comprised: 1) Analysis of regional resources and conflicts in land use objectives; 2) Yield gap and environmental risk analysis; 3) Technical coefficient generation; 4) Farm household modelling; 5) Co-ordination and training.

WP1 Analysis of regional resources and conflicts in land use objectives:

- Further progress was made in making regional (agricultural) development objectives and intended policy measures more explicit (as documented in IRMLA report no. 3). This was achieved through bilateral stakeholder consultations and multi-stakeholder meetings during 4 in-country workshops for each study region.
- Regional MGLP models were developed by NISF and ZU with support from the regional training officer and support of staff from PPS-DPW-WU.

WP2 Yield gap and environmental risk analysis:

- Alterra provided simulation tool to partner IFU-FZK and assistance in input data compilation and conversion.

WP3 Technical coefficient generation:

- The Technical Coefficient Generator, Techno-GIN 3 , has been finalized, documented and released. Based on work for the Philippines, this new model version is now a largely generic tool that will serve as a prototype for each of the other three case studies. Alterra participated in the documentation and a comprehensive evaluation of the tool with numerous test runs.
- As a next step, data on case study specific land use systems and production environments will be used to make the TCG operational for each of the other three case study regions (Tam Duong, Omon, Pujiang). .
- The technical documentation of Techno-GIN 3 is in press as a QASA report jointly published with PRI and PPS of Wageningen UR.

WP4 Farm household modelling:

- Alterra provided input in (data and model) integration activities related to the development of a prototype farm household model for Omon district (S-Vietnam) and Batac-Dingras municipalities (Philippines).

WP 6 Co-ordination and training:

- Initiated, organized or conducted, and had substantial contribution. Reimund Roetter participated as resource person in 4 project workshops held in 2003: 3 in-country workshops in Asia (March/April) and one data and model integration workshop (with training components) held at Wageningen from 29 september to 4 October. Joost

Wolf served as resource person in the Wageningen UR workshop [Note: due to the SARS epidemic, the workshop was not held in June but in September].

- Organized and provided internal and external communication by producing progress reports, newsletters, training materials and workshop documentations (3 CD ROMs and 2 Reports) and maintaining and expanding project website.
- Training and support has been organized and provided to local teams on the basis of individual needs and requests and the plans made during the kick-off workshop at Hanoi, February 2002 (see, IRMLA report no.1).
- Held and documented monthly meetings of Wageningen research groups on scientific, capacity building and other project issues.

5.2.3 What progress has the project made in achieving its objectives over the last year? Is the project still expected to achieve all the original objectives that were specified? Explain any problems/difficulties encountered to date in achieving the objectives of the project (or any envisaged in the future).

Alterra has co-ordinated and facilitated the interdisciplinary work and exchange among partners on the various methodological and case study research questions (with specific contributions made to progress in WP1, WP2 and WP3. As a result, work on the TCG (Techno-GIN 3) has been largely completed (WP3). Likewise, work on designing and developing farm and regional level models is on schedule. The team currently also provides assistance in data integration as required for developing FHMs (WP4).

5.2.4 Any other information you wish to comment upon during this period of twelve months?

Presented IRMLA materials and results and ideas for follow-ups at the FP6 Conference at Brussels (Invited Forum presentation on NETWISE Iniatiative).
Provided partial supervision to two PhD students that are related to the project (Ms Alice Laborte and Mr. Mai van Trinh): see point f).

5.2.5 If the project timetable has slipped or changed, provide an updated project implementation timetable for the remainder of the project.

No change in timetable.

List of papers published:

During the year, one paper was finalized and published as a proceedings paper (1) and three papers were submitted to refereed international journals (2-4). Furthermore, one abstract was submitted and accepted as a conference contribution (5).

1. Marrit van den Berg, Wang Guanghuo, and Reimund Rötter (2003) Decreasing the use of agrochemicals in rural China: setting priorities for research and policy in Zhejiang province. Proceedings of the international seminar on Economic Transition and

Sustainable Agricultural Development in East Asia, Nanjing, P.R. of China, 20-22 October 2003.

