

SYNTHESIS OF EXPERIENCES ON BETTER AGRICULTURAL PRACTICES FOR ENVIRONMENTAL SUSTAINABILITY

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From 6 to 14 August 2003, the Asian Productivity Organization (APO) held a workshop on Environment-Friendly Agriculture in Tokyo, Japan. It involved participants from 17 countries. The group, along with various resource persons, came together to examine the best agricultural practices around Asia that promote and preserve environmental sustainability. The objectives were to see from case studies the environment-friendly agricultural (EFA) practices that currently exist as well as to identify environmentally harmful practices. Moreover, time was given to discuss appropriate ways to mitigate adverse agricultural practices and enhance strategies and measures that would encourage the adoption and expansion of EFA practices.

Since this meeting was a follow-up to a previous APO workshop in 2000 (Impact of Agricultural Practices on Environmental Sustainability in Asia), an excellent starting point was the APO publication of the former proceedings. Also, participants were able to glean from country papers presented, resource papers given by invited experts, field visits to Japanese village areas, small group sessions and individual input and interactions. All of these worked together to bring about a synergy of new insights regarding EFA practices.

From the country and resource papers as well as field visits, it was obvious that a number of better agricultural practices for environmental sustainability do in fact exist. From the VAC (indigenous integrated farming system) model in Vietnam to the Kandy Home Gardens (KHG) in Sri Lanka, to organic farming in Taiwan and Singapore, to the King's New Theory in Thailand and to Sloping Agricultural Land Technology in the Philippines, each country representative was able to share some type of environment-friendly practice or system that was working in his/her country.

ABOUT ENVIRONMENT-FRIENDLY, SUSTAINABILITY, ORGANIC FARMING AND BETTER PRACTICES

A number of ideas and terminology were used during the workshop that overlapped to a certain degree. Even though the main focus was "environment-friendly" agricultural practices, much discussion was placed on sustainability, organic farming and the better practices that encompassed each of the ideas.

EFA practices can be a component of any system. By definition, sustainable farming systems are environment-friendly. Moreover, organic farming is generally held to be environment-friendly but there are cases in which overuse of even organic inputs can cause environmental concerns.

Any agricultural system, whether large-, medium- or small-scale, can have environment-friendly components but not necessarily be sustainable or even organic farming in nature. The oil palm industry in Malaysia, presented as one of the case studies, has strived in the recent past to become an environment-friendly endeavor. From establishment to harvest and processing, much attempt has been made to make the industry as environment-friendly as possible. However, the system would not be described as "organic", but possibly sustainable.

Table 1. A Simple Comparison of Three EFA Practices from the Country Papers

Constraint/ Strategy	VAC	KHG	OFD
Government policies	A successful traditional EFA practice was identified and promoted to other farmers via model farms, extension and pilot projects.	An indigenous practice recognized by the government and promoted to individuals and the nation as a whole.	Council of Agriculture (COA) initiated organic network; various agencies promoted; funds appropriated for national programs.
Institutions	Promotional organization formed (VAC VINA); government intervention to enhance adoption process. Educational and technical programs provided; on-farm seminars, trainings, VAC clubs, etc.	The basic institution for propagation is the Kandyan home; the government has capitalized and incorporated the KHD as a strategy for EFA.	Government support through COA; inter-national foundations (MOA); private organizations (TOAF, TOPA, COAA*, etc.); universities, farmer groups.
Economic and finance	Initial supplies given to encourage adoption. International assistance (UNICEF).	Seeds and seedlings provided to initiate; subsidy and incentives given to encourage home gardening.	Market-driven incentives (i.e., demand) for EFA products. Some government subsidies; free trade market influences.
Sociocultural	Developed from traditional method in the Red River Delta; spread from farm to farm.	A long-term EFA practice indigenous to Sri Lanka; display of environmental consciousness.	Public awareness of EFA products as well as price acceptability.
Technical	Bio-intensive farming encouraged; use of local species; use of natural moisture, solar energy and existing nutrients. Integration of on-farm wastes (e.g., animal manure) back into the system.	Soil erosion prevention for the uplands; diversification of crops and animals; <i>in-situ</i> conservation of crop germ plasm.	Zero or reduced pesticides; tolerance levels of chemicals contained in the product; insurance of quality control and labeling; mechanization to offset high labor costs. Green manure usage.
Resource availability	Self-reliance; protection of environment; improving people's livelihood.	Protection of uplands against soil erosion; preservation of biodiversity.	Protection of groundwater, off-site pollution and global warming/greenhouse issues.

