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Achieving Food Security and Environmental Sustainability in Southeast Asia: A Policy Challenge

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Abstract

In order to get a thorough picture on the possible situation of food and the environment in Southeast Asia in 2030 and to identify the areas that need policy intervention, five scenarios on future food production are reviewed and compared here. These scenarios include: 1) FAO AT 2015/30 which is taken as the baseline development; UNEP's GEO-3 2) *Policy Reform* and 3) *Market Forces* scenarios; and IPCC scenarios 4) *B1* and 5) *A1B* as interpreted and elaborated in IMAGE 2.2 model. Based on these scenarios, a set of policy measures for ASEAN (Association of Southeast Asia Nations) is identified, especially regarding crop production. Increased crop production in the region will be achieved to a large extent by intensification. There is room for ASEAN to foster the integration of environmental concerns into agricultural policy. Closer networking between the agricultural and the environmental unit is very important for more effective and efficient co-operation. It may be necessary for ASEAN to set up a project to formulate a new ASEAN Common Agricultural Policy (ACAP), covering such elements as: developing agri-environmental indicators for the region; improving fertiliser efficiency; limiting pesticide; limiting methane emission from wetland rice; managing agricultural land expansion; limiting soil degradation; directing genetically modified (GM) crops development with close scrutinisation; enhancing rural development; and taking advantage from international agricultural trade by active and co-ordinated participation in trade talks.

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Abbreviations

ASEAN	: Association of Southeast Asia Nations
ACAP	: ASEAN Common Agricultural Policy
AT 2015/30	: Agriculture Towards 2015/30
CGIAR	: Consultative Group on International Agricultural Research
EU	: European Union
FAO	: Food and Agriculture Organization of the United Nations
FAOSTAT	: FAO Statistical Database
GEO-3	: Global Environmental Outlook 3
GMO	: Genetically Modified Organism
ICM	: Integrated Crops Management
IFPRI	: International Food Policy Research Institute
IMAGE	: Integrated Model to Assess the Global Environment
IPM	: Integrated Pest Management
IPCC	: Intergovernmental Panel on Climate Change
IRRI	: International Rice Research Institute
MF Scenario	: The Market Forces scenario of the GEO-3
NGO	: Non-Governmental Organisation
PR Scenario	: The Policy Reform scenario of the GEO-3
RIVM	: The National Institute for Public Health and Environment of the Netherlands
UNEP	: The United Nations Environmental Program
WTO	: The World Trade Organisation

Samenvatting

Deze studie gaat over akkerbouw in Zuid-Oost Azië en de milieugevolgen daarvan. Vijf mondiale scenario's worden vergeleken teneinde een goed beeld te krijgen van de mogelijke situatie in de regio in 2030 met betrekking tot voedsel en milieu. Op grond hiervan zijn onderwerpen geïdentificeerd die om nieuw beleid vragen. In het bijzonder is gelet op mogelijkheden voor beleid van ASEAN, de regionale organisatie van tien landen in Zuid-Oost Azië.

De onderzochte scenario's zijn FAO Agriculture Towards 2015/2030; Policy Reform en Market Forces uit concepten voor de derde Global Environment Outlook (GEO-3); de IPCC-scenario's A1B en B1 maar dan geïnterpreteerd en uitgewerkt met het IMAGE 2.2 model.

Bovenal bepalen menselijke keuzen hoe de toekomst er in de regio er uit zal zien. In het bijzonder geldt dat voor de noodzakelijke beleidsmaatregelen. In al de vijf scenario's moet de gewasproduktie toenemen om in de vraag te voorzien. De mate van toename hangt af van hoe het consumptie-niveau zich ontwikkelt, maar ook van dieetvoorkeuren, zoals vleesconsumptie, en van de export van landbouwprodukten. De toename van de gewasproduktie zal in Zuid-Oost Azië vooral worden bereikt door intensivering van de akkerbouw.

Er blijken inderdaad mogelijkheden voor ASEAN om de integratie van milieu-overwegingen in het landbouwbeleid te bevorderen. Nauwere samenwerking tussen de landbouw- en milieu-eenheden van ASEAN is belangrijk. Wellicht moet ASEAN een nieuw gemeenschappelijk landbouwbeleid voor de regio formuleren. Mogelijke onderdelen daarvan zijn: het ontwikkelen van regionaal toegesneden indicatoren voor landbouw en milieu; efficiënter gebruik van kunstmest door de kennis van boeren te vergroten en door de prijzen van kunstmest en landbouwprodukten te harmoniseren; beperken van het gebruik van bestrijdingsmiddelen door geïntegreerde gewasbescherming en geïntegreerde teelt; het beperken, als onderdeel van mondiaal klimaatbeleid, van de emissie van methaan uit de natte rijstbouw door inzet van de beschikbare technieken; planmatige uitbreiding van landbouwgrond en monitoring van landgebruik; het tegengaan van landdegradatie door speciale programma's; beheerste en nauwkeurig gecontroleerde toepassing van genetisch gemodificeerde gewassen; het bevorderen van plattelandsontwikkeling door duidelijker eigendoms- en gebruiksrechten van land; het aanmoedigen van de inbreng van niet-overheidsorganisaties; betere benutting van toekomstige handel in landbouwprodukten door gecoördineerde deelname in besprekingen.

Summary

This study focuses on crop production and its implications to the environment. Five scenarios on future food production are compared to get a thorough picture on the possible situation of food and the environment in Southeast Asia in 2030, and to identify the areas that need policy intervention. These scenarios include: 1) FAO AT 2015/30 which is taken as the baseline development, UNEP's GEO-3 2) *Policy Reform* and 3) *Market Forces* scenarios, and IPCC scenarios interpreted and elaborated in IMAGE 2.2 model 4) *B1* and 5) *A1B*. A set of policy measures is identified for ASEAN, the regional organisation of the ten Southeast Asian countries. It is particularly human choices that will shape the future. It is a matter of human choice, e.g. by means of policy, whether necessary actions would be taken to protect the environment. The five scenarios altogether show a basically comparable picture where crop production will increase to keep up with the increase in demand. The extent of the increase depends on the assumptions on average daily consumption and diets, and assumptions on export. Increase in crop production to a large extent will be achieved by crop intensification.

There is room for ASEAN to foster the integration of environmental concerns into agricultural policy. Closer networking between the agricultural and the environmental unit is very important for a more effective and efficient co-operation. It may be necessary for ASEAN to set up a project to formulate a new ASEAN Common Agricultural Policy (ACAP), covering several elements as follows: developing agri-environmental indicators for the region; improving fertiliser efficiency by educating farmers and harmonising price of fertilisers and food products; limiting pesticide use by further co-operation in Integrated Pest Management (IPM) and Integrated Crops Management (ICM); limiting methane emission from wetland rice with available technologies; managing agricultural land expansion with careful land-use planning and monitoring; limiting soil degradation with soil conservation management, directing genetically modified (GM) crops development with close scrutinisation, enhancing rural development by promoting clear land rights and encouraging NGOs participation; and benefiting from international agricultural trade by active participation in international trade talks.

1. INTRODUCTION

1.1 Objective

The objective of the study is to evaluate how food security and environmental sustainability in Southeast Asia can be achieved.

1.2 Situation Review

1.2.1 Increasing need for food in Southeast Asia

The world's population and economy are both projected to grow over the next century. This growth is expected to raise the world's demand for human's basic needs, including food. Global food security calls for more production, poverty alleviation and international agricultural trade mechanisms. Let us now look at food production. Under current agricultural systems, increased food production through intensification and land extension will potentially create pressures to the environment, due to the use of fertilisers and pesticides, the increased energy and freshwater demand, and loss of natural areas.

Policy measures are needed if economic, social and environmental sustainability is to be achieved. In relation to food, economic sustainability means increased agricultural productivity and production for regional food security and export. Social sustainability means improved productivity and profitability of small-scale agriculture and ensured household food security, and environmental sustainability means ensured sustainable use and conservation of land, forest, wildlife, fisheries and water resources (UNEP, 1999).

Southeast Asia belongs to the developing world. With its population of about 500 million in the year 2000, it is one of the most populous regions in the world. One of every ten persons in the world today is a Southeast Asian. The region binds ten countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam (Figure 1.1).

Many factors lead to a challenge in meeting food security and environmental sustainability in Southeast Asia. Its population and GDP per capita are projected to increase significantly according to UN projections, hence increasing food demand. But natural resources are limited and the environment is at stake.

1.2.2 Outlook of the world's future

Projections of the world's future have been developed by many international institutions. In relation to food security issues in Southeast Asia, this study considers three outlook sources. The first one is the Agriculture: Towards 2015/30 Technical Interim Report of the Food and Agriculture Organization of the United Nations (FAO), which is further referred to in this report as FAO AT 2015/30. The second one is the Global Environmental Outlook 3 (GEO-3) of the United Nations Environment Programme (UNEP). And the third one is the implementations of the new Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios (SRES) in the Integrated Model to Assess the Global Environment (IMAGE) 2.2 developed by The Dutch National Institute for Public Health and Environment (RIVM).

Figure 1.1 Map of the Region of Southeast Asia
Source: The World Factbook, 2000

FAO AT 2015/30

FAO has been making periodical forward assessments of possible future developments in world food, nutrition and agriculture, including crops, livestock, forestry and fisheries sector. The series include *Provisional Indicative World Plan for Agricultural Development (1970), Agriculture: Towards 2000 (1981), World Agriculture: Towards 2000, an FAO Study (1988),* and *World Agriculture: Towards 2010, an FAO Study (1995).* Currently FAO is preparing its latest forward assessment, *Agriculture: Towards 2015/30*.

The FAO AT 2015/30 Technical Interim Report presents the main quantitative results, with little or no evaluation of the impacts on broader issues such as rural development and poverty, and with little or no analysis of agricultural, international trade and environmental policy issues (FAO, 2000). The reasoning behind this vision includes food demand (determined by population, economic growth, socio-cultural background), development of agricultural technology and management, trade and climate. The FAO vision is developed in a bottom-up approach, where analysis was initially made for individual countries and then aggregated and presented into regional level. The analysis are presented in matrices, showing very detailed data and projections of area, yield, production, demand, supply-utilisation accounts, agricultural land potential and use, etc. of every given country and aggregation. Southeast Asia forms one aggregated region in the analysis, covering all member countries of ASEAN except Brunei and Singapore.

UNEP GEO-3

UNEP, through its GEO series, provides a comprehensive assessment of the state of the global environment, a review of policy responses and an outlook on the future. The outlook of the future is set up by means of scenarios. In GEO-3, four scenarios are considered, namely *Market Forces*, *Policy Reform*, *Fortress World* and *Great Transitions* (Raskin, 2000). The most significant driving forces that currently shape global and regional development, and condition the future in this projection are demographics, economics, social and cultural effects, technology, environment and governance. In contrary to FAO projections, GEO-3 scenarios are developed with a top-down geographical approach. Storylines were initially made at global level, and then zoomed into regional and sub-regional level such as Southeast Asia.

The first two scenarios envision the global system of the 21st century evolving along the lines of globalisation without major surprises. Both scenarios envisions the evolution of institutions and values, the rapid growth of the world economy, and the convergence of global regions towards the norms set by highly industrialised countries. However, compared to Market Forces, in Policy Reform scenario there is less faith that social and environmental stress can be mitigated adequately through the automatic responses of competitive markets. Sustainable goals are pursued as a proactive strategic priority. There is emergence of the political will to constrain and guide market-driven growth with a comprehensive set of sustainable policies. Policy Reform scenario can be categorised as “backcast”, which begins with an image of desirable future conditions and seeks development trajectories to reach this future states (GEO-3 draft).

Fortress World pictures a world descending towards fragmentation, extreme inequality and widespread conflict as socio-economic and environmental stresses mount. In the *Great Transitions* scenario, a new development paradigm emerges in response to the challenge of sustainability, distinguished by pluralism, planetary solidarity, and new values and institutions (GEO-3 draft).

RIVM IMAGE 2.2

RIVM has been developing a global change model for scenario studies called IMAGE. As implementations of the SRES of IPCC, IMAGE considers four main storylines for the future, namely A1, A2, B1 and B2. These storylines were constructed on two axes, one representing the degree of globalisation versus regionalisation, and the other representing the degree of orientation on material versus social and ecological values, as shown in the figure 1.2 below.

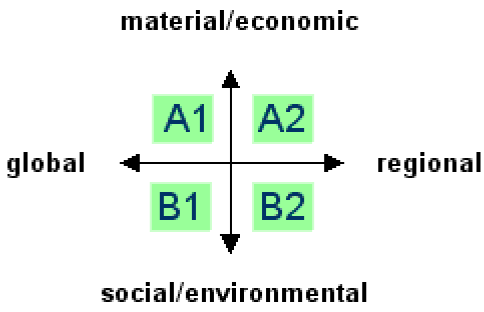


Figure 1.2 Main Storylines for the Future in IMAGE 2.2

Source: IPCC, 2000

Several driving forces are considered as pressure indicators in this model, including economic, population, energy use and supply, and agricultural demand and production. The currently developed IMAGE 2.2 divides the world into seventeen regions to match the regional grouping of GEO-3, with Southeast Asia being one of the regions.

The relevancy of the three outlooks

The three sources of the world's future outlook are currently being developed or almost finished. To obtain a comprehensive picture of Southeast Asian future of food, agriculture and environment, these three sources are thus timely.

The GEO-3 Policy Reform scenario pictures a world that strives to balance the ongoing trends towards globalisation and materialism on one hand, with sustainability on the other hand. There is no profound change from the current flow of global development, but policy intervention is believed to be able to make a difference towards sustainability. It is thus reasonable to incorporate FAO's conservative projection, which is very much rooted on current situation, with this scenario in order to identify what has to be done to meet food security with environmental considerations. Broadly speaking, IMAGE 2.2 B1 scenario matches GEO-3 Policy Reform scenario, as it describes a globalised, convergent world with rapid changes in economic structures toward service and information economy, and emphasises on global solutions to economic, social and environmental sustainability. The B1 scenario will therefore be incorporated as well.

1.2.3 The Association of Southeast Asia Nations (ASEAN)

The Association of Southeast Asia Nations (ASEAN) exists, encompassing all ten countries of the region, to bring together and get all the countries to co-operate in securing the developments of the region. The areas of co-operation include political and security, economic, functional (environment, science and technology, culture and information) and external relations. Food, agriculture and forestry form one sector of the economic co-operation. In its storyline of Policy Reform scenario in Asia Pacific region, GEO-3 envisions that regional institutions such as ASEAN play important roles to bring together countries for further co-operation.

In ASEAN Vision 2020, the countries commit, among other, to enhance food security in the region. It also envisions a clean and green ASEAN with fully established mechanism for sustainable development to ensure the protection of the region's environment, the sustainability of its natural resources and the high quality of life of its peoples.

1.3 Main Research Question

Having reviewed the current situation, a main research question for this study is formulated:
What policy measures, at the ASEAN level, would be appropriate to realise the FAO's Agriculture Towards 2015/30 vision for the region in light of UNEP's GEO-3 Policy Reform scenario and IMAGE 2.2 B1 scenario?

Answering this question, of course, can only contribute a small portion to the huge effort to meet food security and environmental sustainability in Southeast Asia. Other issues linked to food security such as food distribution systems, poverty and conflicts are also crucial and in some cases might pose bigger constraints to food security than the issue of food production. However, those issues will not be discussed in this research.

1.4 Definitions of Main Concepts and Elements

- *Food security*: the condition when every person is assured of access at all times to the food required to lead healthy and productive lives (IFPRI, 1999).
- *Environmental sustainability*: responsible use and conservation of natural resources so as to maintain or improve their states to ensure that the future generations can still have access to them.
- *Policy measures*: actions to be taken within the capacity of ASEAN to eliminate the burdens against achieving food security and environmental sustainability in the region.
- *FAO's Agriculture Towards 2015/30, UNEP's GEO-3 Policy Reform scenario, IMAGE 2.2 B1 scenario*: some scenarios of the future envisioning, among other, the situation of food and the environment in Southeast Asia by the year 2030 (see section 1.2.2).

1.5 Structure of the Report

The *Introduction* chapter presents the background information about the research. It includes the objective, review of present situation, main research question, definitions of main concepts and the research model.

The *Methodology* chapter reveals how the study was developed; it presents the steps and the boundaries of the research.

The third chapter briefly describes the currently known *Environmental Aspects of Crop Production in Southeast Asia*, to give an idea on what kind of environmental problems might arise in Southeast Asia in the future in general due to agricultural activities.

The fourth chapter shows the results of a very important step towards answering the main research question. It presents the *Comparison of the Scenarios* involved in this study, to get a quantitative picture on the possible food and environmental situation in Southeast Asia by the year 2030.

The core answers to the main research question are presented in the *Policy Areas and Measures for ASEAN*, the fifth chapter of this report. It includes the description of ASEAN policy framework, principles of effective agricultural policy, and the analysis of possible policy areas and measures for ASEAN to achieve the target in food production and minimise environmental trade-offs.

Finally, conclusions of the study are drawn and recommendations are presented in the last chapter.

1.6 Research Model

The research model (figure 1.3) shows the logical structure and scoping of this study.