2. Roetter, R.P., C.T. Hoanh, A.G. Laborte, H. Van Keulen, M.K. Van Ittersum, C. Dreiser, C.A. Van Diepen, N. De Ridder and H.H. van Laar, 2003. Integration of systems network tools for regional land use scenario analysis in Asia. Submitted to Environmental Modelling and Software.

3. Van Ittersum, M.K., R.P. Roetter, H. van Keulen, N. de Ridder, C.T. Hoanh, A.G. Laborte, P.K. Aggarwal, A.B. Ismail, A. Tawang, 2003. A systems network (SysNet) approach for interactively evaluating strategic land use options at sub-national scale in South and South-east Asia. Submitted to Land Use Policy.

4. De Ridder, N., Van Keulen, H., Roetter, R**.,** Van Ittersum, M.K., Hoanh, C.T., Aggarwal, P.K., Ismail, A.B., Lansigan, F.P., Francisco, S.R., Lai, N.X., Laborte, A.G., 2004. A generic methodology for strategic land use analysis applied to four sub-national regions in South and Southeast Asia. Submitted to Agriculture, Ecosystems and Environment.

5. Rötter, R.P., Van den Berg, MM, Van Keulen, H., Hengsdijk, H., Wang Guanghuo, Son, TT, Agustin, EO, Lai, NX, Wolf, J. & Van Ittersum, M.K (2003) A multiple-scale modelling approach to integrated resource management and land use systems analysis in East and Southeast Asia: challenges and potential solutions (abstract accepted for elaboration of full paper for IEMS conference MODSS 2004 to be held at Osnabrueck, Germany, 17-21 June 2004.

List number of PhDs and number of MScs:

Finalized: 2 MScs (Ms Xiang Bi, Mr Willy Pradel) supervised by IRMLA partner PPS-DPW-WU – supervision: Dr. R.A. Schipper and Dr. M.K. van Ittersum.
Started: 1 MSc (Ms Anne Gerdien Prins) – supervision by partner PPS: Dr. M.K. van Ittersum and Dr. M.M. van den Berg.
Ongoing: 2 PhDs (Ms Alice Laborte -– A multi-scale land use analysis tool for Ilocos Norte Province, Philippines; and Mr Mai Van Trinh – Integrated nutrient dynamics with special emphasis on erosion and leaching in Vietnam) – with R Roetter, Alterra as co-promotor.

List of conference/seminar/workshop presentations:

Paper presentation on innovative tools for land use systems analysis in Asia at the international workshop on consolidation of eco-regional approaches held at Potchefstroom, South Africa, 17-21 February 2003, by Reimund Roetter.

Paper : Marrit van den Berg, Wang Guanghuo, and Reimund Rötter (2003) Decreasing the use of agrochemicals in rural China: setting priorities for research and policy in Zhejiang province. Presented by M van den Berg at international seminar on Economic Transition and Sustainable Agricultural Development in East Asia, Nanjing, P.R. of China, 20-22 October 2003.

One presentation, Project overview IRMLA held by R Roetter (11 March 2003) at an Wageningen UR wide seminar on sustainable agriculture and environmental quality – for project leaders and research programme leaders related to North South research.

Three x 2 presentations on IRMLA held by R Roetter at in-country workshops and stakeholder meetings at Hangzhou (March 2003), Hanoi (April 2003) and Omon (April 2003)

Various presentations on project set-up and planning held by R Roetter at IRMLA Wageningen UR workshop on integration of data and models, 29 September – 4 October 2003.

5.3 Annual report of Zhejiang University (ZU), P.R. China

5.3.1 Progress over the last year

Progress has been according to plan.

5.3.2 Progress of project

Major activities within the project comprised: 1) farm household survey; 2) delineation of land units and determination of suitability of land areas for specific types of land use; 3) Participation in the training workshops at Zhejiang University and at Wageningen UR; 4) production of input-output relationships with TechnoGIN for use in prototype MGLP land use model; 5) Stakeholder consultations.

Farm household survey

Farm household surveys have been carried out in the Pujiang county. Detailed information of a large number of farmer households was collected. More information is given in Section 3.2.4.