Note: TOAF = Tsesin Organic Agriculture Foundation; TOPA = Taiwan Organic Product Association; and COAA = Chinese Organic Agribusiness Association.

Small-scale organic farming, even though considered to be generally an EFA practice, is not necessarily so by definition. In some cases, it is not even sustainable. For instance, if the economics of organic production cannot support the desired livelihood output of the local farmer, the system is more than likely to be abandoned thus making it non-sustainable.

On the other hand, sustainable agriculture is environment-friendly. Thus any practices that contribute to the conservation of land, water and biodiversity, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable, moves a system towards being more sustainable. Thus generally, organic farming practices, both large- and small-scale, fall greatly within sustainable agriculture. Moreover, it can be said that any EFA practice, in large- or small-scale production, that leads to a potentially greater sustainability.

BETTER AGRICULTURAL PRACTICES IDENTIFIED AND A SHORT ANALYSIS

As stated, a number of better agricultural practices from each country was identified and documented. Some were similar in terms of individual practices (e.g., conservation tillage, reduced or no chemical additives, etc.) yet each unique in their own location-specific situations. Below, three of the identified better practices will be examined as to workshop constraints and strategy groupings.

VAC is food, fish, animal integration farming from Vietnam; KHG is Kandy Home Gardens from Sri Lanka; and OFD is Organic Farming from Developed countries represented by the Taiwan model. There are similarities in each EFA practice identified but also contrasts in major areas of concern. This would be mainly due to specific location approaches and differences of emergent EFA practices.

OVERARCHING THEMES FROM THE VARIOUS CONFERENCE ACTIVITIES

There are a number of common themes that emerged from the workshop participants and the various activities. These include but are not limited to the following:

1. ***Stakeholders at all levels play a role in either impeding or enhancing the application of better agricultural practices for environment-friendly agriculture.***

In one form or another, this idea kept coming up in the papers and small group discussion times. In the field example of the visit to Fukushima prefecture, the participants saw how a positive market and good communication and trust level between producers and consumers could help positively influence adoption and spread of EFA practices. From national government levels all the way down to the farm level, each stakeholder plays a role in shaping the public view as well as practical application of EFA practices. When there are positive relationships with fulfilled role responsibilities, EFA practices can be greatly enhanced. Conversely, if one link in the chain is broken, be it government/policy, research institution, extension agent, consumer or producer, a serious threat exists to implementation of these practices.

2. ***Socioeconomic factors have a strong influence of EFA practices.***

From cases presented to resource person inputs to field visits, a recurring theme was that the socioeconomic standings of a farmer/community/country has a strong influence on practical application of EFA practices. The cases of the more developed countries indicated a higher public knowledge and willingness to adopt EFA practices such as organic farming. Moreover, increased disposable income in these countries predisposes people to be able to purchase higher cost organic products. On the opposite scale of the spectrum, a number of papers and resource persons pointed out that the poorest of the poor are probably some of the best existing examples of EFA practitioners. Due to lack of resources to purchase and access to obtain, chemical inputs are rarely seen among the impoverished. One glaring difference among the poor in regards to EFA practices is the age-old system of slash-and-burn (swidden) agriculture. Some papers and participants criticized slash-and-burn as the major environmental enemy to their respective countries via traditional agricultural practices. However, it is recognized by agriculturists and anthropologists worldwide that swidden agriculture, under traditional conditions of low population densities, is probably a fairly sustainable system, much more so than the modern agricultural practices of high-yielding varieties (HYV), genetically modified organisms (GMO), heavy external inputs (HEI), etc.