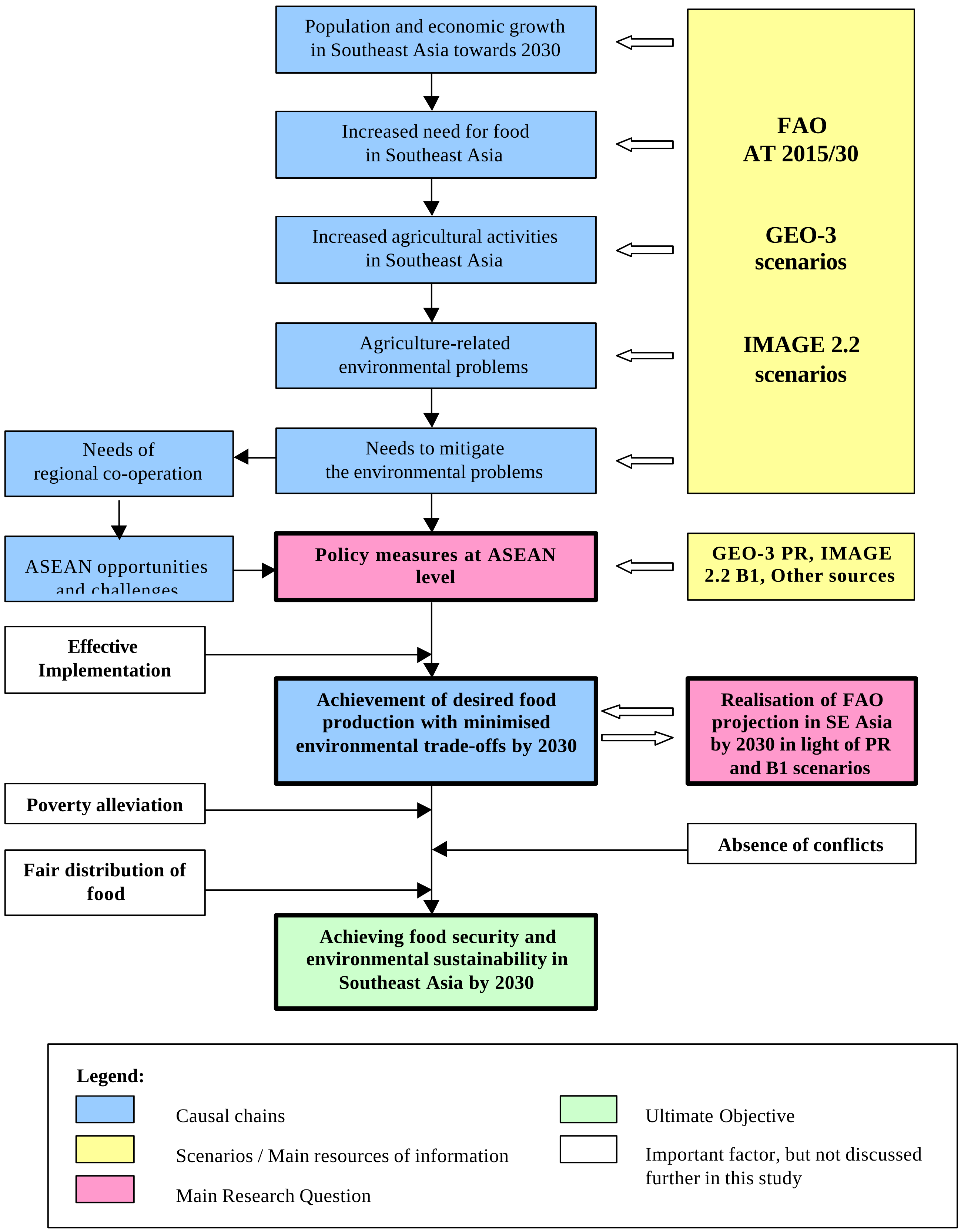


Figure 1.3 Research Model

2. RESEARCH BOUNDARIES AND METHODOLOGY

2.1 Research Boundaries

To be able to conduct the study in sufficient depth, research boundaries must be set. These boundaries include the geographical area, timeframe and agricultural products.

2.1.1 Geographical Area

This research sets its geographical boundary in the regional level - Southeast Asia. This level was chosen instead of national level (individual country) to match GEO-3 visions and IMAGE 2.2 modelling. By matching those two resources, collecting of information is then enabled in the aggregate level. FAO regional level of Southeast Asia excludes Brunei and Singapore. But both countries are net importers of food, so agricultural activities are to a large extent limited to trade.

The second reason is the existence of the Association of Southeast Asia Nations (ASEAN) in the region. The regional governmental organisation has both its capacity and limitation to enhance co-operation in food and agriculture and in environmental issues. This makes it worthwhile to conduct this research.

The third reason is because to our best knowledge study about ASEAN with regards to the visions of GEO-3, FAO AT 2015/30 and IMAGE 2.2 has never been done before. This creates a space to fill in in the continuous attempt to attain global understanding of the harmony between food security and the environment.

2.1.2 Timeframe

The research defines the year 2030 as its time boundary to match the vision of FAO AT 2015/30 and GEO-3. FAO has chosen 2030 because the time horizon would offer a sufficiently long period (about 35 years from the base year 1995/97) to analyse issues of technical agriculture and sustainability (FAO, 2000). GEO-3 has chosen 2002 as its base-year (10 years after the Rio Summit) and looks 30 years back and 30 years ahead.

The year 2030 gives space for the scenarios to envision the world's future beyond what is determined by current demographic impetus, capital stock and institutions, but close enough to be influenced by today's strategic investments. The different scenarios show considerably different states and impacts to the world's socio-economy and environment by then. This is logical, as many environmental impacts of human's actions today take effect in relatively long time. PR scenario envisions a notably different world by 2032 than what Market Forces scenario does. IMAGE 2.2 also shows the significant differences in many of the world's indicators among different scenarios. This gives a clear indication that sustainable policies can and will make the difference. This kind of policies, particularly addressing agriculture and the environment in Southeast Asia, is indeed what we are trying to produce in this research.

Setting the year 2030 as the target year also gives a relatively high degree of uncertainty and speculative nature to this research. Specific policies are difficult to define, as stability in the region is difficult to assess. The policies identified for 2030 will therefore be broad.

2.1.3 Agricultural Products

Agricultural products, not including fishery and forestry, can largely be divided into crops and livestock. This research focuses on crop, because crop production is assumed to significantly lead to both agricultural intensification and land expansion, hence potentially causing environmental problems. FAO projects that crop production in Southeast Asia will increase from some 440 million tons in 1995 to 700 million tons in 2030.

Livestock, on the other hand, is excluded in this research. Although its production is projected to grow at a faster pace than crop (FAO, 2000), in developing countries the growth will be more in the form of intensive production as opposed to grazing system (Seré et al., 1996). Expansion of grazing land, which in some parts of the world is the main cause of deforestation, is in this case negligible in Asia (De Haan et al., 1997). The more important pressures from livestock production will thus be related to the production of animal feed from crop and crop residues. This will be accounted for in crop production.

2.2 Research Methodology

This research commences with the notion that the region of Southeast Asia will need more food in the future, hence more crop production. This will lead to increased pressures on the environment. But how much additional production is needed, and how would that affect the environment? These questions must be answered if one wishes to anticipate the changes by means of policy intervention.

2.2.1 Description of environmental problems related to crop production

A brief study is conducted to point out environmental problems that currently arise as consequences of crop production, especially in Southeast Asia. This is done by literature review. The results are presented in chapter 3.

2.2.2 Setting up comparison of the scenarios

Being a technical analysis, the quantitative projections in FAO AT 2015/30 Technical Interim Report give little attention on environmental sustainability and policy issues. GEO-3 and IMAGE 2.2 outlooks provide more information on such issues. To answer the questions on how much additional food production is needed, and how that would affect the environment, the three outlooks are reviewed.

FAO projection is the baseline development in this study. Giving only one scenario, FAO presents the “most likely outcome” of the world food situation in the future. It is considered realistic and directly addressing food issues. The FAO projection gives detailed information on how much production is expected in the region by the year 2030, and how to achieve that. The question is, *what would be the environmental implications of this projection?*

GEO-3 and IMAGE 2.2 each envisions more than one storyline of the world future, and food and agriculture is not the only sector that is considered in both outlooks. These two outlooks are thus less focused on food security issues, but can critically add environmental and policy perspectives to the FAO projection. GEO-3 and IMAGE 2.2 have their own visions on food production for each of their scenarios, along with the environmental implications. To answer the question above, one needs to know where the FAO projection stands among those visions. Comparison of the three outlooks is thus needed, both quantitative and qualitative.

It is important to keep in mind, however, that GEO-3 quantitative visions are not meant to be rigorous. Instead, they are only meant to give illustrations about the world's future. The figures are derived from PoleStar that has its own limited capacity, which will not be discussed further in this study. When this research is conducted, the GEO-3 writing process is more focused on developing the narrative, hence qualitative visions. Therefore, IMAGE 2.2, which is a modelling framework for global change that provides a quantitative basis for analysing the relative effectiveness of various policy options, is needed to add strength to the quantitative comparison.

Besides helping to analyse the possible environmental consequences of food production in the future, the comparison of the scenarios also serves as a method to identify the areas that need policy measures. This is why the study chooses to incorporate FAO projection with the GEO-3 Policy Reform (PR) scenario and the IMAGE 2.2 B1 scenario (section 1.2.2). The PR scenario, with the support of policy intervention, is a more sustainable alternative to the Market Forces (MF) scenario. The same way applies to the B1 scenario and the A1 scenarios of IMAGE 2.2. Comparing those scenarios - PR to MF, and B1 to A1 - will reveal what differences are found among them, hence what issues needs to be addressed by means of policy efforts.

There are three scenarios within A1 scenario family, namely A1F, A1T and A1B. Which one should be used? These scenarios are distinguished by their technological emphasis in the energy system, A1F is fossil intensive, A1T is technology intensive and A1B is balanced across all energy sources. The A1B scenario fits best to the MF scenario, as A1F is too traditionally dependent on fossil fuels and A1T is too optimistic in envisioning technology development.

Thus there are now five scenarios involved: FAO AT 2015/30, GEO-3 PR and MF scenarios, and IMAGE 2.2 B1 and A1B scenarios. The comparison method now has its structure and richness.

It is necessary to note that the outlooks reviewed here were under way when this study was conducted. The figures presented in the next chapter of this report are subject to changes for the final released version of each outlook. The GEO-3 visions, for example, are currently being distributed around to invite comments. FAO will include broader issues such as rural poverty and environmental policy issues in its final report of Agriculture: Towards 2015/30. However, it is assumed that the changes, if any, will be minor and not radically change the essence of the outlooks that this study is trying to grab.

2.2.3 Identification of policy measures

The next big step towards answering the main research question is identifying the policy measures required to achieve our targets. As described in the earlier section, comparing the scenarios does a part of the work. The comparison reveals several policy areas for ASEAN to address. However, some important issues are not fully covered in the quantitative comparison, such as rural development. To enrich the study, other sources are brought into play. Literature review and expert judgement are resourced. In recommending policy measures, the ASEAN capacity as a regional institution must be considered. A concise study is done, mostly by literature review and interview with ASEAN officials. Interviews were also done to get insights from experts in RIVM, FAO and the World Bank. All of these ingredients are then analysed and integrated, resulting in a set of recommendation of policy measures.

2.2.4 Research flowchart

Figure 2.1 presents the flowchart of the research, showing the steps conducted in the study to answer the main research questions. This illustrates the research methodology described above and how the results of each step are presented in this report.

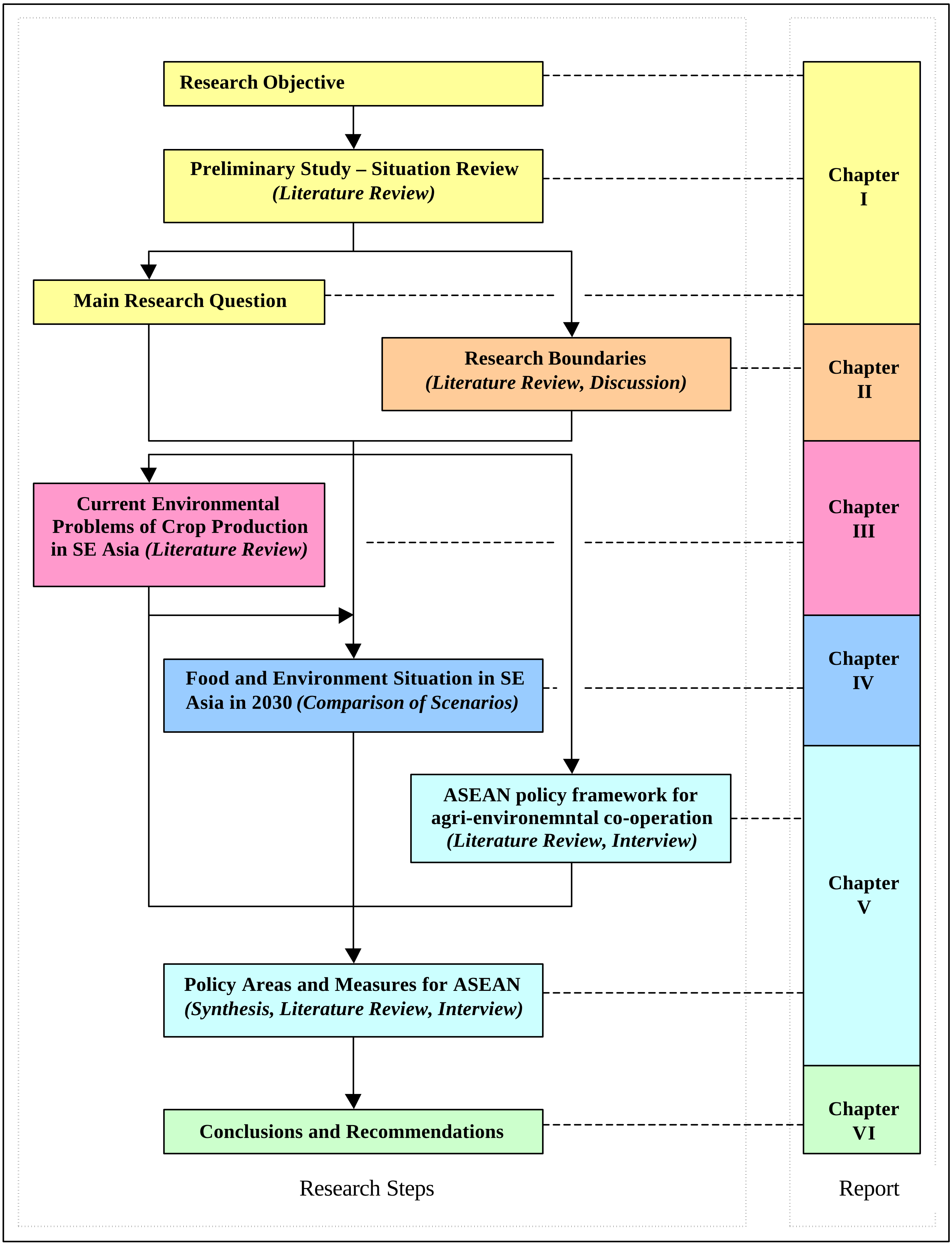


Figure 2.1 Research Flowchart

3. ENVIRONMENTAL ASPECTS OF CROP PRODUCTION IN SOUTHEAST ASIA

3.1 Introduction

Agriculture in general places a heavy burden on the environment in the process of providing humanity with food and fibres. Agricultural activity has been degrading the world's land and water resources. It also generates other adverse environmental impacts, such as threat to biodiversity, climate change, etc. (Alexandratos, 1995; FAO, 2000). All over the world, there has been sufficient evidence of trade-offs between feeding people and protecting the environment. This chapter presents briefly the current environmental aspects of crop production, especially in Southeast Asia. It does not seek to be comprehensive. Instead, it only tries to give a quick illustration on what is happening today and hence what might happen in the future should crop production arise.

3.2 Environmental Problems Related to Crop Production in General

Table 3.1 shows a general summary of environmental issues related to crop production and the relevant impacts. The issues are classified as land use, agricultural technology and input use, and water use.

Table 3.1 Environmental Problems Related to Crop Production

Issues	Impacts
Land Use	
Land cover change (mostly from deforestation)	Damage to hydrological function Threat to biodiversity Soil erosion Climate change Loss of potential production (due to competition with urban and industrial development)
Land degradation (soil erosion, soil fertility decline, salinisation, etc.)	Loss of production
Desertification	Water scarcity Threat to biodiversity
Agricultural Technology and Input Use	
Fertiliser use	Water pollution Climate change
Pesticides use	Water pollution Threat to biodiversity
Genetically Modified Crops (see section 5.4.6)	Threat to biodiversity
Water Use	Water scarcity

Source: FAO, 2000

3.3 Environmental Problems Related to Crop Production in Southeast Asia

As table 3.1 has presented the problems in general, I will now try to zoom in into the environmental aspects of crop production in Southeast Asia. They include agricultural land expansion, land degradation, fertiliser use, pesticide use, water use, and the relationship between agriculture, especially crop production, with climate change.

3.3.1 Land expansion

Agricultural land expansion mostly comes from deforestation, although it is not the only cause of deforestation in Southeast Asia. Collection of wood for domestic fuel, and large-scale logging are other major causes of deforestation. Deforestation leads to release of carbon dioxide, contributing to global climate change. It also affects hydrological function of forests and alters local air temperatures, downwind airflows and humidity. Deforestation also threatens biodiversity, i.e. flora and fauna that might well have commercial potential as food plants, sources of drugs or industrial raw materials in the future (Barrow, 1990). In short, deforestation brings economical as well as ecological losses.

FAO projects limited land expansion by 2030: only about 20% of the incremental crop production in developing countries would come from arable land expansion. The rest would come from intensification. The agri-environmental problems that would arise from crop production would thus be caused mostly by intensification. However, considering the losses related to deforestation, attention should be given to this issue.

3.3.2 Land degradation

Land degradation takes a number of forms, including depletion of soil nutrients, salinisation and soil erosion. Land degradation causes a decline in the productive capacity of the land, hence reducing potential yields. Farmers may need to use more fertiliser or manure in order to maintain yields, or they may temporarily or permanently abandon some plots. Degradation may also induce farmers to convert land to lower-value uses. For example, farmers may plant cassava, which demands few nutrients, instead of maize, or convert cropland to grazing land. Farmland degradation can also have important negative effects off the farm, such as deposition of eroded soil in streams or behind dams. Hot spots of land degradation in Southeast Asia include salinisation in the irrigation systems in northeastern Thailand and soil erosion on the sloping lands of Southeast Asia (Scherr and Yadav, 1996).