Delineation of land units and determination of land suitability

Six land units were identified in Pujiang county that are suitable for crop production. For each land unit, the degree of suitability for different types of land use were determined, as based on four criteria, i.e. land accessibility, irrigation water availability, surface relief and soil properties. Digital land unit maps for Pujiang were produced. For more information, see Section 3.2.3.

Participation in training workshops and production of input-output relationships for MGLP

Training workshops were held from March 29 to April 4, 2003 at Zhejiang University and from September 29 to October 4, 2003 at Wageningen University. Main focus of the first workshop was on current land use and cropping systems and on the use of TechnoGIN for analysing input-output relationships of cropping systems. In the second workshop in Wageningen the input-output relationships for the main cropping systems in Pujiang were produced with TechnoGIN and next used in the prototype MGLP for Pujiang. For more information, see Sections 3.2.5 and 3.2.6.

Stakeholder consulations

The first scenario analysis results were presented to the stakeholders. Discussions between scientists and stakeholders in Pujiang indicated the required improvements of the scenarios. For more information, see Section 3.2.7.

List of papers published:

Marrit van den Berg, Wang Guanghuo, and Reimund Rötter (2003) Decreasing the use of agrochemicals in rural China: setting priorities for research and policy in Zhejiang province. Proceedings of the international seminar on Economic Transition and Sustainable Agricultural Development in East Asia, Nanjing, P.R. of China, 20-22 October 2003.

List number of PhDs and number of MScs:

Planned Ph.D. study :
Input – output calculation for land use scenario analysis in Pujiang county : Mr. Fang Bin, deadline July 2004.
Planned Msc. study:
Estimation of potential yields for Pujiang case study using different methods, and MGLP analysis for Pujiang : Ms. Xie Wenxia.

5.4 Annual report of National Institute for Soils and Fertilizers (NISF), Vietnam

5.4.1 Progress over the last year

The progress of the work has been according to the project plan.

5.4.2 Progress in achieving project objectives

Major activities within the project comprised: 1) stakeholder workshops at NISF; 2) production of input-output relationships for the main land use types with TechnoGIN for use in MGLP model; 3) production of digitized land unit map; 4) design of a prototype MGLP model for Tam Duong; 5) Participation in training workshop at Wageningen UR.

Stakeholder workshops
The objectives and problems for development of the Tam Duong district have been determined. This is done by organising stakeholder meetings, by discussions with planning officers, and by collecting information from district planning offices. For more information, see Sections 3.3.1 and 3.3.2. The resulting information is needed for the MGLP applications and analyses.

Production of input-output relationships for main land use types
For the main land use types in Tam Duong the input-output relationships have been calculated for the suitable land units. These calculations have been performed with TechnoGIN (Section 2.2).

Production of land unit map
A land unit map is produced for Tam Duong on the basis of soil, climate and DEM maps (see Section 3.3.4). The land unit map presents the suitability and limitations for crop production.

Design of MGLP model for Tam Duong
A prototype MGLP has been developed for the Tam Duong district. This model can be used to analyse the possible decisions on land use and their consequences. First results from MGLP application for Tam Duong are presented in Section 3.3.5.

Wageningen Workshop
This workshop was held from 29 September to 4 October 2003 at Wageningen University. The main work was on first, improving knowledge on model application and use and second, applications of models (TechnoGIN and MGLP) to the Tam Duong district. Dr. Tran Thuc Son, Dr. Nguyen Van Chien and Dr. Pham Qua Ha participated in the Wageningen workshop.

List of papers published:

none

List of number of PhD and number of MScs:

Ph.D.-study: Mr Mai Van Trinh – Integrated nutrient dynamics with special emphasis on erosion and leaching in Vietnam.

5.5 Annual report of Mariano Marcos State University (MMSU), Philippines

5.5.1 Progress over the last year

Progress has been according to plan.

5.5.2 Progress of project

Major activities within the project comprised: 1) Analysis of farm household survey output; 2) Application of technical coefficient generator to produce input-output tables for Dingras; 3) Design of farm household model for Dingras; 4) Participation in the training workshop at Wageningen UR; 5) Two stakeholder consultation workshops at MMSU.