The slash-and-burn controversy aside, it could be proposed that a traditional bell curve would graphically represent socioeconomic status of a nation/farmer and their willingness as well as interest in adoption of EFA practices. The major bulk of the average farmers in the world would fall somewhere in the middle where producers' and consumers' interest would be more focused on maximum production and affordable food prices, respectively. The two extremes where a greater likelihood of receptivity resides would be the wealthier places/persons where consumers can "afford" and support demand of EFA produce and the "poorest of the poor" who are basically subsistence farmers trying to make enough food for security within their family lines.

3. ***We have a multitude of government policies encouraging and even legislating EFA practices. Why aren't they being implemented?***

From group to group and individual to individual, this observation was constant. Each country paper documented well the government policies and programs aimed at implementation of EFA practices. From a "plethora" of policies seen and discussed in a number of country papers to practical legislative struggles of regulating slash-and-burn farming in the uplands, the political structures and especially legislation seemed to be in place for giving a framework to successful application of EFA practices in each country represented. Yet, a huge gap consistently exists between policy and practice.

Most participants seemed to be in consensus by agreeing that this problem was due to a lack of political will. However, the fact of the "plethora" of policies says that a political will does exist for EFA. The problem for lack of action is more likely due to a collective lack of awareness, sociocultural and economic barriers, or even unhealthy attitudes towards EFA.

Another plausible reason for the lack of translation of policies into action is the lack of clear strategic action plans, implementation plans and inadequate monitoring mechanisms. Resolutions are passed, laws are made (in regards to EFA practices) but due to the lack of these mechanisms, little translates to on-ground programs.

4. ***Site-specific and case-by-case criteria should determine EFA practices applied.***

In each of the country papers as well as the resource papers presented, there was a strong theme about paying attention to site- and case-specific needs in the application of better agricultural practices for environmental sustainability. For instance, the way to approach EFA practices with plantations, corporations and wealthier farmers could be economically driven via incentives/penalties whereas EFA practices for smaller, grassroots farmers/groups might focus more on production, social organizations, etc. Moreover, the agricultural problems for a country like the Maldives is radically different from the problems in a country such as Lao DPR necessitating site, case, cultural, etc., considerations. Also, there was a focus in many of the papers of in-country attempts at identifying particular eco-zones for widely applying EFA practices. This was especially seen in the resource paper presented from Vietnam.

5. ***Interdisciplinary and multidisciplinary teams are needed to help identify, design and help implement EFA practices on a community or nationwide basis.***

Prof. Tanaka's resource paper urges those wishing to see EFA practices adopted need to step out of the mainstream agricultural research mode that is vertical in nature and expand their research biases to include anthropocentric tools. Other papers deal with the need of multidisciplinary teams to help communities as well as countries develop sound EFA practices.

6. ***Ensuring quality control at all levels for organic products is a great concern.***

How can a consumer be totally confident in the organically produced product that is marketed? A strong interaction and relationship developed between producers and consumers would be a good step towards building trust and ensuring quality control. This was seen in the case of the groups' field visit to Fukushima prefecture where producers and consumers have developed a symbiotic-like relationship. However, in absences of such consumer-producer interaction, further measures are needed to ensure that touted organic products are indeed what they say they are. Standardized labeling and regulations were issues for all country participants. What should be the standards and whose regulations should be followed? In some countries, there was more than one certifying board for organic products, which led to confusion and loss of confidence in consumers. Also, a lack of regulation for producers who "label" their products at their own discretion is common.