3.3.3 Fertiliser use

Increases in biomass do require additional uptake of nutrients that may come from both organic and mineral sources. Historical data has shown the relationship between cereal production and fertiliser: one-third of the increase in cereal production worldwide during the 1970s and 1980s has been attributed to increased fertiliser consumption (FAO, 2000). However, the use of fertilisers should be limited because, besides its positive consequences to maintain soil fertility and soil organic matter levels, it also has its negative aspects. These aspects include groundwater nitrate contamination and eutrophication of surface waters by nitrogen and phosphate, soil acidification by release of ammonia, and the emission of nitrous oxide (N_2O), which is one of the greenhouse gases that cause global climate change (FAO, 2000; IPCC, 2000).

Food output in Asia has become critically dependent on the nutrient (Smil, 2000). Since the 1960s, agriculture throughout Southeast Asia has come increasingly to rely on chemical fertilisers as well as pesticides. With high rainfall and high temperatures it is difficult to prevent these chemicals from contaminating streams, ponds, groundwater and even marine environment (Barrow, 1990). Limiting fertiliser applications is one of many policy challenges in agri-environment issue.

3.3.4 Pesticide use

Pest damage to crops is a major constraint on food production. Severe pest problems are not unusual at regional or local level. A variety of measures is now in use to assist in controlling pests. Pesticides are an integral and indispensable tool in current agriculture (Laegreid et al., 1999).

However, the use of agricultural chemicals must be limited to avoid related environmental problems, including water pollution and loss of biodiversity, and human health problems. Hundreds of millions of farm workers and consumers (globally) are exposed to excessive levels of pesticides; pesticide-induced farm worker mortality and morbidity is still common in developing countries. Many of the pesticides in widespread use are still fairly broad spectrum, thus the negative impacts of pesticides on beneficial insects, birds, other non-target organisms and ecosystem function continue to be widespread (FAO, 2000; Smil, 2000).

3.3.5 Water use

Water is an important factor for agricultural production. It is estimated that at present in developing countries, irrigated agriculture, with about a fifth of all arable land, accounts for about 40% of all crop production and almost 60% of cereal production (FAO, 2000).

The issue related to water use for irrigation is the irrigation efficiency, i.e. the ratio between the estimated consumptive water use in irrigation and irrigation water withdrawal. Irrigation water withdrawals normally far exceeds the consumptive use of irrigation because of water lost in its distribution from its source to the crops. However, FAO (2000) states that in humid areas (such as Southeast Asia) the issue of irrigation efficiency is much less relevant than in water scarce regions (such as Near East / North Africa regions) and is likely to receive little attention.

3.3.6 Impacts of agriculture on climate change

Agriculture contributes about 30 percent of the global anthropogenic emission of GHGs, among other comprising of 40 percent of methane and 80 percent of nitrous oxide emission (FAO, 2000). Over a 100 year time horizon, methane has a global warming potential of 21 and nitrous oxide 310, which means that methane and nitrous oxide are respectively 21 and 310 times more powerful than carbon dioxide in contributing to atmospheric warming (IPCC, 2000).

Methane emission
Agriculture can contribute to methane (CH_4) emissions through rice cultivation and enteric fermentation of cattle (IPCC, 2000). Southeast Asia is a major producer of rice, thus this issue should be addressed, whereas livestock will not be considered in this research (section 2.2.3). Methane emissions from rice cultivation are primarily a function of emission factor and assumed rice cropland area. In turn, emission factors depend on cultivation method (wet versus dry), water management practices, type of rice variety planted, and cropping patterns (IPCC, 2000).

Nitrous oxide emission
Agricultural activities and animal production systems are the largest anthropogenic sources of nitrous oxide emission. Emission from agricultural soils occur through the nitrification and denitrification of nitrogen in soils, particularly that from mineral or organic fertilisers. Emissions are very dependent on local management practices, fertiliser types, and climatic and soil conditions, and are calculated by multiplying an emission factor by the sum of mineral and organic nitrogen applied as fertiliser (IPCC, 2000).

3.3.7 Impacts of climate change on agriculture

Climate change impacts on agriculture remains uncertain. Direct impacts on crop production from increased photosynthesis (CO_2 fertilisation effect), improved water use efficiency and changes in precipitation could be beneficial to some regions and possibly negative to other regions. Changes in local climate (i.e. precipitation and temperature) can both shorten and lengthen the growing season of crops, and thus potential yield. With increasing CO_2, all plants use water more efficiently. Hence, reduced moisture availability can be offset by enhanced water-use efficiency. Climate change would indirectly affect agriculture through changes in water availability and the impact on pest populations (FAO, 2000; RIVM, 2001). A closer look at the IMAGE 2.2 model will give an illustration on how climate change will affect agriculture in Southeast Asia by the year 2030. This will be discussed in chapter 4.

4. COMPARISON OF THE SCENARIOS: CROP PRODUCTION AND THE ENVIRONMENT IN SOUTHEAST ASIA IN 2030

4.1 Introduction

To obtain a quantitative and thorough understanding of crop production and the related environmental consequences in Southeast Asia until 2030/2032, the five scenarios from the three future outlooks are reviewed and compared. The scenarios are the FAO projection, the GEO-3 Policy Reform and Market Forces scenarios, and IMAGE 2.2 B1 and A1B scenarios. All figures and estimates presented in this chapter are for the region Southeast Asia, covering all of the ten ASEAN countries for GEO-3 and IMAGE 2.2 scenarios, and all ASEAN member countries except Singapore and Brunei for FAO scenario.

The indicators selected are those that are related to food security in general, crop production and relevant environmental issues. The data are not always available, or readily available, for every chosen indicator for all the three sources. To resolve this, “hidden” data are pulled out whenever possible. In most cases the figures are converted to the units used in GEO-3. For many of the indicators, growth rates are calculated to show the trends, which are considered more relevant for comparisons than the absolute figures. This is because the base-year data for indicators can be significantly different among the three outlooks, due to differences in definitions or differences in the methods used. As mentioned in chapter 2, it is necessary to note that the outlooks reviewed here are under way when this study is conducted. The figures presented in the next chapter of this report are subject to changes for the final released version of each outlook.

The figures and trends revealed in the comparison matrix reflect the reasoning behind the three outlooks of the future. Below is the discussion on each of the indicators, followed by summary of the three outlooks.

4.2 Demography, Economy and Society

4.2.1 Population

Projections on population are presented in Table 4.1 below.

Table 4.1 Population Projections

	Base-year			2030*				
	FAO 1996	**GEO-3 1995**	**IMAGE 1995**	**FAO**	**GEO-3 PR**	**IMAGE B1**	**GEO-3 MF**	**IMAGE A1B**
Population (million)	484	480	480	705	699	656	719	656
Growth from base-year (% per year)				**1.1**	**1.0**	**0.9**	**1.1**	**0.9**

* For GEO-3: estimates for the year 2032

Using the same source (UN Population Projection), base-year data have the same figures, noting that the base-year of FAO is 1996 instead of 1995. The GEO-3 MF scenario uses Mid-Range projections of the UN 1998 revision and FAO uses world population trends of UN1999. Both show similar projection for 2015, considering that FAO does not include Brunei and Singapore which population comprises 0.7% of total population in the region in 1995 and assuming that the proportion is constant in the timeframe. In GEO-3 PR scenario, the figures are lower than MF due to assumed declines in fertility rates associated with declining poverty and through more active family planning efforts (Raskin, 2000). The population growth in IMAGE 2.2 is lower because it is based on SRES population from the UN 1998 Long-Range medium projection along with IIASA variants. A1 and B1 scenarios envision identical population growth, which is lower than for A2 and B2 scenarios (IPCC, 2000).

4.2.2 GDP per capita

The scenarios for GDP per capita are presented in Table 4.2. GDP per capita is expressed in three different units in the three scenarios, namely 1995 US$ PPP in GEO-3, 1995 US$ in IMAGE 2.2 and 1987 US$ in FAO AT 2015/30. They are converted into 1995 US$.

Table 4.2 GDP Per Capita Estimates

	Base-year			2030*				
	FAO 1996	GEO-3 1995	IMAGE 1995	FAO	GEO-3 PR	IMAGE B1	GEO-3 MF	IMAGE A1B
GDP per capita**	931	4805	1478	3363	13407	5171	12031	7165
GDP per capita in thousand 1995 US$ PPP***	3.4	4.8	3.8	12.2	13.4	13.4	12.0	18.7
Growth from base-year (% per year)				**3.8**	**2.8**	**3.6**	**2.5**	**4.6**

* For GEO-3: estimates for the year 2032
** For GEO-3 in 1995 US$ PPP, IMAGE in 1995 US$, FAO in 1987 US$.
*** Conversion factor: 1995 US$ PPP = 2.63 x 1995 US$ PPP = 3.64 x 1987 US$.

The base-year data of IMAGE 2.2 and FAO are similar. FAO figure for 1996 is lower than IMAGE for 1995 because FAO leaves out two wealthiest countries of the region: Brunei and Singapore. The GEO-3 figure is higher than IMAGE, probably because the “purchasing power parity” method used in comparing different currency values used a different “basket of goods”.

It is interesting to see that although in general the MF scenario is assumed to be comparable with A1B, and PR to B1, their envisioned economic growth contrast. GEO-3 assumes higher growth in PR than in MF whereas in IMAGE the growth is higher in A1B than in B1. The reason is that the PR assumptions reflect more rapid convergence between developed and developing countries compared to the MF scenario (Raskin, 2000), thus disparities between countries would be smaller. The A1 storylines in IMAGE strongly emphasise economic growth as the ultimate target worldwide as opposed to B1 storyline that emphasises sustainability.

FAO, with its envisioned economic growth for the region, is more optimistic than GEO-3, comparable to IMAGE 2.2 B1, but not as optimistic as the A1B scenario.

4.2.3 Hunger incidence/ Incidence of undernourishment

GEO-3 and FAO use this indicator in addressing food security. The figure represents the fraction of the total population in the region that experience hunger, or whose food intake does not provide enough calories to meet their basic energy requirements. The estimates are shown in Table 4.3.

Table 4.3 Hunger Incidence / Incidence of Undernourishment Estimates

	Base-year		2015			2030*		
	FAO 1996	GEO-3 1995	FAO	GEO-3 PR	GEO-3 MF	FAO	GEO-3 PR	GEO-3 MF
Hunger Incidence (% of total population)	**13.2**	**13**	**7.2**	**6**	**9**	**4.0**	**3**	**8**
Growth from base-year (% p.a)			-3.1	-3.8	-1.8	-3.5	-3.9	-1.3

* For GEO-3: estimates for the year 2032

The PR scenario envisions the fulfilment of the target for reducing hunger as one of its social sustainability goals. This is in line with FAO 1996 World Food Summit goal to halve the number of chronically undernourished persons in developing countries by no later than 2015.

FAO itself is not very optimistic about reaching that target, although still shows a more rapid decrease than GEO-3 MF scenario. The reason why FAO is not too optimistic is because a further reduction of incidence of undernourishment would require high rates of growth of aggregate food demand, income growth and better distribution (FAO, 2000). The PR scenario is therefore questionable because compared to FAO it envisions lower increase in average daily consumption, lower economic growth, lower growth in livestock production and only slightly higher crop production, but it envisions more rapid decrease of hunger incidence. One explanation might be that in PR scenario, poverty, one of the causes of food insecurity, is alleviated rapidly due to sustainable policies, whereas the FAO AT 2015/30 technical report does not look into such broader issues.

4.3 Food and Agriculture

4.3.1 Average daily consumption

This indicator expresses the per capita direct human consumption of food in kcal/capita/day. In GEO-3 it is called “average daily consumption”, in IMAGE “daily caloric demand (for agricultural product)”, and in FAO AT 2015/30 “per caput food consumption”. The estimates are presented in Table 4.4.

Table 4.4 Average Daily Consumption Estimates

	Base-year			2030*				
	FAO 1996	**GEO-3 1995**	**IMAGE 1995**	**FAO**	**GEO-3 PR**	**IMAGE B1**	**GEO-3 MF**	**IMAGE A1B**
Avg. Daily Consumption (kcal/cap)	2660	2575	2863	3016	2880	3418	2870	3463
Growth from base-year (% per year)				**0.4**	**0.3**	**0.5**	**0.3**	**0.6**

* For GEO-3: estimates for the year 2032

The base-year data of GEO-3 is comparable to that of FAO, noting the one-year-difference of base-years and an annual increase of about 0.4%. The IMAGE 2.2 estimate for 1995 is about 10% higher than GEO-3 although both are claimed to be derived from the same source (FAO). Because of this difference, the rates of change are more relevant to compare than the absolute figures.

The increases in average daily consumption are consistent with increases in GDP per capita and in food production (both crop and livestock), which makes the growth in GEO-3 higher for PR than for MF, and in IMAGE 2.2 higher for A1B than for B1. FAO projects a slightly higher growth than GEO-3, but lower than IMAGE 2.2.

4.3.2 Share of animal products

This indicator shows the proportion of the daily average consumption per capita that comes from animal products (meat, milk, eggs). The estimates are presented in Table 4.5.

Table 4.5 Share of Animal Products Estimates

	Base-year			2030*				
	FAO 1996	**GEO-3 1995**	**IMAGE 1995**	**FAO**	**GEO-3 PR**	**IMAGE B1**	**GEO-3 MF**	**IMAGE A1B**
Share of animal products (%)	6	7	7	9	11	16	10	18
Growth from base-year (% per year)				**1.2**	**1.2**	**2.4**	**1.0**	**2.7**

* For GEO-3: estimates for the year 2032

The share of animal products in the human diets increases in all scenarios. Together with increases in vegetable oils and sugar consumption, this reflects a shift in diets towards more luxury products, along with increasing incomes.

IMAGE 2.2 shows the highest increase compared to GEO-3 and FAO, which is consistent with its high vision in economic growth. The idea of a converging world in A1 and B1 scenarios might explain why the increase is so high, because consumption patterns in developing regions are assumed to move towards those in developed regions.

The difference of visions between GEO-3 and IMAGE is once again shown here; GEO-3 envisions higher increase in PR than in MF, IMAGE envisions higher increase in A1B than in B1. The IMAGE 2.2 assumption is based on the environmental and health aspects associated with the production and consumption of meat and (to a lesser extent) eggs. These environmental and health aspects are assumed to be important in the B1 and B2 scenarios and less so in the A1 and A2 scenarios (RIVM, 2001). GEO-3, on the other hand, envisions that in PR scenario equity will increase among and within countries, whereas in MF inequity will increase.

4.3.3 Meat and milk production

Table 4.6 shows the estimates on meat and milk production in the future.

Table 4.6 Meat and Milk Production Estimates

	Base-year			2030*				
	FAO 1996	**GEO-3 1995**	**IMAGE 1995**	**FAO**	**GEO-3 PR**	**IMAGE B1**	**GEO-3 MF**	**IMAGE A1B**
Meat & Milk Prod (Mt)	13	12	12	35	32	89	31	113
Growth from base-year (% per year)				**3.0**	**2.7**	**5.9**	**2.6**	**6.6**

* For GEO-3: estimates for the year 2032

In all scenarios meat and milk production is projected to increase faster than crop production. This reflects the consumption pattern with increasing share of animal products in average daily consumption. GEO-3 and FAO AT 2015/30 figures (both production and growth rate) are comparable, whereas IMAGE figures are significantly higher. This is due to its vision on the share of animal products in daily consumption, which is also significantly higher compared to GEO-3 and FAO.

Increase in meat and milk production requires extension of grazing land and/or more production of animal feed from crop or crop residues. In Southeast Asia, the increase would probably come mostly from intensification, hence requiring more feed crop production (Section 2.1.3).

4.3.4 Crop production and total crop production

"Crop production" here refers to the volume of production of food (and feed) crops and biofuel crops, but excluding industrial crops, sugar cane, vegetables and fruits. "Total crop production" expresses volumes of production of total crop, including cereals, roots & tubers, pulses, raw sugar, vegetables and fruits, oilcrops and industrial crops. Crops for animal feed and biofuel crops are taken into account. Lists of commodities are presented in Appendix 1. The estimates on crop and total crop production are presented in Tables 4.7 and 4.8.

IMAGE 2.2 has the estimates on crop production available, but not on total crop production. The figures of total crop production for 1995, however, is available, thus future productions are estimated assuming the same growth rates as crop productions. FAO AT 2015/30 has both data available. Base-year data for both indicators are comparable among the different scenarios. Differences in figures might be caused by the different lists of countries, the different lists of commodities (although it is tried to be inclusive for all outlooks) or different methods of reporting for each crop, for example biomass or products weights.

Table 4.7 Crop Production Estimates

	Base-year		2030		
	FAO 1996	IMAGE 1995	FAO	IMAGE B1	IMAGE A1B
Crop Production (Mt)	**253**	**233**	381	695	867
Growth from base-year (% per year)			**1.2**	**3.2**	**3.8**

Table 4.8 Total Crop Production Estimates

	Base-year			2030*				
	FAO 1996	GEO-3 1995	IMAGE 1995	FAO	GEO-3 PR	IMAGE B1	GEO-3 MF	IMAGE A1B
Total Crop Prod (Mt)	**441**	**418**	**480**	700	689	1432	641	1786
Growth from base-year (% per year)				**1.4**	**1.4**	**3.2**	**1.2**	**3.8**

* For GEO-3: estimates for the year 2032

Crop and total crop production corresponds to average daily consumption and trade assumptions. GEO-3 and FAO envisions more or less the same growth rates, with PR scenario being closer to FAO projection. IMAGE 2.2 envisions a much higher growth of crop production, in response to higher domestic crop demand and trade assumptions. Also, higher meat and milk production in IMAGE 2.2 leads to higher feed crop production.