Farm surveys
Farm surveys have been carried out for Dingras and Batac counties. The interview topics and the collected information is given in Section 3.4.4 on farm typology.

Production of input-output tables
TechnoGIN-3 has been applied for calculating the required inputs (e.g. labor, fertiliser nutrients) to attain target yield levels for the main land use type (LUT) – land unit – technology combinations in Dingras. The main land use types and land units for which the input-ouput relationships have been produced, are given in Section 3.4.5. See Section 2.2 for information on the modelling approach and output of TechnoGIN-3.

Farm household model
To analyse the decisions on land use in Dingras county, a farm household model has been developed. For more information on the structure and input data of this model for Dingras, see Section 3.4.5 and for information on the model variables and output, see Section 3.4.6.

Workshop at Wageningen UR, September-October 2003
The workshop focussed on farm household modelling and input-output estimation. Epifania O. Agustin and Dionision S. Bucao participated in the workshop.

Stakeholder consulation workshops at MMSU
The first workshop was held in April 7-11 2003. The main focus was on a) consultation of stakeholders on land use and resource management issues; b) presentation of capabilities of model approaches and data requirements. For more information, see Section 3.4.3.

The second workshop was held in August 2003 to give feed-back to stakeholders on the progress in model development.

List of papers published:

Hoanh, C.T., Roetter, R.P., Aggarwal, P.K., Bakar, I.A., Tawang, A., Lansigan, F.P., Francisco, S.,Lai, N.X., Laborte, A.G., 2000. LUPAS: an operational system for land use scenario analysis. In: Roetter, R.P., Keulen, H. van, Laborte, A.G., Hoanh, C.T., Laar, H.H. van (Eds.), Systems research for optimizing future land use in South and Southeast Asia. SysNet Research Paper Series No. 2, IRRI, Los Banos, Philippines.

Ponsioen, T., Laborte, A.G., Roetter, R.P., Hengsdijk, H., Wolf, J., 2003. TechnoGIN-3: a technical coefficient generator for cropping systems in East and South-east Asia. Quantitative Approaches in Systems Analysis QUASA report no. 26. Alterra & The C.T. de Wit Graduate school for Production Ecology & Resource Conservation, Wageningen, The Netherlands. 67 pp.

Rötter, R.P., C.T. Hoanh, A.G. Laborte, H. Van Keulen, M.K. Van Ittersum, C. Dreiser, C.A. Van Diepen, N. De Ridder and H.H. van Laar, 2003. Integration of systems network tools for regional land use scenario analysis in Asia. Submitted to Environmental Modelling and Software.

De Ridder, N., Van Keulen, H., Roetter, R., Van Ittersum, M.K., Hoanh, C.T., Aggarwal, P.K., Ismail, A.B., Lansigan, F.P., Francisco, S.R., Lai, N.X., Laborte, A.G., 2004. A generic methodology for strategic land use analysis applied to four sub-national regions in South and Southeast Asia. Submitted to Agriculture, Ecosystems and Environment.

List number of PhDs and number of MScs:

Finalized:
2 MScs of Ms Xiang Bi and of Mr Willy Pradel, Optimizing resource use of farm households in Batac, Philipines.

Ongoing:
PhD work of Ms Alice Laborte, A multi-scale land use analysis tool for Ilocos Norte Province, Philippines;
MSc work of Ms Anne Gerdien Prins, Farm household modelling in Batac.

5.6 Annual report of Cuu Long Delta Rice Research Institute (CLRRI), Vietnam

5.6.1 Progress over the last year

The work has been according to the project plan.

5.6.2 Progress in achieving objectives of project:

Major activities within the project comprised: 1) digitized land unit map for O Mon district; 2) characterisation of the main agricultural production activities in the O Mon district; 3) generation of input-output relationships for the main production activities; 4) development of a prototype farm household model for O Mon district; 5) participation in the Wageningen workshop.