Moreover, a skilled labor force and knowledgeable and qualified extension agent to serve as inspector for organic products seemed far off for most participating countries. Training, education, attitude shift, and more importantly, financial resources (sadly lacking in many cases), are needed to enable professional and proper monitoring of organic products. There are some good international

guidelines (i.e., International Federation of Organic Agriculture Movement [IFOAM]) on what is environmentally and anthropogenically safe; however, these need to be evaluated against local needs and constraints and standardized.

7. ***The average farmer's attitude towards EFA is basically negative.***

During the first small group session, the majority of the group seemed to indicate that one major obstacle to EFA practices was that of the individual and collective farmer's attitude towards the practices themselves. For reasons of economics, non-willingness for risk introduction and just plain being "comfortable" with their proven systems of chemicals, cultivation and cultural practices, most country representatives expressed they had observed farmer reluctance to move towards proven EFA practices. However, it was pointed out by other group members that it was not only farmers' attitudes, but also the attitude of all people, especially the education establishment. Moreover, a challenge was given at the close of the conference to examine ourselves and see if we are personal models of promoting EFA practices as well.

8. ***The need for networking at all levels for a unified effort***

A clear need was expressed for a unified effort by all promoters and implementers of better agricultural practices for environmental sustainability to develop effective channels of communication. There is a need at inter-communication among promoters, practitioners, trainers and implementers. There is an extra-communication need to consumers, groups, individuals and society as a whole about the benefits, safety and sustainability of EFA practices. Overlapping and general lack of coordination and cooperation were seen as impediments to EFA practice expansion.

9. ***There is a strong need for education and awareness at all levels to ensure the adoption of environment-friendly better agricultural practices.***

A major strategy emerging from almost every participant was the need for more and better education and awareness programs if there is to be a large shift from conventional practices to environment-friendly ones. A paradigm shift is needed in our formal education systems where not only do we have courses in sustainable agriculture and environmental studies but where instructors themselves believe and model the same. From preschool to kindergarten to primary and on to secondary school, each grade should have culturally and age-appropriate lessons towards this new paradigm. Governments, NGOs and peoples' organizations alike should play an important role in positively influencing the collective societal mindset towards environmentally friendly practices.

FIELD VISIT AND OBSERVATIONS

On 11 and 12 August of the workshop, a field visit was conducted to Fukushima prefecture. During the visit, the participants went to and met with the leaders and farmers of Atsushiokanou village. After a briefing in the village office, a field tour was made of where organic farming practices were being applied and a local farmer was interviewed. Also during our field exposure, a brief visit was made to a JA (agriculture cooperative) market where there was a mix of organic and non-organically produced products.

The group's observations about the field visits (in relation to environment-friendly better agricultural practices) were:

Positive:

- Cooperatives were formed and the financial incentives for farmers existed
- There was a favorable policy environment
- There was good promotion of products; a good display was presented to consumers
- Farmer-farmer cooperation/linkages were established
- Reasonable product prices were in existence
- There was a well-organized farmer market
- There was a need perceived of the household (in response to organic farming)
- There was a fair price given for the farmers' organically-produced products
- There was a product assortment not just one product
- There was government commitment to the farmers
- There was political support (e.g., JA, etc.)

- There was identification of the problem and attempt to solve it (overproduction of rice) at the community level
- There was an overall positive attitude of the farmers to work with the consumers to produce a product that was demanded by the market (e.g., organic produce)
- There were assured prices and a good market for the local farmers.

Negative:

- There should be more and better demonstration farms in the villages promoting EFA in order to motivate farmers
- The local government should take a more active role to ensure the quality of food produced (e.g., make sure that it is organic)
- There needs to be a labeling of their organic products
- There should be more identifying of farming activities.