4.3.5 Total crop area, total harvested area and cropping intensity

“Total Crop Area” refers to the area of arable land used for total crop production. “Total Harvested Area” refers to the total area that is actually harvested. If more than one crop is grown each year (i.e. the cropping intensity is greater than one), the total harvested area of all crops is larger than the actual food crop area. In regions where part of the land is left fallow each year, the harvested area is smaller than the total arable area for food crops (i.e. the cropping intensity is less than one).

“Cropping intensity” represents the average number of food crop cycles that can be obtained in a region on its agricultural land. In regions dominated by irrigated crop production, the cropping intensity exceeds 100%, indicating that on the average more than one crop is grown on the same land each year (RIVM, 2001).

Table 4.9 Total Crop Area Estimates

	Base-year			2030*				
	FAO 1996	GEO-3 1995	IMAGE 1995	FAO	GEO-3 PR	IMAGE B1	GEO-3 MF	IMAGE A1B
Total Crop Area (Mha)	**92**	**89**	**88**	105	98	122	94	141
Growth from base-year (% per year)				**0.4**	**0.3**	**0.9**	**0.1**	**1.4**

* For GEO-3: estimates for the year 2032

Table 4.10 Total Harvested Area Estimates

	Base-year		2030		
	FAO 1996	IMAGE 1995	FAO	IMAGE B1	IMAGE A1B
Total Harvested Area (Mha)	**91**	**90**	111	158	179
Growth from base-year (% per year)			**0.6**	**1.6**	**2.0**

Table 4.11 Cropping Intensity Estimates

	Base-year		2030		
	FAO 1996	IMAGE 1995	FAO	IMAGE B1	IMAGE A1B
Cropping Intensity (%)	**98**	**103**	105	128	127
Growth from base-year (% per year)			**0.2**	**0.6**	**0.6**

Base-year data are comparable for all scenarios. GEO-3 shows higher increase of total crop area in PR than MF because there is more production required. For the same reason IMAGE 2.2 shows higher increase in A1B than B1. IMAGE 2.2 figures for 2030 are the highest among the three outlooks, because it envisions the highest production. FAO projects a higher increase in crop area in the next 30 years compared to GEO-3. With about the same increase in domestic crop demand (0.5-0.7% per year), this means that GEO-3 visions are more towards strong intensification in crop production. This is also reflected in the increase of fertiliser use that will be discussed in its section below.

GEO-3 does not use the indicator "cropping intensity". The base-year estimate in IMAGE 2.2 for this indicator is higher than that of FAO, probably because of the exclusion of some commodities as discussed in the previous section on (total) crop production. The future projection in IMAGE 2.2 also shows much faster increase than FAO, indicating more optimistic assumption on agricultural development.

4.3.6 Irrigated cropland

Table 4.12 presents the estimates on area of irrigated cropland. IMAGE 2.2 gives no estimates of future irrigated areas.

Table 4.12 Irrigated Cropland Estimates

Irrigated Cropland	Base-year		2030*		
	FAO 1996	GEO-3 1995	FAO	GEO-3 PR	GEO-3 MF
Absolute Area (Mha)	16	15	22	19	19
Relative (% of total crop area)	18	17	20	19	20

* For GEO-3: estimates for the year 2032

The base-year and projected data of GEO-3 and FAO are comparable. In 30 years, irrigated cropland will comprise about 20% of total cropland, increasing from about 17-18% in 1995/1996. With increasing crop area, the water used for irrigation will also increase. This will be discussed in the section on water withdrawal for agriculture. GEO-3 assumes the same area of irrigated cropland in both MF and PR scenario.

4.3.7 Cereal harvested yield

Cereal harvested yield expresses the cereal production per unit of area. The estimates are presented in Table 4.13.

Table 4.13 Estimates on Cereal Harvest Yield

	Base-year			2030*				
	FAO 1996	GEO-3 1995	IMAGE 1995	FAO	GEO-3 PR	IMAGE B1	GEO-3 MF	IMAGE A1B
Cereal Harvest Yield (t/ha)	**3.13**	**3.07**	**3.19**	4.07	5.24	5.44	5.16	5.39
Growth from base-year (% per year)				**0.8**	**1.5**	**1.5**	**1.4**	**1.5**

* For GEO-3: estimates for the year 2032

The base-year data are more-or-less comparable for the three outlooks, but the future visions of GEO-3 and IMAGE are much more optimistic than FAO, indicating optimistic assumptions on agricultural development.

4.3.8 Crop Self-Sufficiency Ratio

Crop Self-Sufficiency Ratio (SSR) represents the amount of crop production divided by the domestic demand of that crop. SSR exceeding a value of 1 implies that the region is a net exporter. The estimates are shown in Table 4.14.

The base-year data are somewhat different in the three outlooks, probably because different commodities are included in each of them. The SSR values in GEO-3 and FAO AT 2015/30 decrease in the future, but in IMAGE 2.2 they increase. This is because in IMAGE crop production increases at a much higher rate than crop demand, reflecting the assumptions on trade.

Table 4.14 Crop SSR Estimates

	Base-year			2030*				
	FAO 1996	**GEO-3 1995**	**IMAGE 1995**	**FAO**	**GEO-3 PR**	**IMAGE B1**	**GEO-3 MF**	**IMAGE A1B**
Crop SSR	**1.16**	**1.25**	**1.10**	1.11	1.15	1.27	1.06	1.22
Growth from base-year (% per year)				**-0.1**	**-0.2**	**0.4**	**-0.4**	**0.3**

* For GEO-3: estimates for the year 2032

4.3.9 Crop net trade

Crop Net Trade is obtained from the amount of exported products minus imported products, or production minus domestic demand. The estimates are shown in Table 4.15.

Table 4.15 Crop Net Trade Estimate

	Base-year			2030*				
	FAO 1996	**GEO-3 1995**	**IMAGE 1995**	**FAO**	**GEO-3 PR**	**IMAGE B1**	**GEO-3 MF**	**IMAGE A1B**
Crop Net Trade (Mt)	**61**	**84**	**44**	69	90	304	36	322
Growth from base-year (% per year)				**0.4**	**0.2**	**5.7**	**-2.2**	**5.9**

* For GEO-3: estimates for the year 2032

The base-year estimates of the three outlooks are different. As in the case of total crop production, the differences might be caused by the different list of countries, the different lists of commodities or the different methods of reporting for each crop, for example harvested vs. marketed products.

If we look at the change rate it shows that IMAGE 2.2 has the highest vision of increase. This high assumption explains why crop production is so high in IMAGE 2.2 compared to the other two outlooks. Globalisation, the key feature of A1 and B1 scenarios, is the reason why global trade will sharply increase. If this assumption is corrected to match the FAO projection, one can expect more-or-less similar pictures of crop development.

GEO-3, on the other hand, shows lower increase than FAO, even a decrease in MF scenario. Considering the storylines, one might question this finding because the MF scenario envisions strong economic growth and globalisation. As agricultural products have been one of leading export commodities of the region to boost its economy, one can thus expect higher increase of export in the MF scenario. One explanation might be that MF envisions export growth in other commodities, or even a shift towards service-based economy in the region to catch up with its counterparts in the western world. This connects closer to the storyline. The vision that crop export volumes in PR scenario are higher than in MF, however, is consistent with its vision of economic growth as reflected in GDP per capita.

Here we can see that trade assumptions greatly affect projections on production. In other words, projections on food production in one region are very sensitive to the assumptions on trade.

4.3.10 Domestic crop demand

Estimates on domestic crop demand (the total amount of crop required for domestic consumption in the region) are presented in Table 4.16. The figures are resolved by dividing total crop production by crop SSR. Again, because of the difference in the numbers for “total crop production” probably caused by differences in definitions, the figures for this indicator are also different for the three outlooks. However, the revealed change rates indicate increases in all outlooks, due to growing population and average daily consumption.

Table 4.16 Domestic Crop Demand Estimates

	Base-year			2030*				
	FAO 1996	GEO-3 1995	IMAGE 1995	FAO	GEO-3 PR	IMAGE B1	GEO-3 MF	IMAGE A1B
Domestic Crop Demand (Mt)	**380**	**334**	**436**	631	599	1127	605	1464
Growth from base-year (% per year)				**1.5**	**1.6**	**2.7**	**1.6**	**3.5**

* For GEO-3: estimates for the year 2032

In GEO-3, lower population increase in PR scenario is compensated by higher average daily consumption, giving similar increase of total domestic crop demand in both PR and MF scenarios. IMAGE 2.2 envisions the same population growth in A1B and B1 scenarios so that different rates of increase in domestic crop demand directly reflect differences in increase in the average daily consumption.

4.3.11 Overall indicators

Overall indicators include crop demand per capita, crop export per capita, crop production per capita, crop area per capita and crop yield. These five indicators are derived from calculation of available data and are used in this study to give an overall impression of the dynamics of agricultural activities in the region according to each scenario (Table 4.17).

Table 4.17 Overall Indicators Estimates

	Base-year			2030*				
Indicators	FAO 1996	GEO-3 1995	IMAGE 1995	FAO	GEO-3 PR	IMAGE B1	GEO-3 MF	IMAGE A1B
Crop Demand per capita (t/cap)	**0.79**	**0.70**	**0.91**	0.89	0.86	1.72	0.84	2.23
Crop Export per capita (t/cap)	**0.13**	**0.17**	**0.09**	0.10	0.13	0.46	0.05	0.49
Crop Prod per capita (t/cap)	**0.91**	**0.87**	**1.00**	0.99	0.99	2.18	0.89	2.72
Crop Area per capita (ha/cap)	**0.19**	**0.19**	**0.18**	0.15	0.14	0.19	0.13	0.21
Crop Yield (t/ha)	**4.79**	**4.70**	**5.45**	6.67	7.03	11.74	6.82	12.67

* For GEO-3: estimates for the year 2032

GEO-3 and FAO visions are comparable. This is understandable because GEO-3 refers to FAO in agricultural issues. In FAO and PR scenarios, crop demand will increase to about 0.9 ton/capita by the year 2030/2032, export will increase to 0.1 ton/capita and crop production will reach 1.0 ton/capita.

In the IMAGE 2.2 scenarios, agricultural activities (production and trade) per capita will strongly increase, and not surprisingly higher in A1B than in B1. In general, the A1 and B1 scenarios (where 'globalisation' is an important aspect) are associated with an increasing volume of trade between regions. This is expressed by an increasing ratio between trade and regional consumption. This ratio is assumed to be highest in the A1 scenario because it is associated with high economic growth (IMAGE 2.2 Documentation).

Crop area per capita will decrease in GEO-3 and FAO, indicating that increase in crop production will result from intensification. In IMAGE it will slightly increase, but the increase in crop production is already so high that even a slight increase in crop area per capita still indicates strong agricultural intensification. This is directly shown by crop yield. It is interesting to look at the very high assumption of crop yield increase in IMAGE 2.2 scenarios. The increase reaches more than 2% per year over 35 years period, which is higher than the achievement of 1.5% annual increase during the 35 years period of 1962-1996. Keeping in mind that during 1962-1996 the so-called Green Revolution[1] was involved, it is questionable whether the IMAGE 2.2 assumption of a very advanced and rapid agricultural development, exceeding the past development, could be reached.

4.4 Environmental Pressure

4.4.1 Water withdrawal for agriculture

Table 4.18 shows estimates on water withdrawal for agricultural purposes (irrigation).

Table 4.18 Estimates on Water Withdrawal for Agriculture

	Base-year		2030*		
	FAO 1996	GEO-3 1995	FAO	GEO-3 PR	GEO-3 MF
Water withdrawals for agriculture (billion m3)	**28**	**90**	**41**	**142**	**145**
Total water resource (billion m3)	7023	5868	7023	5868	5868

* For GEO-3: estimates for the year 2032

It is clear that comparison of the estimates is not possible. Both visions use the term “withdrawal” which is the amount of water actually extracted from water resources, as opposed to the actual amount of water used for irrigation. Thus the same definitions are used in both visions, but it is not in the scope of this research to assess the reliability of the estimates.

However, two conclusions can be drawn from these figures. First, the irrigation water in the region will increase in the future because of increased production. Second, the amount of water withdrawn for agriculture is relatively low compared to the total availability of water resources. In general, water availability is not a problem in Southeast Asia even when competition with other sectors (domestic, industry) is considered. Nevertheless, water quality may be an important aspect to consider since water pollution caused by the use of fertilisers and agricultural chemicals might occur. Bad irrigation practices can also lead to salinisation, as is serious in Northeast Thailand (Scherr and Yadav, 1996).

It is important to note that regional outlook on water availability might mask countries’ and local’s specifics. Some areas may encounter problems regarding water quantity for agricultural purposes. This issue should then be addressed at national level and will not be discussed further in this study.

4.4.2 Land area

Table 4.19 shows the estimates on land area according to its uses. There is a difference of 5 million ha between the data on total land area of GEO-3 and IMAGE 2.2, which might be caused by inclusion or

[1] The Green Revolution refers to the period in the 1960s and 1970s when agriculture production was sharply increased by intensification, with the combination of better seeds, expanded irrigation, and high fertiliser and pesticide use.

exclusion of water bodies. However, this difference is only about 1% of the total land area so it is negligible.

GEO-3 and IMAGE 2.2 use different classifications of land use. GEO-3 classifies them as built environment, cropland, natural forest, pasture, protected and other. IMAGE 2.2 classifies agriculture land (which is further divided into cropland and pasture), managed forest land and natural vegetation (Appendix 2). Built-up areas and bioreserves (corresponds to "protected" in GEO-3) are not shown on IMAGE 2.2 maps and graphs, but they are proportionally incorporated into all other land use types. Because of this reason, comparisons are only made for cropland, pasture and natural forests. The latter is a term used in GEO-3, interpreted as being the comparison of "mature forest" of IMAGE 2.2, which is part of "natural vegetation". Differences in definitions lead to differences in estimates for natural forests for the base-year.

Table 4.19 Land Area Estimates

	1995		2032			
	GEO-3	**IMAGE**	**GEO-3 PR**	**IMAGE B1**	**GEO-3 MF**	**IMAGE A1B**
Total Land Area (Mha)	436	441	436	441	436	441
Cropland (Mha)	88.9	87.8	97.7	124.5	93.7	145.8
Pastureland (Mha)	17.0	20.6	14.8	42.1	14.8	46.8
Natural Forest (Mha)	226.7	278.7	208.4	231.9	197.5	211.0

Crop area has already been discussed previously. Pastureland will increase according to IMAGE 2.2 but decrease in GEO-3. In both visions, however, meat and milk productions are envisioned to increase in such high rates that both visions agree that the increase will come from intensification rather than extensification. Livestock intensification means feed requirements will increase, hence increasing the environmental pressure from feed crop production.

Base-year data of nature forests is higher in IMAGE 2.2 than GEO-3. Different definitions have already been discussed above. The fact that the figure in IMAGE includes portion of built up areas and bioreserves also explains why it is higher. In both outlooks the forest area will decrease, in a faster pace in IMAGE 2.2 than in GEO-3, and in a faster pace in the less environmentally sustainable scenarios than the more sustainable ones. The rates of decrease in all scenarios, between 0.2-0.4% per year in 35 years, are lower than that of 1990-2000 according to FAO, which is 1.0% per year. However, it should be kept in mind that forest fires in the region in the period of 1990-2000 had really boosted the deforestation rate. The message coming from these estimates is that agricultural land in the region will increase at the expense of the forests.

4.4.3 Fertilisers consumption

GEO-3 presents annual use of synthetic N-fertiliser. FAO has the data on synthetic NPK-fertiliser. IMAGE 2.2 has data on both parameters, the average ratio between N-fertiliser and NPK-fertiliser (58%) is then used to obtain the numbers of each parameter missing in the other two outlooks. The estimates are shown in Table 4.20.

Table 4.20 Fertiliser Consumption Estimates

4.1.1.1.1 Indicators	Base-year			2030*				
	FAO 1996	**GEO-3 1995**	**IMAGE 1995**	**FAO**	**GEO-3 PR**	**IMAGE B1**	**GEO-3 MF**	**IMAGE A1B**
Synth. N-fertiliser (Mt)	4.5	3	4.4	6.4	5	7.9	7	10.4
Synth. NPK-fertiliser (Mt)	**7.7**	**5.2**	**7.4**	11.1	8.6	13.3	12.1	17.6
Growth from base-year (% per year)				**1.1**	**1.4**	**1.7**	**2.3**	**2.5**

* For GEO-3: estimates for the year 2032

The base-year data are comparable between FAO and IMAGE, whereas GEO-3 data is lower. In all scenarios, fertiliser consumption will increase to raise production. IMAGE shows the highest growth rate, which is consistent with its highest growth rate of crop production.

Three additional indicators calculated from the data in the three outlooks are presented here, namely fertiliser use per hectare, per ton of products and per capita. “Fertilisers” here refers to synthetic NPK-fertilisers. The figures are shown in Table 4.21.

Table 4.21 Fertiliser Consumption Per Unit Area, Production and Population

Fertiliser Consumption	Base-year			2030*				
	FAO 1996	GEO-3 1995	IMAGE 1995	FAO	GEO-3 PR	IMAGE B1	GEO-3 MF	IMAGE A1B
Per hectare (kg/ha)	86	58	84	105	88	109	129	125
Per ton prod (kg/t)	17.5	12.4	15.4	15.9	12.5	9.3	18.8	9.9
Per capita (kg/cap)	16	11	15	16	12	20	17	27

* For GEO-3: estimates for the year 2032

Fertiliser use per hectare cropland will increase in all outlooks, confirming intensification. Fertiliser use per ton products will decrease in IMAGE and FAO scenarios, indicating either more efficient fertiliser application or increasing use of organic fertilisers or both. It is interesting that by the year 2032, the fertiliser use per ton products increases in MF scenario and stays at the same level as in 1995 in PR scenario. First, it proves that lower number indicates a more sustainable practice. Second, if lower number is to be achieved by more efficient application, then even the PR scenario finds it hard to promote it within the timeframe.