Land unit map
A digitized land unit map is produced on the basis of the soil map and a flooding map. The units on this land use map differ with respect to their potential and limitations for agricultural use. For more information, see Section 3.5.4.

Main agricultural production activities
The most promising land use types have been selected for the O Mon district, as given in Section 3.5.4.

Generation of input-output relationships for production activities
Input-output relationships have been produced for the main combinations of land use type, land unit and type of production technology in the O Mon district. These input-output-relationships have been produced with TechnoGIN (see Section 2.2).

Development of farm household model
The input-output relationships are used in the the prototype farm household model (FHM) for O Mon. The mathematical description of the FHM is given in Section 3.5.5. More background information about the FHM for O Mon is given in Section 2.3.

Participation in Wageningen workshop
Dr. Nguyen Xuan Lai and Mr. Nguyen The Cuong participated in the workshop in September/October 2003 at Wageningen UR. Main focus was on the further development of the farm household model.

List of papers published

Hoanh, C.T., Roetter, R.P., Aggarwal, P.K., Bakar, I.A., Tawang, A., Lansigan, F.P., Francisco, S., Lai, N.X., Laborte, A.G., 2000. LUPAS: an operational system for land use scenario analysis. In: Roetter, R.P., Keulen, H. van, Laborte, A.G., Hoanh, C.T., Laar, H.H. van (Eds.), Systems research for optimizing future land use in South and Southeast Asia. SysNet Research Paper Series No. 2, IRRI, Los Banos, Philippines.

Lai, N.X., D.M. Jansen, C.T. Hoanh, V.T.K. Hoa, H.V. Nghiep, P.Q. Hung and T.Q. Tuan, 2000. The development and application of SysNet methodology for exploring land use options in Can Tho Province, Vietnam. In: Roetter, R.P., H. Van Keulen, A.G. Laborte, C.T. Hoanh & H.H. Van Laar (Eds), Systems research for optimizing future land use. SysNet Research Paper Series No. 2, IRRI, Los Baños, Philippines, pp. 105-115.

De Ridder, N., Van Keulen, H., Roetter, R., Van Ittersum, M.K., Hoanh, C.T., Aggarwal, P.K., Ismail, A.B., Lansigan, F.P., Francisco, S.R., Lai, N.X., Laborte, A.G., 2004. A generic methodology for strategic land use analysis applied to four sub-national regions in South and Southeast Asia. Submitted to Agriculture, Ecosystems and Environment

List numbers of PhDs and number of MScs:

Ph.D. work of Daan Kayser (Ph.D. student of the University of Utrecht, the Netherlands), ‘Social and economic change in the Mekong delta, Vietnam’. For information on his field work that was done in close collaboration with the IRMLA team at CLRRI, see Section 3.5.3.

5.7 Annual report of Institut für Meteorologie und Klimaforschung – Atmosphärische Umweltforschung – Forschungszentrum Karlsruhe GmbH (IMK-FZK), Germany

5.7.1 Progress over the last year

Progress has been according to plan.

5.7.2 Progress of project

The activities of IMK-IFU refer to WP2 (Yield gap and environmental risk analysis). While the activities in the first year of this work package were devoted to yield gap analysis, the second year addressed the risk assessment. A detailed description of the available results is given in Section 2.4..

The objectives of WP2 were defined as follows:

- To determine yield probabilities, frequencies of adverse weather phenomena and assess their possible impact on production and economic risks under current and future (improved) management practices
- To establish guidelines to adjust management practices to prevailing climatic fluctuations in selected areas

The analysis of potential and water-limited yields in the first year has revealed relatively small year-to-year variation in the yield levels at the four IRMLA regions. While the comparison with actual yield records is still ongoing, the focus of WP2 in the second year has shifted from the short-term dynamics to the long-term trends in climate-induced risks.

At this point, we have established a data base on short-term dynamics and have projected long-term trends for the specific conditions of the four regions. Jointly with other data from farm surveys, this information will be integrated into a comprehensive analysis of climate-induced risks in the remaining course of the project and integrated into the IRMLA land analysis tools. Thus, the work of WP2 is basically on track to comply with the objectives related to yield gap and environmental risk analysis.