SEMINAR RESULTS IN TERMS OF OBJECTIVES

The three aspects of sustainable development in agriculture according to the APO priorities are: 1) sustainable resource management; 2) value addition through sustainable agriculture; and 3) policy setting for sustainable agriculture. This workshop was to look at these three issues in the light of current measures that could mitigate adverse agricultural practices to sustainability and to discuss strategies and measures for the adoption of environment-friendly practices. The major ones identified are:

Measures Towards Mitigation of Harmful Practices in EFA Identified

1. Total closed on-farm farming systems. This would include organic practices of farmers (such as in the Japanese case presented by Michio Uozumi) with even bio-fuels produced in-situ.
2. Better management systems such as a reduction of water usage in rice production, better fertilizer placement, etc. (identified by Dr. Minami and Prof. Tanaka).
3. Improved mitigation technologies such as chemical nitrogen inhibitors, slow and time-released fertilizers, etc.

Strategies and Measures for Accelerated Adoption of EFA

1. Use of a people-based/watershed management approach (Dr. Anbumozhi, J. Jeffrey Palmer) whereby stakeholders are involved in the process of designing and implementing their EFA practices. This takes into account indigenous knowledge.
2. Merging of disciplines (scientific and cultural) for interdisciplinary approach to sustainable agriculture (Prof. Tanaka).
3. Legislation and political will with active follow-up by the appropriate implementing agencies (Teoh) such as in the case of the oil palm industry.
4. True incentives offered to implementers of environment-friendly practices including production, harvesting and marketing activities (Workshop outputs).
5. Awareness campaigns on all levels (producer, consumer, business, etc.) about the positive benefits of EFA (Workshop and field trip outputs).

CONCLUSION

A wealth of information is included in the following proceedings in relation to EFA practices for environmental sustainability. The resource papers present a case for EFA issues and practices from the global perspective all the way down to the village level. The country papers critically examine the *pros* and *cons* of EFA practices in their respective settings. The workshop outputs and field visit observations yield additional insight into this timely topic.

The proceedings well document the struggles, successes, and insights based upon the experiences of the participants. It is hoped that through the reading and digesting of the information, you will be able to gain a better understanding of the issues shaping our global and local movements towards more environment-friendly sustainable agricultural practices. It is a critical issue facing the world and each

citizen. Whether or not we succeed in this endeavor to ensure a brighter future for our generations to come will largely depend upon the choices we make today.

As you read these papers, case studies and workshop outputs, please remember that there are no perfect models, even collectively, for environment-friendly better agricultural practices. Mostly, all these experiences, taken together, give at best a panoramic view of what environment-friendly and sustainability should be.

May you enjoy these proceedings and may they challenge you to make choices for a more sustainable earth through environment-friendly better agricultural practices.

1. THE GLOBAL NITROGEN/CARBON CYCLES AND AGRICULTURAL PRACTICE FOR ENVIRONMENTAL SUSTAINABILITY

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INTRODUCTION

Japanese writer Ryotaro Shiba wrote “*To You Who Live in the 21st Century*” as a textbook for Japanese sixth graders. The following is an excerpt.

“There is a thing that has not changed until today since a long time ago and that will not change in the future. It is that such nature as air, water and soil. These are the things that humans and other animals, plants and microorganisms depend on to live. Nature is the unchanging value. It is because humans cannot survive without inhaling air and they will dry out and die without water... In the 21st century, science and technologies will be further advanced. Science and technologies shall not swallow humans like a flood. I hope that your steadfast lives will control science and technologies and put them on the right track just like you would correct the water flow of a river.”

Shiba is right in saying that nature is the unchanging value. However is nature unchanging in reality? The air is not what it used to be. The atmospheric concentrations of such substances as carbon dioxide, methane, and nitrous oxide that promote global warming have been rapidly increasing. Such substances as chlorofluorocarbons, nitrous oxide, and methyl bromide that deplete the ozone layer have been increasing in the atmosphere. Acid rain falls from the air. Water is not what it used to be. The groundwater has a high content of nitrates and it is not suitable for drinking any longer. The river water has been eutrophied in accordance with an increase in the concentration of nitrogen and phosphorus. The soil suffers the same fate. The soil that has been nurtured strenuously over tens of thousands of years is washed away into rivers instantly due to erosion. Microorganisms in the soil are dying because of excessive application of agricultural chemicals and fertilizers. We can hear the shrieks of pain from the earth and the atmosphere from all around the world.