Translating this indicator (fertiliser use per ton products) into fertiliser efficiency, B1 scenario is very optimistic that it will improve by 2030, followed by A1B and FAO. GEO-3, on the other hand, is pessimistic in which the efficiency will stay at the same level in PR scenario and even decrease in MF scenario. This indicates that policy intervention is necessary to improve efficiency, or at least to prevent from it from decreasing.

Regarding fertiliser use per capita, FAO estimates remain constant in time. This means that environmental problems related to fertiliser use, assuming that the level of problems remains the same per unit fertiliser, will increase directly as a result of increasing population.

4.4.4 Methane emission

IMAGE 2.2 classifies the sources of methane emission from land use into several categories, namely biomass burning, fuelwood burning, agricultural waste burning, savanna burning, landfills, sewage, wetland rice, animals and animals waste. Considering the scope of the research, only emission form wetland rice will be discussed here. GEO-3 and FAO do not have data on this matter. However, FAO does have data on the area of wetland rice so the methane emission can be calculated using the emission factor used in IMAGE 2.2 (211 kg CH_4/ha wetland rice). The data are shown below.

Table 4.22 Methane Emission Estimates (Mt CH_4)

	Base-year		2030		
	FAO 1996	IMAGE 1995	FAO	IMAGE B1	IMAGE A1B
From Total Land Use		**16.2**		25.5	29.3
From Wetland Rice	8.5	8.7	**9.3**	**8.8**	**9.2**

The emission estimates are comparable between IMAGE and FAO, indicating similar estimates on wetland rice area. IMAGE, however, envisions higher rice production in the future than FAO (Table 4.23). It can be concluded that IMAGE expects higher level of intensification in rice production.

Table 4.23 Rice Production Estimates

	Base-year		2030		
	FAO 1996	IMAGE 1995	FAO	IMAGE B1	IMAGE A1B
Production (Mt)	**135**	**131**	192	244	253
Growth (% per year)			**1.1**	**1.8**	**1.9**

Table 4.24 Rice Harvested Yield Estimates

	Base-year		2030		
	FAO 1996	IMAGE 1995	FAO	IMAGE B1	IMAGE A1B
Harvested Yield (ton/ha)	**3.3**	**3.4**	4.4	6.3	6.2
Growth (% per year)			**0.8**	**1.8**	**1.8**

Table 4.24 shows that IMAGE 2.2 assumes higher rice yield compared to FAO, hence higher level of intensification. Considering that emission factor for methane depends on cultivation method, water management practices, type of rice variety planted, and cropping patterns (section 3.3.6), it may not be appropriate to apply exactly the emission factor used in IMAGE 2.2 to FAO projection. However, this study will not look into this emission factor in more detail because it may be too technical. The message is already clear from this analysis, that methane emission will probably increase by 2030 due to the increase in wet rice cultivation, and that intervention is therefore needed to limit this emission.

4.4.5 Nitrous oxide emission

There are several sources of nitrous oxide emission from land use, namely fertilisers, indirect fertilisers, crop residues, biological N-fixation, etc. The sources mentioned here are the ones that are related to crop production. As in the case of methane emission, the estimates of nitrous emission for FAO projections are derived from calculation using the emission factors used in IMAGE 2.2. Those factors are 0.0125 kg N_2O/kg N for direct N_2O emission and 0.0075 kg N_2O/kg N for indirect N_2O emission associated with fertiliser use. The estimates are shown in Table 4.25.

The base-year figures of FAO are slightly lower than IMAGE 2.2 although the estimates of fertiliser use are higher. This is because in IMAGE 2.2 fertiliser from animal manure is included in the calculation of the emissions. Increasing fertiliser use will cause an increase in nitrous oxide emission. Biological N-fixation and crop residues will increase with increasing production of leguminous crops such as pulses and soybeans, thus increasing nitrous oxide emission.

Table 4.25 Nitrous Oxide Emission Estimates (Mt N)

Sources of Emission	Base-year		2030		
	FAO 1996	IMAGE 1995	FAO	IMAGE B1	IMAGE A1B
Total Land Use		0.220		0.474	0.582
Fertilisers	*0.056*	0.057	*0.080*	0.113	0.140
Indirect Fertilisers	*0.033*	0.041	*0.048*	0.081	0.100
Crop Residues		0.013		0.049	0.056
Biological N-fixation		0.003		0.009	0.010
Others		0.084		0.149	0.164

From the calculation above we can expect an increase in nitrous oxide emission by 2030. Limiting fertilisers is necessary to limit this emission.

Figure 4.1 shows annual emission of nitrous oxide from upland crops and wetland rice fields in Southeast Asia in 1995. Wetland rice fields have higher emission than upland crops in most areas, due to higher fertiliser use.

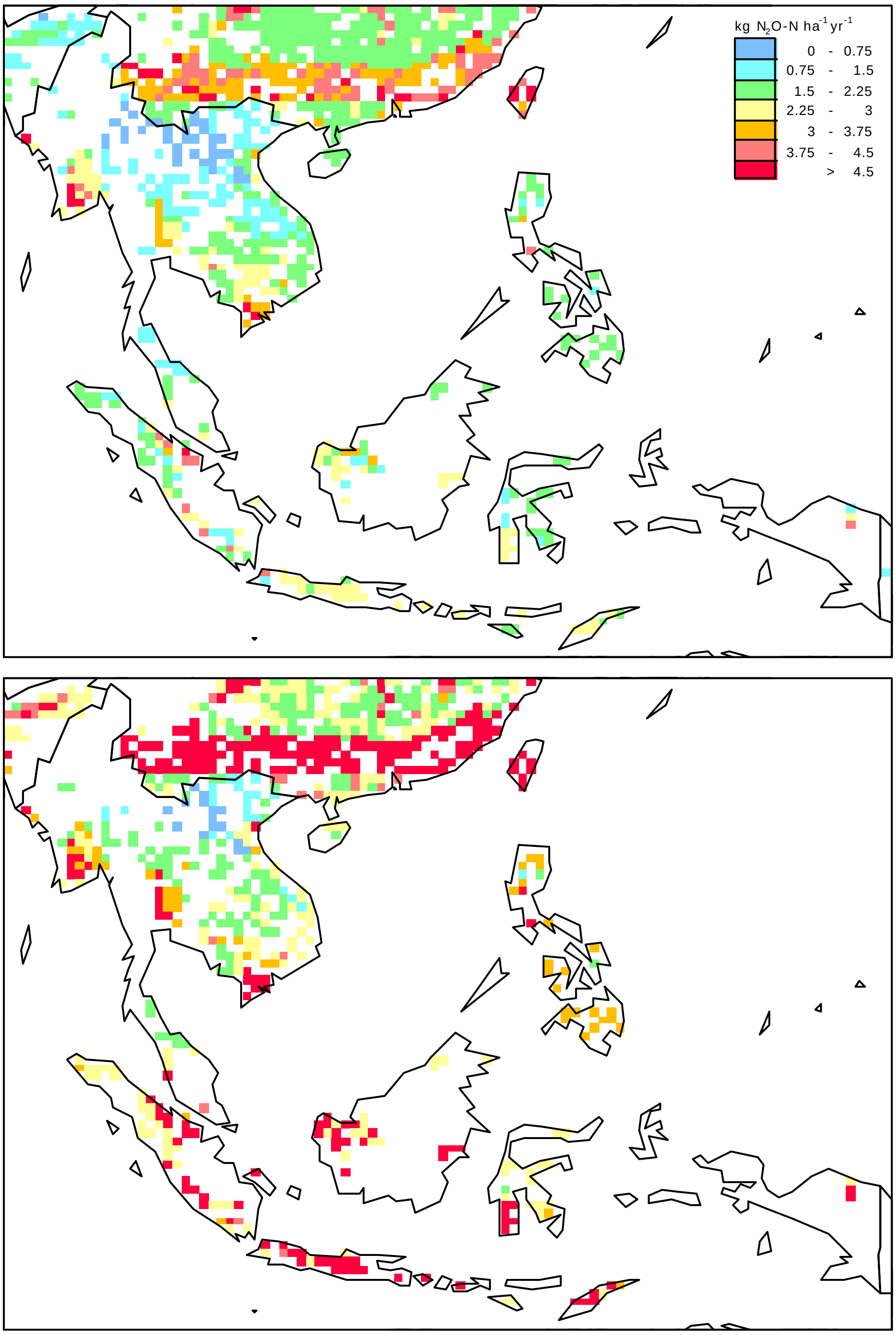


Figure 4.1 Annual emission of nitrous oxide (N_2O) from upland crops (upper panel) and wetland rice fields (bottom panel) in 1995 based on FAO

Source: Bouwman et al., 2001

4.4.6 Land degradation

FAO refers to Scherr and Yadav (1996) that there are hot spots of land degradation in Southeast Asia, where the situation is already serious and could get worse in the future. These hot spots include salinisation in the irrigation systems in northeastern Thailand and soil erosion on the sloping lands of Southeast Asia.

GEO-3 refers to IMAGE 2.2 modelling in identifying vulnerability to water-induced soil degradation in the future (RIVM, 2000). The qualitative modelling approach for land degradation in IMAGE 2.2 is restricted to the assessment of the land's sensitivity to water erosion, which is the most prominent cause of land degradation in the world. Other forms of land degradation risks such as salinisation and wind erosion are not simulated (RIVM, 2001).

The risk to water-induced soil degradation reflects land use and natural conditions (soil properties, slope, and also climate) and land management. Agricultural demand is one of the driving factors of changes of vulnerability. In MF scenario, the "very high erosion risk" in Southeast Asia by 2030 sharply increases and the "high erosion risk" slightly increases. In PR scenario, the very high risk increases but not as much as in MF scenario, whereas the high risk increases at the same level as in MF scenario (Figure 4.2). Whether land degradation actually occurs is not only determined by the risk but also by the effectiveness of soil conservation management (RIVM, 2000).

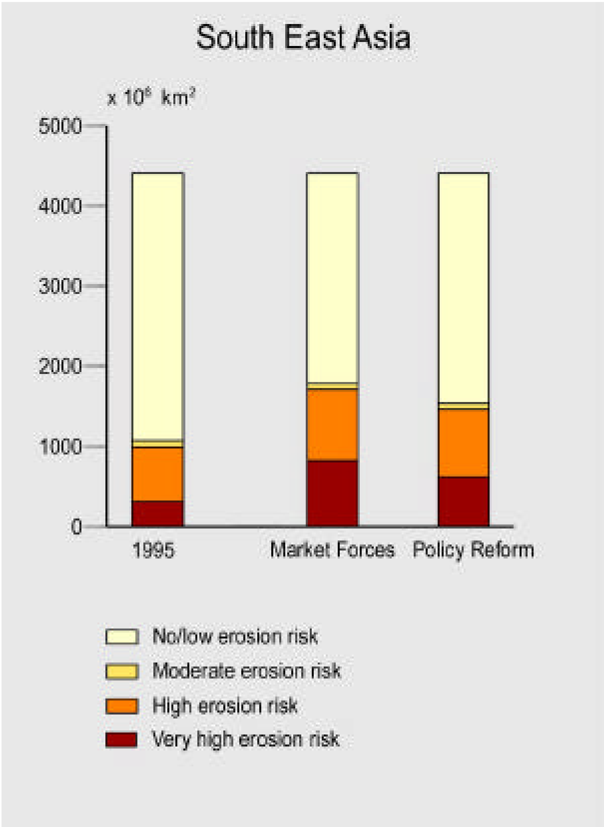


Figure 4.2 Vulnerability to water-induced soil degradation by the year 2030
Source: RIVM, 2000

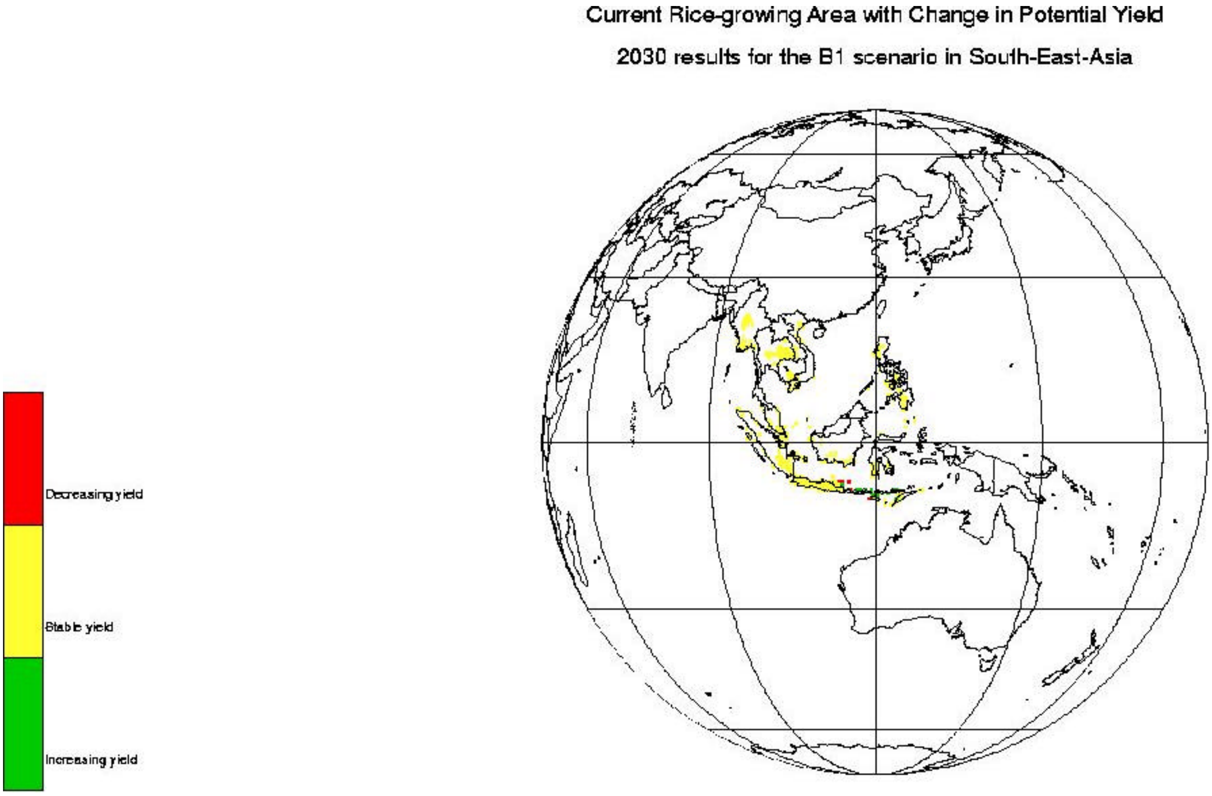
This figure indicates that policy measures taken in the PR scenario might lead to lower risk. This means that policy needs to address the issue of land management to limit land degradation in the future.

4.4.7 Climate change impacts on crop yield

FAO projects that the climate change impacts on agriculture in all likelihood will be minor before 2030 (FAO, 2000).

IMAGE 2.2 presents the areas within the 1990 crop growing areas where potential yields decrease (more than 10%) or increase (more than 10%) compared to the 1990 level or remain stable. Here, potential yield is modeled as a function of climate and CO_2 concentration (caused by CO_2-fertilisation and enhanced water-use efficiency). Again, GEO-3 is using IMAGE modeling for this indicator as well (RIVM, 2000).

IMAGE 2.2 shows that for Southeast Asia, under both B1 and A1B scenarios, potential yields will be mostly stable by the year 2030, except for rice that will decrease in some parts of Indonesia (Figure 4.3). However, there are several uncertainties in assessing the impacts on agricultural yields. This indicator represents the potential yield and not the actual yield. For the latter, several other factors, including adaptation, play an important role. Fertilisation impacts and improvement of water use efficiency caused by increased CO_2 have been measured mostly under laboratory conditions. The impacts under field conditions are less certain. Because the impacts are minor, this issue will not be discussed further in this study.