List of papers published:

Wassmann, R., N. Xuan Hien, C. Thai Hoanh, and T.Tuong, (2003) Sea Level Rise affecting hydrology and rice production in the Vietnamese Mekong Delta. Climatic Change, in press.

List number of PhDs and number of MScs:

None

List of conference/seminar/workshop presentations:

R. Wassmann, N. X. Hien, C. T. Hoanh, T. P. Tuong, December 2002.. Sea Level Rise affecting future resource management in Vietnamese Mekong Delta. Presentation at German-Vietnamese Workshop on Sustainable Utilisation and Management of Land and Water Resources in the Mekong Delta, Vietnam; Ho Chi Minh City.

R. Wassman**,** October 2003**.** Status report on WP2. Presentation at IRMLA workshop in Wageningen.

R. Wassman, October 2003. Sea Level Rise Affecting Hydrology and Rice Production in the Vietnamese Mekong Delta. Poster at Deutscher Tropentag.

5.8 Annual report of Group Plant Production systems, Department of Plant sciences, Wageningen university (PPS-DPW-WU), The Netherlands

5.8.1 Progress over the last year

Progress has been according to plan.

5.8.2 Progress of project

Major activities of the Plant Production Systems group comprised: 1.Finalization and documentation of Technical coefficient generator TechnoGIN (see WP3); 2. Development of a prototype farm household model (see WP4); 3. Training and support (see WP6)

WP3 Technical coefficient generation

- The Technical Coefficient Generator, Techno-GIN, has been finalized and documented. This version will serve as a prototype for each of the four case studies: case study specific land use systems, production environments and data will be further used to make the TCG operational for each of the 4 regions.
- Local teams have been trained and supported in the development and application of Techno-GIN

WP4 Farm household modeling

- A prototype farm household model has been developed, which will be used and applied by two teams to their case studies and specific problems, i.e. Omon district (S-Vietnam) and Batac-Dingras municipalities (Philippines).
- These two local teams have been supported in development of farm household models & regional models
- The local teams have been supported in data storage, cleaning and analysis
- For Batac first operational farm household models for a number of farm types are available and in the testing phase.

WP 6 Training

- Training and support has been provided to local teams on the basis of individual needs and requests (particularly via Marrit van den Berg, Tommie Ponsioen, Lu Changhe).
- Marrit van den Berg, Tommie Ponsioen and Martin van Ittersum participated in the stakeholder workshop in Tam Dao, Omon and Batac-Dingras in March-April 2003. Dr. Lu Changhe (paid via PPS-DPS-WU) contributed to the workshop in Pujang-Zeijang.
- Training workshop in Wageningen prepared and held, with intensive contributions of Marrit van den Berg, Tommie Ponsioen, Lu Changhe and Martin van Ittersum. Note: due to the SARS epidemic, the workshop was not held in June but in September.
    -

List of papers published:

1. Marrit van den Berg, Wang Guanghuo, and Reimund Rötter (2003) Decreasing the use of agrochemicals in rural China: setting priorities for research and policy in Zhejiang province. Proceedings of the international seminar on Economic Transition and Sustainable Agricultural Development in East Asia, Nanjing, P.R. of China, 20-22 October 2003.

2. Van Ittersum, M.K., R.P. Roetter, H. van Keulen, N. de Ridder, C.T. Hoanh, A.G. Laborte, P.K. Aggarwal, A.B. Ismail, A. Tawang, 2003. A systems network (SysNet) approach for interactively evaluating strategic land use options at sub-national scale in South and South-east Asia. Submitted to Land Use Policy.

3. Rötter, R.P., C.T. Hoanh, A.G. Laborte, H. Van Keulen, M.K. Van Ittersum, C. Dreiser, C.A. Van Diepen, N. De Ridder and H.H. van Laar, 2003. Integration of systems network tools for regional land use scenario analysis in Asia. Submitted to Environmental Modelling and Software.