Why is the “thing that has not changed until today since a long time ago and that will not change in the future” changing? It is certainly because our science and technologies we have promoted and followed in the 20th century are about to swallow nature like a flood. In other words, our science and technologies have changed material cycles at the global level. If science and technologies had been used based upon environment-friendly principles, the “thing that has not changed until today since a long time ago and that will not change in the future” would have remained as it had been.

The abnormality of the material cycles has become spatial environmental problems at the global level. It starts as point pollution by heavy metals such as cadmium and mercury and develops into pollution covering extensive areas exemplified in eutrophication of lakes by nitrogen and phosphorus. Various chemical substances emitted into the atmosphere in accordance with human activities and a population increase cause spatial problems.

There are a large number of problems related to agriculture and global environmental changes, including global warming, depletion of the ozone layer, acid rain, and soil erosion. Considering such pressure on agriculture and the global environment, the issues of food security and environmental conservation we are currently facing are serious. What is more serious is the concern about the

interactions between various phenomena of environmental deterioration. Many problems are linked with the global cycles of nitrogen and carbon in their basic nature.

Interactions of various phenomena that erode the environment, or multiple phenomena, including the interaction between global warming and ultraviolet rays, are major components to environmental deterioration at the global level. In this paper, interactions of such phenomena are related to agriculture and will be sorted out based on the nitrogen and carbon cycles and future possible implementation of technical measures will be discussed.

EVERYTHING FLOWS

Nitrogen and carbon are the elements that show the importance of “everything flows” and the principle of “all things being in flux” better than any other elements. Humans have created many substances such as plastics, radioactive materials, and chlorofluorocarbons that cannot “flow.” They are disposed of without “flowing,” continue to pile up and are pushing to the limits the earth where we live. If we do not realign our minds and souls to “flowing systems” – the true nature of nitrogen and carbon, the earth will be irreparable some day.

However, we human beings have already interrupted seriously the flowing nature of nitrogen and carbon. We have effected environmental changes through the rising concentration of nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4) in the atmosphere and the rising concentration of nitrate (NO_3^-) nitrogen in the groundwater.

The increase of nitrogen and carbon concentration and a change in their cycles in the biosphere has caused various changes in the global environment, including global warming, destruction of the ozone layer, acid rain phenomenon and pollution of groundwater. As a result, all areas of the biosphere from the groundwater to the stratosphere are now exposed to the threat of global environmental changes.

Such changes can be largely attributed to the fixation of atmospheric nitrogen (N_2). Gaseous nitrogen comprises about 78 percent of the atmosphere. Humans, through the production of N-based chemical fertilizers, have accelerated the conversion process of gaseous nitrogen to nitrogen-based agricultural soil amendments. In addition, fixed nitrogen is applied to the earth without any consideration into such factors as the balance of the ecological system, place and time. As a result, natural nitrogen “cycles” have been changed.

A similar phenomenon can be observed in carbon. Carbon fixed in the earth’s crust is mined and used for energy in the form of coal and petroleum oil. As a result, the atmospheric concentration of carbon dioxide has continued to rise. Carbon, under reduction conditions, turns into methane as the final product due to the activities of microorganisms in accordance with human activities. An increase in concentration of such gases in the atmosphere is a major cause of global warming.

For “smooth cycles” of nitrogen and carbon, it is necessary to control the conditions of their fixation and thus have power over what “flows.”