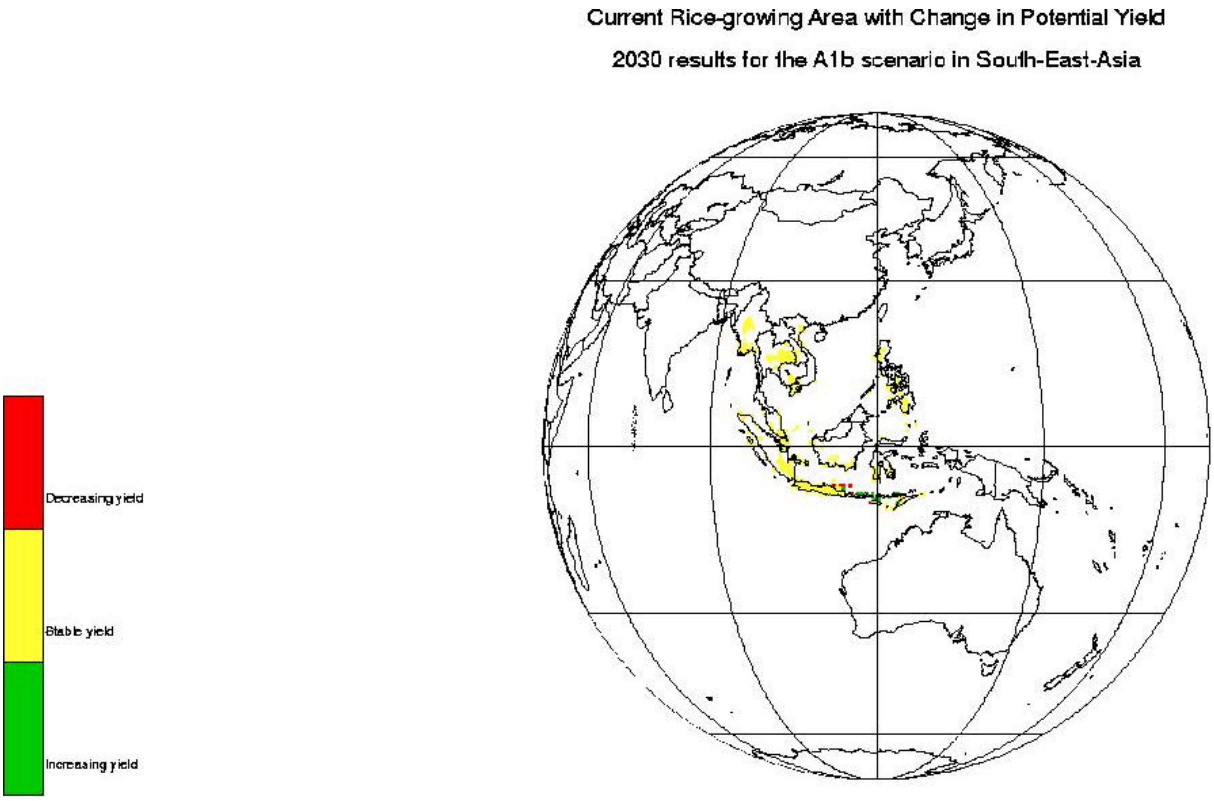


Figure 4.3 Change in Potential Yield in Current Rice Growing Area in Southeast Asia (1995-2030), in B1 Scenario (upper panel) and A1B Scenario (bottom panel)
Source: RIVM, 2001

4.5 Outlook Summary

4.5.1 FAO AT 2015/30 Technical Report

The figures presented in FAO AT 2015/30 Technical Report represents outcomes of quantitative analysis on the projected food and agriculture states in the future. It is a projection of “what is likely to be” rather than “what it ought to be” from a normative perspective. FAO projection is based on conservative assumptions and is very much rooted in the present situation.

There are increases in almost all of the indicators reviewed in this research, except for crop SSR. Decreased crop SSR means that crop production will not keep up with demand growth. Export volume will still increase in absolute numbers but decrease in average volume per capita. Limited crop area calls for higher yield in the future. Increased fertiliser consumption is projected but there will be slowdown in the increase. Incidence of undernourishment will be halved after 2015 but before 2030. Increasing population naturally makes it a hard job to decrease the number.

4.5.2 UNEP GEO-3

In general both MF and PR scenarios envision similar trends in all of the indicators related to food and agriculture. Population and economy grows, leading to increases in food demand and production. Crop production, however, does not grow as much as domestic demand, causing a decrease in crop SSR. Crop export will increase in PR but decrease in MF scenario. An important vision is that hunger incidence will decrease in both scenarios.

The PR scenario, supposedly a more “sustainable” scenario, envisions lower population growth than the MF scenario, due to assumed declines in fertility rates associated with declining poverty and through more active family planning efforts. It also envisions higher economic growth and faster alleviation of hunger incidence. A slightly higher average daily consumption with higher share of animal products in people’s diets will lead to higher livestock production. Decreasing pastureland indicates higher needs of feed crops, thus leading to higher pressure on the environment although at the same time this also means lower environmental pressure due to land conversion. PR scenario, compared to MF, foresees higher crop demand and production per capita, larger crop area per capita and higher crops yield. These are supposed to be achieved with lower fertiliser consumption. This calls for a more efficient fertiliser application, through management options and technological solutions. Agricultural policies must thus, among other, be directed towards these goals.

4.5.3 IMAGE 2.2

As in the case of MF and PR scenarios in GEO-3, in IMAGE 2.2 both A1B and B1 scenarios share a more-or-less similar vision on the future trends of food-and-agriculture indicators reviewed in this report. Population and economy grows, leading to increases in food demand and production. In contrast to GEO-3, in IMAGE 2.2 crop production exceeds domestic demand, due to an increase in desired crop SSR in response to sharp increase in the demand of crop export. In almost all indicators, IMAGE 2.2 shows relatively higher growth compared to GEO-3 and FAO. This is obviously shown in the sharp increase of GDP per capita, average daily consumption, crop demand, crop production, crop area and, mostly, crop export and crop yield. Correction in export assumption and yield increase will probably lead to projections closer to that of FAO.

The A1 storyline in IMAGE are based on strong economic growth and materialism whereas B1 storyline is based on social and environmental values. That is why B1 envisions lower economic growth than A1B, lower daily caloric intake with lower share of animal products, leading to lower livestock production. It also envisions lower domestic crop demand and lower export demand, thus lower crop production. Lower crop area and lower level of fertiliser consumption are needed to achieve the desired production, hence there will be lower land conversion for agriculture and lower environmental impacts from fertilisers.

4.5.4 General Summary

The five scenarios altogether show a basically comparable picture where crop production will increase to keep up with the increase in demand. The extent of the increase, however, is different in each scenario, depending on the assumptions on average daily consumption and diets, influenced mostly by income, and assumptions on export. In most indicators under “food and agriculture” section, IMAGE 2.2 A1B scenario envisions the highest figures and growth rates for the year 2030/2032, followed subsequently by B1, PR and MF scenarios. FAO technical projections, which are intended to reflect a realistic future with little analysis of environmental policy issues, falls between B1 and PR scenarios (Figure 4.4).

In general it can be concluded that the “realistic” FAO projections relates closer to GEO-3 PR and IMAGE 2.2 B1 scenario. One can thus expect that the environmental implications of food production in Southeast Asia until 2030 will be somewhere in the extent of those envisioned by PR and B1 scenarios, which both rely on policy interventions. Comparing PR with MF, the fact that FAO vision is closer to PR means that FAO envisions a relatively high crop productivity to achieve regional food security and export. On the other hand, FAO envisions a relatively lower productivity growth to achieve environmental sustainability, because it is closer to B1 than to A1B. The challenge would now be to identify policies to realise the projection.

Towards 2030, Southeast Asia will experience further population and economic growth, despite the economic crises that struck the region a few years ago. As population and income increase, so will food demand for domestic consumption. Crop export is expected to grow as well. The result will be an increase in crop production, which to a large extent will be achieved by crop intensification. Environmental problems related to crop intensification cannot be avoided under the current practice and technology. Those, however, can be mitigated through sustainable agricultural policies, which will be the focus of the next chapters.

	A1B	B1	FAO	Policy Reform	Market Forces
Population	↗	↗	↗	↗	↗ (red)
GDP per capita	↗ (red)	↗	↗	↗ (red)	↗
Average Daily Consumption	↗ (red)	↗	↗	↗	↗
% Share of Animal Prod. in Daily Cons.	↗ (red)	↗	↗	↗ (red)	↗
(Total) Crop Production	↗ (red)	↗	↗	↗ (red)	↗
(Total) Crop Area	↗ (red)	↗	↗	↗ (red)	↗
Crop Net Trade	↗ (red)	↗	↗	→	↘
Crop Yield	↗ (red)	↗	↗	↗ (red)	↗
Deforestation	↗ (red)	↗		↗	↗ (red)
Fertiliser Efficiency	↗	↗ (red)	↗	→	↘
Methane emission from wetland rice	↗ (red)	↗	↗		
Risk of soil degradation	↗ (red)	↗	↗	↗	↗ (red)

Note: Arrows indicate increase/decrease of the indicators during 1995-2030. Red arrows indicate stronger increase/decrease of one scenario compared to its counterpart (i.e. A1B vs. B1, or MF vs. PR).

Figure 4.4 Summary of the Scenarios

5. POLICY AREAS AND POLICY MEASURES FOR ASEAN

5.1 Introduction

This chapter examines the opportunities for co-operation within ASEAN framework to meet the desired food production by the year 2030 with environmental consideration. The ASEAN policy framework is described to give an idea about the organisation, its challenge and its opportunities; after that comes the identification of principles of effective agricultural policies, and then several policy areas to deal with food production and the environment are proposed.

5.2 ASEAN Policy Framework

5.2.1 ASEAN Decision-making Process

ASEAN is not a supranational government that has authority over its individual members. It employs consensus-building approach towards problems. ASEAN decisions are reached either unanimously or consensual. Agreements are made and signed by all member countries. However, the implementations at national level are voluntary by means of legal enactment of each member country. In this regard one can say that if compared to the European Union, ASEAN has a looser structure.

The areas of co-operation include political and security, economic, functional and external relations. Food, agriculture and forestry form one sector of the economic co-operation. Environment is a part of functional co-operation.

To give a quick illustration on the decision-making mechanism of ASEAN, the basic process is described below. This description is mostly extracted from information found on ASEAN website[2] on the internet and by no means exhaustive.

The work flows from the heads of government to ministers to senior officials to regional committees and finally to ASEAN secretariat. ASEAN is based more on meetings than on permanently existing bodies. The Meeting of the ASEAN Heads of Government is the most important meeting. The heads of governments meet in ASEAN summit, formally every three years and informally every year. The ASEAN Ministerial Meeting (AMM) is the next in importance. This is an annual meeting among the ASEAN Foreign Ministers to draw up policy guidelines and co-ordinate ASEAN activities. After that comes the ASEAN Economic Ministers (AEM) meeting. The AEM meet every year to direct economic co-operation and integration.

Minister for specific sectors of economic co-operation meet when necessary to give guidance on ASEAN co-operation. The sectoral economic ministers report to the AEM. The ASEAN Ministers on Agriculture and Forestry (AMAF) have been meeting every year since 1979. Meetings of ministers in other fields of ASEAN co-operation, such as Health, Environment, Labour, Education, etc. are held when necessary to draw up programmes of co-operation. They report to the AMM. A Joint Ministerial Meeting convenes when necessary, usually before the summit, to facilitate the co-ordination and consultation on ASEAN activities.

Supporting these ministerial bodies are 29 committees of senior officials and 122 technical working groups. To organise and carry out ASEAN activities at country level, each member country has a

[2] The website address is www.aseansec.org

national secretariat in the foreign ministry. To initiate, advise, co-ordinate and carry out ASEAN activities, the position of ASEAN Secretary General is created and the ASEAN Secretariat is established. The ASEAN Secretariat is located in Jakarta, Indonesia and the function is to enhance co-ordination and implementation of policies, projects and activities of the ASEAN bodies.

5.2.2 Development towards integration of environmental concerns into agricultural policies

The agricultural co-operation dated back in 1979, when the ASEAN Agriculture Ministers met for the first time in Manila, Philippines. The countries expressed their commitment in accelerating the pace of agricultural and rural development for the benefit of the small farmers. Being part of the Green Revolution, the region put its priority in the supply and procurement of fertilisers, pesticides and other agricultural inputs, which then encouraged the establishment of fertilisers and pesticides manufacturing plants in some member countries. The ASEAN Common Agricultural Policy (ACAP) was adopted, where the Ministers agreed to establish the ASEAN Quarantine Ring for common plant and animal protection, the pooling of research in technology in food and agriculture and the sharing of training and extension resources.

Environmental consideration on forestry and land-use was brought up in 1981, with the signing of Jakarta Consensus on ASEAN Tropical Forestry if the third AMAF meeting. In the same meeting it was decided to endorse co-operation in water management for agriculture.

ASEAN's earliest initiative on environmental co-operation was the ASEAN Sub-regional Environmental Programme (ASEP) of 1977. Numerous policy documents have been issued ever since. The link between agriculture and the environment is specifically mentioned for the first time in the Agreement of the Conservation of Nature and Natural Resources of 1985. The agreement was signed by the Ministers of Foreign Affairs of the (then) six member countries. In Chapter III, Article 10(a) of the agreement, it is agreed that "the Contracting Parties, wherever possible, shall endeavour *to promote environmentally sound agricultural practices* by inter alia, controlling the application of pesticides, fertilisers and other chemical products for agricultural use, and by ensuring that agricultural development schemes, in particular for wetland drainage or forest clearance, pay due regard to the need to protect critical habitats as well as endangered and economically important species." The agreement was subject to ratification by the contracting parties. The implementation was up to each member country. However, there is no clause mentioning sanctions to be imposed if the contracting party did not implement the agreement.

At the 1992 Summit, ASEAN explicitly recognises the link between environmental issues and sustainable development. Through the Singapore Declaration 1992, ASEAN pledged "to play an active part in protecting the environment by continuing to co-operate by promoting the principle of sustainable development and integrating it into all aspects of development." Following the Summit, the AMAF meeting in 1992 agreed to focus co-operation on, among others, conserving natural resources and improving agricultural and forestry sustainability.

The trend is under way towards more integration of environmental concerns into agricultural policies. Currently ASEAN is working on several agricultural co-operations that are directly or indirectly promoting environmental sustainability. The Strategic Plan of Action in ASEAN Co-operation in Food, Agriculture & Forestry 1999-2004 points out management, sustainable utilisation and conservation of natural resources as one of the strategic thrusts. However, this is supervised by the agricultural unit without sufficient co-ordination with the environmental unit. The latter has its own programmes that in some areas coincide with agricultural interests, such as protection on genetic resources, which is being developed at the moment.

5.2.3 Challenges and Opportunities

The above description shows that the key institutional framework and the commitment of member countries are already in place to move towards greater integration of environmental concerns into agricultural policies in ASEAN.

ASEAN's unique loose intergovernmental structure and consensus decision-making mechanism, often referred to by researchers and analysts as "the ASEAN way", has raised both criticism and positive comments (ASEAN-ISIS, 1992; Chin, 1995; Henderson, 1999; Narine, 1998; Sandhu et al., 1992). It lacks power for rigorous enforcement of policies, but on the other hand it provides room for adoption and adjustment to the needs and concerns of each member countries. I see this more as a good foundation to encourage voluntary actions, which tend to give better results than forced participation.

Based on current development and the strongly rooted "ASEAN way", ASEAN is likely to maintain its institutional framework in the foreseeable future, with no tendency towards any form of supranationalism. Of course, one can expect changes, but it is reasonable to believe that the changes would be in the direction of higher level of regional co-operation and, other than economic integration, not regional integration like for example the European Union. The policy measures proposed here, therefore, are supposedly implementable under such assumptions.

ASEAN needs to enhance closer networking between the agricultural unit and the environmental one. Mutual discussions and consultations can make use of the expertise of both parties to come to better integration of environmental concerns into agricultural policy. This will lead to a more effective and efficient co-operation, avoiding any unnecessary overlapping. The role of ASEAN Secretariat is vital, acting as the communication centre of all co-operation units. It might be useful to formally set up a project within ASEAN to fully integrate environmental concerns into agricultural policy, to make sure that adequate resources and attention are dedicated to it. The target is to have a new ASEAN common agricultural policy (ACAP) by 2005, in order to achieve the desired agricultural production and environmental sustainability by 2030. The 25 years period will provide sufficient time for directing agricultural development. Further study to come up with the details of setting up this project is definitely needed, but this report attempts to point out some policy areas and measures that this particular project needs to address as the elements of the ACAP.

ASEAN can take advantage of the existence of numerous agricultural research centres in the region, established on international, regional (intra-ASEAN) or national initiatives, to support and extend its policy-making capacity. International Rice Research Institute (IRRI) in the Philippines, Natural Resources and Biodiversity Institute (NAREBI) in Thailand, ASEAN-Asian Vegetable Research and Development Centre (AVRDC), etc. are to name a few. ASEAN's link to international organisations in relations to agricultural and environmental policy should be maintained and extended in the future. These organisations include FAO, International Food Policy Research Institute (IFPRI), Consultative Group on International Agricultural Research (CGIAR), the World Trade Organisation (WTO), United Nations Development Programme (UNDP), the European Union (EU), etc.

5.3 Principles of Effective Agricultural Policy

It is by nature very difficult, if not almost impossible, to determine what policies will be effective to achieve certain goals in the future, especially if the time horizon is relatively long, say 30 years. There are many uncertainties in economic, social and political conditions in the future. Successful implementation of a policy, one of many factors leading to the effectiveness of the policy in attaining its aims, depends on many interrelated factors that are sometimes unpredictable. It is, however, not improbable to point out several principles that the policies need to carry in trying to minimise trade-offs between agricultural development and the environment. These principles are listed below.

First, any reform in agricultural policy can only be successfully adopted if they bring economic benefits to governments at national level and to farmers at household level. At the national level, the challenge is thus to mobilise the willingness of governments to give priority to long-term benefits rather than short-term ones. Environmental and health costs should be taken into account in cost-benefit analysis at the planning stage of agricultural policy-making. At the household level, efforts to minimise trade-offs between production and the environment must be centred on actions that improve household food security and are profitable on time scales which meet the farmers' differing circumstances or risk perceptions, as suggested by Alexandratos (1995). UNEP in its GEO 2000 supports this last notion as the essence of social sustainability in relation to food. Pretty (1995) states that if farmers are forced or coerced they may adopt new practices, but will only continue if their incomes are dependent on the practices. This first principle is reflected in policies such as agricultural subsidies and incentives, allocation of public investments, certification schemes of agricultural products, etc.

Second, unless the affected parties have a sense of ownership, development schemes have little likelihood of success (Pinstrup-Andersen and Cohen, 2000). Alexandratos (1995) states that strategies must clearly define responsibilities and allocate rights of access to or use of environmental resources. Well-defined and secure property rights should be established for the main resources used in agriculture (Witcover and Rosegrant, 1995).

Third, success depend greatly on people's participation and decentralised resource management (Alexandratos, 1995). Policies addressing changes in agricultural technologies or management options would have to be operationalised at the grassroots level, i.e. by the farmers. This requires a communication structure for dissemination and translation of policies. Pretty and Hine (2000) states that lack of information and management skills are a major barrier to the adaptation of sustainable agriculture. Communication should go both ways: from policy-maker to the end-target and vice-versa. Development efforts must engage farmers as active participants, not passive recipients (Pinstrup-Andersen and Cohen, 2000).