4. De Ridder, N., Van Keulen, H., Roetter, R., Van Ittersum, M.K., Hoanh, C.T., Aggarwal, P.K., Ismail, A.B., Lansigan, F.P., Francisco, S.R., Lai, N.X., Laborte, A.G., 2004. A generic methodology for strategic land use analysis applied to four sub-national regions in South and Southeast Asia. Submitted to Agriculture, Ecosystems and Environment.

List number of PhDs and number of MScs:

Finalized: 2 MScs: Ms Xiang Bi, Mr Willy Pradel: Optimizing resource use of farm households in Batac, Philippines – supervision: Dr. R.A. Schipper and Dr. M.K. van Ittersum.

Ongoing: 2 PhDs : Ms Alice Laborte - A multi-scale land use analysis tool for Ilocos Norte Province, Philippines; Mr Mai Van Trinh – Integrated nutrient dynamics with special emphasis on erosion and leaching in Vietnam and 1 MSc : Ms Anne Gerdien Prins: Farm household modelling in Batac, Philippines – supervision: Dr. M.K. van Ittersum and Dr. M.M. van den Berg.

List of conference/seminar/workshop presentations:

1. Marrit van den Berg (2003). Paper presented at the international seminar on Economic Transition and Sustainable Agricultural Development in East Asia, Nanjing, P.R. of China, 20-22 October 2003.

2. Marrit van den Berg, Wang Guanghuo, and Reimund Rötter (2003) Decreasing the use of agrochemicals in rural China: setting priorities for research and policy in Zhejiang province. Proceedings of the international seminar on Economic Transition and Sustainable Agricultural Development in East Asia, Nanjing, P.R. of China, 20-22 October 2003.

3. Marrit van den Berg & Gideon Kruseman (2003)Poster presentation at the 25th International Conference of the Interational Association of Agricultural Economists, Durban, South Africa 16-22 August 2003. Modeling crop production in less-favored areas: Combining economic and biophysical methods

5.9 Annual report of Plant Research International (PRI), Wageningen, The Netherlands

5.9.1 Progress over the last year

Progress has been according to plan.

5.9.2 Progress of project

The main contribution to the project are:

- Contribution to multi-stakeholder workshops in Pujiang, Tam Duong and Dingras to further establish stakeholder platforms (April 2003).
- Contribution to the further development of technical coefficient generators for cropping systems in Dingras, Pujiang, Tam Duong and Omon.
- Contribution to the identification of future cropping systems in each of the case study areas.
- Development of a technical coefficient generator for animal activities.
- Contribution to the linking of different project components (technical coefficient generators and LP-models).
- Contribution to the training workshop on regional and farm household modelling and input output estimation at Wageningen UR (October 2003).
- Contribution to yield estimation using crop growth simulation models and in-country support of Zhejiang University with the definition of cropping systems (November 2003)

List of papers published:

1. Hengsdijk, H. & M.K. van Ittersum, 2003. Formalizing agro-ecological engineering for future-oriented land use studies. European Journal of Agronomy 19: 549-562.

2. Hengsdijk, H. & M.K. van Ittersum, 2003. Dynamics in input and output coefficients for land use studies: a case study for nitrogen in crop rotations. Nutrient cycling in Agroecosystems 66: 209-220.

3. Ven, G.W.J. van de, Ridder, N., de, Keulen, H. van, Ittersum, M.K. van, 2003. Concepts in production ecology for analysis and design of animal and plant-animal production systems. Agricultural Systems 76: 507-525.

4. Hengsdijk, H., 2003. An introduction to the Technical Coefficient Generator for land use systems in Tigray. Developed within the project Policies for Sustainable Land Management in the Ethiopian Highlands. Plant Research International Nota 241.

List number of PhDs and number of MScs:

Zhong Jiayou: Options for rice-based farming systems in a humid subtropical region: a case study for Jiangxi Province, China

List of conference/seminar/workshop presentations:

Hengsdijk, 2003. Data requirements for the LUPAS methodology. Presentation at Pujiang stakeholder meeting April 2003.

Other output:

Support in the generation of technical coefficients of a PhD-student from Eritrea studying at the University of Groningen (Netherlands) who is working with farm household models in Eritrea, similar to the models developed within IRMLA for South-East Asia.