5.4 Identification of Policy Areas and Measures

It has been pointed out in the earlier section that ASEAN needs to enhance integration of environmental concerns into agricultural policy. It might be valuable for ASEAN to develop a new ASEAN common agricultural policy (ACAP) to replace that of 1979 (see 5.2.2 and 5.2.3). The policy areas mentioned below are recommended as the elements of the new ACAP, whereas the policy measures serve as ideas for further implementation of the ACAP.

The policy areas are identified after examining the scenarios in chapter 3, including fertiliser use, methane emission associated with rice production, agricultural land expansion and soil degradation. Other issues that are not quantified in the scenarios but are essential in crop production in Southeast Asia are also indicated, such as pesticide use and the role of biotechnology. Rural development as the socio-economic basis of food production will be discussed briefly, followed by a glance at the trade perspective. The importance of agri-environmental indicators will end this section. Discussion on each policy theme is followed by policy measures that ASEAN needs to take in addressing the issue.

5.4.1 Fertiliser use

FAO projections suggest improved fertiliser efficiency in the region, from some 17.5 kg fertiliser per ton of products in 1996 to some 16 kg fertiliser per ton of products in 2030. GEO-3 PR and IMAGE 2.2 B1 scenarios show lower mineral fertiliser consumption than the MF and A1B scenarios, respectively (Table 4.21 and 4.22). This means that policy intervention is needed to limit fertiliser use and its negative impacts to the environment (see 3.3.3).

There are many proven ways to cut nutrient losses and improve fertiliser efficiency. Soil testing, choice of appropriate fertilising compounds, maintenance of proper nutrient ratios, and attention to the timing and placement of fertilisers are the most important direct measures of universal applicability. Indirect approaches that can either reduce the need for synthetic fertilisers or increase the efficiency of their use rely primarily on greater contributions by biological N-fixation and on good agronomic practices embracing crop rotations, conservation tillage, and weed control (Smil, 2000).

The relatively low price of fertilisers might cause inefficiency of fertiliser use in Southeast Asia. Steinfeld (1998) confirms the competitive price and ease of inorganic fertiliser management in the region if compared to manure. Noordwijk and Scholten conducted a research on the effects of fertiliser price on feasibility of efficiency improvement and concluded that fertiliser prices in Indonesia, for example, were too low relative to rice to make optimum use of existing techniques for efficiency improvement (Noordwijk and Scholten, 1994). They further suggest that if governments wish to stimulate efficient fertiliser use, the introduction of technical improvements should be stimulated by maintaining price ratios between fertiliser and food products. This, on one hand, will allow fertiliser to be used for increasing food production, and on the other hand make it worthwhile to increase efficiency and reduce wastage.

Another reason for inefficiency is farmers' lack of knowledge about fertilisers. The region is dominated by farmers with relatively low educational background, who have the perception that higher fertiliser input will automatically bring about higher yields. Inappropriate quantity, timing and methods of fertiliser application lead to inefficiency, where significant amount of the fertilisers is not taken up by the plants but released to the environment instead. Some fertiliser producers that take advantage of the farmers' lack of knowledge worsen the situation. They appealingly promote and sell fertilisers to farmers, often with misleading information about the products.

Using a market instrument such as price policy is one solution. ASEAN should facilitate member countries in harmonising price of fertilisers and food products in the region. The success of ASEAN countries in reducing pesticide use during the 1990s may serve as an example, showing the first principle of effective agricultural policy brought into reality (see 5.4.5).

Another solution is educating farmers. Joint effort to improve the knowledge of farmers can be done, and in fact is being developed, through the co-operation in Integrated Crops Management (ICM) approach. This refers to the integration of nutrient management and pesticides management. The basic principle is to increase the knowledge of farmers on local conditions and the physiology of plants. Farmers are guided to formulate fertiliser rates and or pesticides for application to fields based on the observation of soil condition, pressures of pests and population of their natural enemies, and the development of the plants. At the moment ASEAN is starting to work on this approach (see 5.2.2), learning from the experience of co-operation in IPM (see 5.4.5). What the member countries should consider is the mechanism, from regional to local level, of the delivering of information to and involving participation from the farmers. In this respect ASEAN should encourage collaboration and empowerment of farmers group (see section 5.4.7).

5.4.2 Wetland rice and methane emission

Based on the FAO projection for the rice growing area, annual methane emission from wetland rice in Southeast Asia will increase from 8.5 Mt in 1996 to 9.3 Mt in 2030. The IMAGE 2.2 B1 scenario will lead to lower methane emission than A1B by the year 2030 (Table 4.22). Cutting production to cut emission is not an option, since it can mean jeopardising food security in the region. IRRI has been conducting research to find how methane emission from rice fields can be further curtailed without sacrificing yields.

IRRI (2001) discovers that high emission rates are associated with specific management practices and that management practices can be modified to reduce emissions without sacrificing yields. Proposed solutions include intermittent drainage in irrigated systems, which can also save water beside reducing emissions, improved crop residue management (through composting, mulching and early incorporation of organic manure), and direct seeding, which also results in less labour and water input. They suggest that rice-growing countries must try to persuade farmers to adopt mitigation technologies while avoiding any unnecessary burdens for them.

This particular issue has not been addressed in ASEAN. In this regard, ASEAN can assign a specific working group to assess the feasibility of adopting mitigation technologies in each member countries. Further, training and extension similar to IPM scheme can be adopted. Availability of baseline information is necessary when it comes to greenhouse gases emissions. ASEAN can play a role here by establishing such information centre at the regional level.

5.4.3 Agricultural land expansion

FAO projects that cropland in Southeast Asia will expand from some 92 million hectares in 1995 to some 105 million by 2030, or by 0.4 percent annual increase (Table 4.9). GEO-3 and IMAGE 2.2 estimations hint that this expansion will come from the conversion of natural forests (Section 4.4.2).

Increased need of crop always initiates either intensification or land expansion, or combination of both. Determining which one will be better for the environment is not easy since each creates its own pressures to the environment. Intensification leads to problems related to agricultural inputs such as fertilisers, pesticides and irrigation, whereas land expansion at the expense of deforestation leads to problems related to the loss of natural areas.

If, in contrast to FAO projection, one wishes to achieve the desired crop production by 2030 and at the same time cease cropland expansion, hence maintaining the area of 92 million hectares to produce 700 million tonnes of crops, then the average crop yields would have to be increased from 4.8 t/ha in 1996 to 7.6 t/ha by 2030 instead of 6.7 t/ha (see Table 4.18). It means an annual increase of 1.3 % during the period of 35 years instead of 0.9%. This requires a more-or-less similar level of intensification as achieved during the period of 35 years from 1962-1996, which was 1.5 % annual increase of crop yield. But that period includes the era of Green Revolution, with the average fertiliser use, for example, increased by 8.3 % per year. If FAO expects fertiliser use to increase “only” by 1.1 % per year during 1996-2030, then it seems impossible not to expand crop area. Even a 0.9 % annual increase of crop yield is already high, considering current knowledge and technology. Of course, there is a hope in advanced technology, such as biotechnology, to boost production by intensification, but it may be too optimistic to expect a 1.3 % annual crop yield increase during the entire period of 1995-2030. In addition, biotechnology may have its own pressures to the environment as well (see 4.4.6).

Land availability may be an issue in some regions of the world. Looking at Southeast Asia, it seems that an additional 13 million hectares can still be provided by conversion of natural forests. GEO-3 assumes total potential cultivable land of 141 million hectares in 1995, or a spare of 52 million uncultivated. Built environment will expand, thus competing with agricultural expansion, but there is still enough land available for expansion, although not desirable.

Based on the calculation above, it is reasonable to say that cropland expansion at the level projected by FAO is affordable. It might be the best compromise between limiting both agricultural intensification and land expansion, to attain the desired food production. The policy challenge would then be how to manage the land expansion. Careful land-use planning, so as to identify which forest areas are the most suitable for conversion with the least environmental risks, is necessary. ASEAN should facilitate member countries in expanding and exchanging their capacity, knowledge and technology in land-use planning, for example with the use of Geographical Information Systems (GIS).

Further, monitoring of agricultural practices is necessary to ensure that the land that is cleared for agriculture is managed in a proper way to give desired yield and avoid creation of marginal and abandoned land. ASEAN can also facilitate this kind of capacity exchange among ASEAN countries and also with countries and organisations outside ASEAN. Another important issue in land expansion is how land in the forest is brought into the agrarian domain with clear land rights. This will be discussed in section 5.4.7.

5.4.4 Land degradation: soil mining, salinisation, soil erosion

Limiting fertilisers, as proposed in section 5.4.1, does not necessarily mean cutting its use in every agricultural land. Some areas do require higher fertiliser inputs to restore soil nutrients or to prevent their depletion. An example of bad practices is the cultivation of cassava in marginal land. This practice in many places has lead to complete chemical soil degradation. Scherr and Yedev (1996) also point out other hot spots of land degradation in Southeast Asia. Salinisation will be a major threat in the irrigation systems in northeastern Thailand and soil erosion will create serious production problems on the sloping lands of Southeast Asia. The risk of water-induced soil erosion in the future is higher in MF than PR scenario (section 4.4.6).

Although these issues raise more concerns at the national and local level than at the regional level, ASEAN can have a role in facilitating transfer of knowledge of mitigation measures, such as soil conservation management and related incentives for farmers, among its member countries and with outside organisations.

5.4.5 Pesticide Use

None of the outlooks examined in this study makes quantitative projections on pesticide use in the future. According to FAO, it is difficult to project future rates of pesticide use in any detail. However, more intensive use of land (reduced fallows, more multiple cropping) will contribute to further, though modest, increases in pesticide use in developing countries (Alexandratos, 1995). FAO AT 2015/30 projects that improved economic conditions in some developing and transition countries might lead to increased pesticide use. The increase in average temperatures, which will occur with climate change, will magnify the risk of crop damage by pests, thus calling for more efforts in pest control.

Pesticides are necessary to protect crops; terminating the use will probably upset productions. However, pesticides use must be limited to avoid associated human health and environmental risks (see 3.3.4). Alternative pest control methods are needed. According to Laegreid et al. (1999), combination of pesticides with biological and mechanical control methods has had much success and represents the present trend. This approach is called IPM, where pesticide application is reduced through increased attention to field conditions. Pest populations are monitored and controlled rather than eradicated and special attention is given to avoiding damage to beneficial or harmless insects. Chemicals are used only when an attack surpasses a certain threshold.

Under its agricultural co-operation framework, ASEAN has been carrying out co-operation in IPM since 1996 when a regional training on IPM in fruits for agricultural extension officers was conducted in Thailand. Because IPM is demanding on professional skills of farmers, extension and training are definitely needed. Until today, training programs on IPM for other crops are being developed and implemented. The organisation has also endorsed harmonisation of maximum residue limits (MRL) for specific pesticides for specific crops that are widely traded between ASEAN member countries.

The success should be maintained for further limiting the use of pesticides, anticipating the increase in use. Coverage for more crops and more pesticides in the teamwork of IPM and MRL can be expected in the future. Co-operation on ICM (see 5.4.1) is on track and the region can look ahead to more sustainable agricultural practices.

Pretty (1995) implies that the region can boast the success of the cut in pesticide subsidies that lead to the decrease in pesticide use whilst still increasing rice yields during the late 1980s until mid 1990s, as evident in Indonesia, Malaysia, the Philippines, Thailand and Vietnam. The countries did save national spending on subsidies while farmers achieved yield increases. The first principle of effective agricultural policy (see 5.3) is mirrored in this case. Although this policy was done under individual countries' initiatives rather than under ASEAN co-operation framework, the success can be replicated for other agricultural inputs such as fertilisers.

5.4.6 Genetically Modified Crops

In response to the increasing food demand, biotechnology offers an alternative to mainstream food production. A genetically modified organism (GMO) is defined as an organism whose genetic characteristics are changed through genetic manipulation or modification (ASEAN website). The technology involved in GM crops can speed up plant breeding, increase crop yields by up to 20 percent or more, improve pest resistance or pest control methods, produce cultivars that can tolerate saline soils and thereby help to reclaim degraded land (FAO, 2000). The GM technologies are expected by many to help the world meet its food needs, not only through quantity but through nutritional quality as well (Diaz-Bonilla and Robinson, 2001).

FAO (1999) states that from experience to date GM crops can have a number of environmental benefits. These benefits include reduced needs for pesticides, though these gains are not necessarily permanent as pests can overcome the resistance of GM crops; lower pressures for crop land development and deforestation; and increased opportunities to take marginal land out of production for set-aside or to cultivate some crops less intensively.

On the other hand, there are a number of environmental and human health risks (FAO, 1999; Persley, 2000). Potential health risks of GM foods include toxicity, carcinogenicity, food intolerance, the risk of the use of gene markers for antibiotic resistance, etc. Environmental risks include the potential for spread of traits from GMO to the same or related species, plants (including weeds), the build-up of resistance in insect populations, and the potential threat to biodiversity posed by widespread monoculture of GM crops.

Persley (2000) also identifies socio-economic impact of biotechnology. There is a risk that modern science may bypass the needs of poor people, unless countries have policies in place to ensure that small farmers have access to delivery systems, production resources, markets and infrastructure. In such cases, larger farmers are likely to capture most of the benefits through early adoption of the technology, expanded production, and reduced unit costs.

In short, despite the proven advantages of GM crops in terms of technical and nutritional values, there are controversies worldwide, ranging from their safety for human consumption, through the risks to the environment, to issues such as international trade and intellectual property rights.

ASEAN is in a way in favour of GM crops. Quoting from its website, about GMO frequently asked questions: "biotechnology will bring environmental and agricultural benefits such as increased yields, improved quality of seed grains, increased level of nutrients in certain crops, reduced pesticide use and soil erosion, increased energy savings and tolerance of crops." Specific risks to health and the environment are not mentioned although it is stated that "no one can guarantee that GMOs will never cause unforeseen problem. That is why it requires regulation and scrutinisation by comprehensive systems of checks and balance."

So far, ASEAN has shown its concern over GM crops in terms of the health and, to some extent, environmental risks through the endorsement of the ASEAN Guidelines on Risk Assessment of Agriculture-Related Genetically Modified Organisms (GMOs) in 1999. It also plans to carry out workshops on the use of the guidelines for decision-makers and administrators in ASEAN countries.

ASEAN may need to seek intra- and extra-regional support for capacity building to encourage more research co-operation in GMO development. Higher level of co-ordination with international research institutions will do the job, for example with CGIAR and IFPRI. In regions such as Southeast Asia, issues concerning the risks to biodiversity and socio-economic impacts of GMO development need to be addressed. The first is critical because the region is home to the world-known biodiversity richness. The latter is important because the region is dominated by small farmers who are vulnerable to introduction of such high technology.

GMO should be carefully applied until the risks are better identified, by limiting it to certain crops only after thorough risk-benefit analysis are conducted. A special committee should be set up to co-ordinate this risk-benefit analysis among member countries. This analysis should cover also the risks to biodiversity and the socio-economic impacts of GMO.

In addition, communicating the facts about GM foods is mandatory. Governments must make sure that adequate and correct information is shared among producers and consumers at all level. ASEAN's role here is in harmonising regulations for marketed GM products, both for intra and extra ASEAN markets.

5.4.7 Rural development

In addition to farm management and technological solutions mentioned above, attention should also be given to rural development with regards to agricultural socio-economy. Glaeser (1995) states that ecological change in agriculture is not only a technical problem and that it has to be reconstructed within a holistic approach to agriculture as a sociocultural system.

"Farmers" in Southeast Asia are often part-time farmers, living in rural areas to farm for six months and in urban areas to work in a factory for the other half of the year. The seasonality of agricultural production in the region – highlighted for example by *musim mati* ('dead season') in Peninsular Malaysia, or *musim lapar* ('hungry season') in eastern Indonesia - illustrates temporal fluctuations in village production (Rigg, 1997).

This situation is not desirable since part-time farmers would have less possibility to implement changes in farming management and technology. They do not focus on agriculture, while many of the measures proposed here to mitigate the environmental impacts of agriculture would need high level of knowledge, skills and dedication of the farmers.

Rigg (1997) also states that education and the media have encouraged younger people to regard agriculture as a low-status activity, and the life of farmer as hard and burdensome. In short, an occupation to be avoided. The forces of social and economic changes in rural areas of Southeast Asia have their roots, more likely than not, in the non-farm economy. Driven by rising needs, and often constrained in agriculture by a contracting resource base and unfavourable terms of trade, rural inhabitants are turning to non-farm activities.

Projection in FAOSTAT 2001 shows that although population in ASEAN countries will increase from 480 million in 1995 to 709 million in 2030, people living in rural areas will remain the same, about 318 million. GEO-3 Polestar even makes lower projection, with only about 280 million rural inhabitants by 2032. With rural inhabitants turning to non-farm activities as indicated by Rigg, the increasing crop production in the region will have to make do with fewer labours. The region will have to come up with policy that promotes agricultural management and technology for less labour-intensive production. At the same time, policy measures must be taken to keep farm-economy attractive to Southeast Asians.

By simple calculations, larger agricultural land divided by a fewer number of farmers in the region in the future results in larger area per farmer. As one can expect higher yield in the future, larger area per farmer will bring about higher income to farmers. This seems promising, but it might be too simplifying the case. Other issues like property rights must be considered. Granting land rights to farmers (whether to individual or community) is one solution to make farm-economy more attractive, as it gives security of access to land. In addition to that, sense of ownership induces farmers' investment in sustainable resource management, thus benefiting the environment.

The issue of land tenure is more a national issue rather than regional. However, as rural economy - or more specifically agricultural economy - is crucial to the overall economy of the region (Rigg, 1997; Seda, 1993), it is important for ASEAN to put this issue one element of the ACAP.

Important in rural development is that rural inhabitants have access to education in general and to participation in decision-making process. Numerous non-governmental organisations (NGOs) are active in this field. As in many cases NGOs have more resources than the governments to dedicate their work in rural development, ASEAN does and should further encourage networking of NGOs in the region and promote a higher level of collaboration among governments and NGOs.

5.4.8 International trade

In the previous chapter we see how assumptions on international trade greatly affect the projection on crop production. We know that more export leads to more production and in turn leads to more pressure on the environment. But how exactly does agricultural trade affect the environment?

Trade, the environment and sustainable agricultural development are related, mainly because trade permits the location of production to be separated from the point of consumption. More trade can reduce overall pressures on the environment as measured at the global level, if it shifts production to locations where resource endowments are more appropriate to produce any given amount of output in more sustainable, or less unsustainable, ways. In the end, any given amount of output will be produced with the least demands on the environment if both exporting and importing countries have policies that embody the environmental externalities into the cost of production and the prices of the traded goods. (Alexandratos, 1995). However, more trade will increase transport, which has some environmental consequences as well. It is therefore necessary to include the environmental costs of transport to the prices of traded goods.

Market instruments such as eco-labelling and other certification schemes have been introduced to international agricultural trade, although in general still in a very initial stage and probably not yet include all environmental externalities concerned.

The main export crop commodities in 1996 from Southeast Asia include rice, cassava, vegetable oils (especially palm and coconut oil), cocoa, coffee, rubber, and some tropical fruits. It will continue to be so by 2030 according to FAO projections. IMAGE 2.2 even expects higher growth in export, especially biofuel crops from the region. Whether this will lead to improvement or degradation from environmental point of view depends on the methods employed in the production of each crop. Current state reflects the competitive advantages of the region in producing the commodities, which may include availability of natural resources, labour, climate suitability, and even historical aspects such as colonialisation (Fryer, 1990; Hayami, 2000). The environmental costs have not been adequately considered so far.

Examples exist showing bad practices in the cultivation of the commodities. In response to international demand, plantation of cash crops is widely in practice in the region, such as coffee plantations in Indonesia and banana in the Philippines. Continual cropping of a single crop tends to result in soil degradation and an increase in pest incidence; counter application of fertiliser and chemicals causes serious stress on environment and human health (Hayami, 2000). Cultivation of cassava, an important export commodity to the European Union countries, in marginal land in the region has lead to complete chemical soil degradation.

Improving the agricultural practices related to those commodities is one solution. But, in a larger context, joint efforts must be brought together in formulating international agricultural policy in the years ahead. It will not be until all countries adopt mutual policies that take into account environmental externalities into food prices that the international agricultural trade harmonises the environment. Of course, this is not an easy task. Trade-offs between the environment and economic growth always surface.

One of emerging agendas is the ongoing debate over current WTO agreements concerning agriculture. These agreements include the Agreement on Agriculture (AoA), the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), the Agreement on the Application of Sanitary and Phytosanitary Measures, and the Agreement on Technical Barriers to Trade[3]. In those agreements, environmental standards, often set by developed countries, are often too stringent for developing countries. There are fears that the agreements might serve as a new form of protectionism.

To gain from trade talks, countries must participate effectively in the negotiations (Pinstrup-Andersen et al., 1999). ASEAN has played and can further play a role here in supporting for more balanced international policy-making mechanism. ASEAN participation in international standard-setting organisations is crucial to protect the region's interest. If the region lacks the capacity in meeting the environmental standards and regulations required by international market, technical co-operation or technology transfer might be the solution.

Another issue, however, arise on whether all member countries of ASEAN share the same interests in international agricultural trade. The association covers countries with very diverse economic conditions, from the very wealthy, net importers of agricultural products Brunei and Singapore, through one of the world's largest exporters of agricultural products Thailand, to the least developed and most food-insecure Cambodia. The consensus-based decision making of ASEAN is expected to play a role here, to make sure that the mandate given to ASEAN to bring to international forums really represents the interests of the region as a whole, without leaving any member country behind.

Research should also be done in investigating which region is most environmentally suitable for which crop. ASEAN should support and encourage research to find the most suitable and sustainable agricultural practices in the region.

In trade, consumers can have significant power, especially in an MF-like world. Consumer behaviour determines what goods will sell and what not. Environmentally aware consumers, who prefer environmentally friendly products, will encourage environmentally sustainable practices. In relation to food, it is important to realise that diets are a matter of choice, be it for economical (including those related to food price and food distribution), cultural or ecological reasons. The latter, however, usually represents a higher tier of choice, in most cases holds only for people with more alternatives and higher purchasing power.

When talking about ASEAN trade, consumers are those outside ASEAN and inside ASEAN. The EU countries and Japan, for example, are important importers of vegetable products, whereas Indonesia and Cambodia are important importers of Vietnamese rice. Again, consumers' diversity makes a difference in this case. Having higher purchasing power, some EU consumers are relatively strict in choosing products while people in less rich countries would go for cheaper products regardless of the

[3] Visit www.wto.org for complete review of the agreements.

environmental values. Research needs to be done on how to influence consumer's behaviour towards environmentally friendly food products in less developed countries.

5.4.9 Agri-environmental indicators

Suppose all the policy measures proposed above are already in place, then how can one assess that the agricultural practices are now better from the environmental point of view? How does one know that the agricultural activities in an area are environmentally sound? To answer these questions, one needs agri-environmental indicators. Such indicators transform physical and monetary data about agricultural activities and the state of the environment into decision supporting information. With the help of the indicators, it is possible to better understand complex issues in the domain of agriculture and environment, to show developments over time, and to provide quantitative information (Commission of the European Communities, 1999). Examples of agri-environmental indicators are the risk of water erosion, soil organic carbon, residual nitrogen, etc., as being used by the Canadian government (Smith and McRae, 2000).

ASEAN needs to develop agri-environmental indicators to be able to monitor and assess progress in integrating environmental concerns into agricultural policy. As ASEAN is at the moment developing common criteria and indicator for sustainable forest management in the region, it can use similar approach in developing agri-environmental indicators. The organisation can learn from the experience of other organisations that have been working on such indicators, such as EU, the Organisation for Economic Cooperation and Development (OECD), the Agriculture and Agri-Food Canada, etc.

The implementation of such indicators would require a comprehensive database on agriculture and the environment. Such database will greatly contribute to further integration of environmental concerns into agricultural policy. Establishment of agri-environmental indicators is a vital element of the proposed new ACAP.

5.5 Summary

There is room for ASEAN to foster the integration of environmental concerns into agricultural policy. Closer networking between the agricultural co-operation unit and the environmental unit is necessary for a more effective and efficient co-operation. ASEAN as a regional organisation should take measures to ensure regional food security and environmental sustainability. It can assist the exchange of knowledge and technology among member countries and with other countries and organisations, extend the research capacity of member countries, facilitate training and extension, provide guidelines related to sustainable agriculture, and bring the voice of member countries into international forums.

There are three principles of effective agricultural policy. First, any reform in agricultural policy can only be successfully adopted if they bring economic benefits to governments at national level and to farmers at household level. Second, policy must give the affected parties a sense of ownership. Third, success depends greatly on people's participation and decentralised resource management.

Taking FAO projections on crop production as regional targets for the year 2030, policy intervention is needed to minimise the trade-offs between crop production and the environment. It is recommended that ASEAN set up a project to formulate a new ASEAN Common Agricultural Policy (ACAP) by 2005, which covers several elements as follows:

- Improving fertiliser efficiency by educating farmers and harmonising price of fertilisers and food products.
- Limiting pesticide use by further co-operation in Integrated Pest Management (IPM) and ICM.
- Limiting methane emission from wetland rice with available technologies.
- Managing agricultural land expansion with careful land-use planning and monitoring.

- Limiting soil degradation with soil conservation management.
- Directing genetically modified (GM) crops development with close scrutinisation.
- Enhancing rural development by promoting clear land rights and promoting the role of NGOs.
- Benefiting from international agricultural trade by active participation in international trade talks.
- Developing agri-evironmental indicators for the region.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This report has presented the future crop production and its environmental consequences in Southeast Asia, and identifed policy areas and measures for ASEAN to address the food-environment domain towards 2030. The overall conclusions of this research are clustered into three themes: the general findings, the current environmental problems related to crop production in Southeast Asia and the possible situation of food and the environment by the year 2030. The proposed policy areas and policy measures for ASEAN are presented in the later section of recommendations.

6.1.1 General findings

The entire study has led to several important and interesting findings. By analysing the scenarios, it becomes obvious that the world's future could go different directions depending on the forces that shape it. Apart from aspects beyond human reach such as uncontrollable natural disasters, it is particularly human choices that will shape the future. Human preference on what to eat, and whether to eat imported food products, for example, will influence agricultural activities and in turn affect the environment.

It is also a matter of human choice, i.e. by means of policy, whether necessary actions would be taken to protect the environment. It is commonly understood that trade-offs between human activities and protecting the environment always surface. From this study it is clear that securing production to feed people does have its impacts on the environment, and in some cases, a solution to one problem may create another problem. A perfect example is choosing between balancing agricultural land expansion and intensification. Careful analysis of complex problems would hopefully help in finding the most appropriate solutions, thus helping in decision-making process.

As regards regional co-operation in agricultural development and the environment, this study suggests enhancing regional co-operation in Southeast Asia through ASEAN. As the key institutional framework and the commitment of member countries are already in place, there is room for ASEAN to foster its capacity in integrating environmental concerns into agricultural policy. The recommendations for co-operation are presented in section 6.2.

6.1.2 Environmental problems related to crop production in Southeast Asia

Important environmental problems currently happening in Southeast Asia in relation to crop production include the followings.

- Heavy reliance on chemical fertilisers. It has caused water contamination and emission of nitrous oxide (N_2O), which is one of the greenhouse gases that cause global climate change.
- Pesticide use. It has brought about environmental problems including water pollution and loss of biodiversity, and human health problems due to unsafe application.
- Deforestation caused by agricultural land expansion. It leads to the release of carbon dioxide contributing to climate change, affects hydrological function of forests, alters local climate and threatens biodiversity. Deforestation brings economical as well as ecological losses.
- Land degradation, including depletion of soil nutrients, salinisation, and soil erosion. Hot spots of land degradation in Southeast Asia include salinisation in the irrigation systems in northeastern Thailand and soil erosion on the sloping lands.

- Methane emission associated with rice cultivation. Wetland rice cultivation broadly applied in the region has led to significant methane emission, contributing to climate change.

6.1.3 Food and the environment in Southeast Asia in 2030

Comparison and analysis of the FAO projection, GEO-3 Policy Reform and Market Forces scenarios and IMAGE 2.2 B1 and A1B scenarios reveals the following findings.

- The five scenarios altogether show a basically comparable picture where crop production will increase to keep up with the increase in demand. The extent of the increase, however, is different in each scenario, depending on the assumptions on average daily consumption and diets, influenced mostly by income, and assumptions on export.
- In most indicators under “food and agriculture” section, IMAGE 2.2 A1B scenario envisions the highest figures and growth rates for the year 2030/2032, followed subsequently by B1, FAO, PR and MF scenarios.
- Until 2030/2032, Southeast Asia will experience further population and economic growth, which will increase food demand for domestic consumption. Combined with growth in crop export, this will result in an increase of crop production, which to a large extent will be achieved by crop intensification.
- Highlighted environmental aspects of increased crop production include:
  - Increased fertiliser consumption leading to water contamination and nitrous oxide emission.
  - Increased methane emission associated with rice production.
  - Increased risk of land degradation.
  - Further, although limited, crop land expansion at the expense of natural forests.
- FAO technical projection falls between IMAGE 2.2 B1 and GEO-3 Policy Reform scenarios. The environmental implications of food production in Southeast Asia until 2030 may well be expected to be somewhere in the same extent as those envisioned by PR and B1 scenarios, which both rely on policy interventions. The important message is that policy intervention is necessary to minimise trade-offs between food production and the environment.

6.2 Recommendations

Based on the findings above, this study has come up with several recommendations, which in general can be categorised into policy areas and measures for ASEAN and areas that need further research.

6.2.1 Policy areas and measures for ASEAN

It might be useful for ASEAN to formally set up a project to fully integrate environmental concerns into agricultural policy, to make sure that adequate resources and attention are dedicated to it. The target is to have a new ASEAN Common Agricultural Policy (ACAP) by 2005, in order to achieve agricultural development and environmental sustainability by 2030. Below are some policy areas and measures that this particular project needs to address as the elements of the ACAP.

1. To improve fertiliser efficiency by:
   - harmonising price of fertilisers and food products.
   - co-operation in the development and implementation of Integrated Crops Management (ICM).
2. To limit pesticide use by further co-operation in Integrated Pest Management (IPM) and ICM.
3. To limit methane emission from wetland rice by:
   - assessing the feasibility of adopting mitigation technologies in each member country.
   - coordinating training and extension for adopting the technologies; the co-ordination scheme can be similar to IPM scheme.
   - establishing baseline information centre on greenhouse gases emissions.

4. To deal with agricultural land expansion by:
   - facilitating member countries in expanding and exchanging their capacity in land-use planning, for example with the use of Geographical Information Systems (GIS).
   - facilitating member countries in expanding and exchanging their capacity in monitoring of agricultural practice to ensure that the land that is cleared for agriculture is managed in a proper way.
5. To avoid soil degradation by facilitating transfer of knowledge of soil conservation management, among its member countries and with outside organisations.
6. To direct genetically modified (GM) crops development with close scrutinisation by:
   - encouraging more research co-operation in GM crops development by higher level of co-ordination with CGIAR, IFPRI, etc.
   - setting up a more thorough risk-benefit analysis for each GM crop, including the risks to biodiversity and the socio-economic impacts.
   - ensuring adequate regulations of marketed GM products.
7. To address rural development in the region by:
   - encouraging member countries to promote clear land rights for farmers.
   - encouraging networking of NGO in the region and promoting higher level of collaboration among governments and NGO.
8. To gain benefits for all member countries from international agricultural trade by:
   - active and co-ordinated participation in international trade talks.
   - encouraging research to find the most suitable and sustainable agricultural practices in the region.
9. To develop agri-evironmental indicators by own research and learning from the experience of other organisations.

6.2.2 Further research

This study has indicated several areas that need further research, including:

- Detailed study on how to set up the ACAP project in ASEAN, including the clear targets and timeframe and resources (personnel, financing, etc.).
- What agri-environmental indicators are suitable for Southeast Asia and how to implement them.
- How sustainable agriculture practices in general can be adopted at grassroot level, i.e. by farmers, for example through education and an effective and efficient communication networking.
- How to influence consumer behaviour towards more environmentally friendly food, for example through price policy and the use of communication media.
- Risks of GM foods on the environment, human health and farm-economy.

There is also a need for research on the relationship between livestock production and the environment, and sustainable development of fishery as another food source.

Having mentioned in the beginning of this report that this study can only contribute a small portion to the huge effort to achieve food security and environmental sustainability in Southeast Asia, research on other issues determining food security is necessary. These issues include poverty eradication, fair distribution of food in terms of availability and accessibility, and prevention and elimination of conflicts.

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Important Websites

ASEAN	: www.aseansec.org
CGIAR	: www.cgiar.org
FAO	: www.fao.org
FAOSTAT	: http://apps.fao.org/default.htm
IFPRI	: www.ifpri.org
IRRI	: www.irri.org
RIVM	: www.rivm.nl
UNEP	: www.unep.org
WTO	: www.wto.org

Appendix 1: List of Commodities

In "Crop Production"

FAO AT 2015/30	IMAGE 2.2
Cereals: wheat, rice (paddy), maize, barley, millet, sorghum, other cereals	Cereals: temperate cereals (wheat: barley, oats, rye, wheat), rice, maize, tropical cereals (millet, sorghum)
Starch: potatoes, sweet potatoes, cassava, other roots, plantains	Roots and tubers: cassava, potatoes, sweet potatoes, yams
Pulses (beans)	Pulses (beans)
Vegetable oils and oilseeds: rape seed, palm oil, soybeans, groundnuts, sunflower seed, sesame seed, coconuts, other oilseeds	Oil crops: groundnut, sesame seed, soybean, sunflower seed, rape seed
	Biofuel crops: Sugar cane, maize, woody biomass, non-woody biomass

In "Total Crop Production"

FAO AT 2015/30	IMAGE 2.2	GEO-3
Cereals: wheat, rice (paddy), maize, barley, millet, sorghum, other cereals	Cereals: temperate cereals (wheat: barley, oats, rye, wheat), rice, maize, tropical cereals (millet, sorghum)	Cereals: rice, other cereals
Starch: potatoes, sweet potatoes, cassava, other roots, plantains	Roots and tubers: cassava, potatoes, sweet potatoes, yams	All other crops
Pulses (beans)	Pulses (beans)	
Vegetable oils and oilseeds: rape seed, palm oil, soybeans, groundnuts, sunflower seed, sesame seed, coconuts, other oilseeds	Oil crops: groundnut, sesame seed, soybean, sunflower seed, rape seed	
	Biofuel crops: Sugar cane, maize, woody biomass, non-woody biomass	
Vegetables	Vegetables	
Fruits: banana, citrus fruit, other fruit	Fruits	
Sugar raw	Sugar raw	
Industrial crops: cocoa beans, coffee beans, teas and mate, tobacco, seed cotton, jute and hard fibres, rubber	Industrial crops	

Appendix 2: Land Use Classification

GEO-3	IMAGE 2.2
Cropland	Area of food crop and biofuel crop (part of Agricultural Land)
Pasture	Area of grass and fodder (part of Agricultural Land)
Natural Forest	Mature Forest (part of Natural Vegetation)
Protected	Bioreserves*
Built Environment	Built-up Areas*
Other	

* not shown in map and graphs of IMAGE 2.2 but proportionally incorporated into other land-use types.