CHANGES OF FORMS OF NITROGEN AND CARBON AND THEIR CYCLES IN THE ENVIRONMENT

Nitrogen

Nitrogen is essential to life. It is a fundamental component of the molecules called amino acids. These are indispensable to the maintenance of life. Amino acids are combined to form protein, which transfers and stores such small molecules as enzymes and oxygen. Nitrogen is an essential component of the bases that make up deoxyribonucleic acid (DNA.) DNA is the molecule that carries genetic codes of all organisms.

Nitrogen also plays important biological roles. For example, there are organisms that use nitrogen in an oxidative form as a substitute for oxygen during respiration while there are others that are able to oxidize reduced nitrogen with oxygen to liberate energy. In fact, nitrogen has various aspects when oxidized and reduced. Its oxidation states range between +5 and -3. What is most important in the ecosystem are NO_3^- , NO_2^- , NO_2 , NO , N_2O , N_2 , NH_3 and NH_4^+ . This means that biologically mediated redox reactions are dependent upon the nitrogen cycles. The fact that the combinations of nitrogen change in accordance with the oxidation-reduction reaction shows that nitrogen moves from one reservoir to another in a different physical location.

Nitrogen fixation, denitrification, and nitrification are involved in transfer of nitrogen into other systems. Nitrogen fixation is a reaction of forming another nitrogen compound by using molecular nitrogen in the atmosphere. Nitrogen fixation is performed biologically and industrially. In the industrial fixation, the Haber-Bosch process reduces nitrogen gas to ammonia. However, it requires high pressure under high temperature and consumes a great amount of energy.

On the other hand, biological fixation is performed under natural conditions by nitrogen-fixing organisms. Nitrogen is reduced to ammonia by nitrogenase activities and taken into organisms. This process is an important part of nitrogen cycles on the earth and aids in securing a source of nitrous nutrition for plants.

Denitrification is a process of aerobic bacteria, in the absence of oxygen, producing N_2 or N_2O by using nitrite and nitrate nitrogen (NO_2^- and NO_3^-) as an electron acceptor of respiration. Nitrification is a reaction of the oxidation of ammonia nitrogen by the activities of microorganisms and the production of nitrite and nitrate nitrogen (NO_2^- and NO_3^-). Nitrifying bacteria, ubiquitous in the soil, performs nitrification.

Nitrifying bacteria is divided into two types – ammonium-oxidizing bacteria that oxidize ammonia nitrogen into nitrite nitrogen and nitrite oxidizing bacteria that oxidizes nitrite into nitrate nitrogen. N_2O is produced and emitted into the atmosphere in the nitrification process.

Nitrogen flows in various forms in the soil, earth crust, ocean, plants, animals, and the atmosphere. Nitrogen is in the soil as organic and inorganic components at one time. It is in the human body as an organic component and in the atmosphere as gaseous matters at other times. It flows in cycles beyond space and time.

Carbon

Carbon also flows in cycles in various forms, sometimes organic and other times inorganic, in the atmosphere, ocean, earth crust, plants, animals, and the soil. Carbon exists in the ecosystem in such forms as carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), and carbonate (CO_3^{2-}), hydrogen carbonate (HCO_3^-), organisms, fossil fuel, sediments, and rocks. The first three gases exist in the atmosphere and the following two salts exist in the water system.

Just like nitrogen, the states of oxidation of carbon range widely between +4, in the form of CO_2 , and -4, in the form of CH_4 . It exists in the forms of H_2CO_3 , HCO_3^- , and CO_3^{2-} in the ocean and $CaCO_3$, $CaMg(CO_3)_2$ and $FeCO_3$ and other forms in the solid phase.

NITROGEN AND CARBON CYCLE CHANGES IN THE HUMAN ZONE

The birth of the earth dates back to 4.6 billion years ago. After earth's birth, it was composed of the atmosphere, hydrosphere, crustal sphere, biosphere, and pedosphere. About 10,000 years ago, a new sphere called the anthroposphere appeared. Later, the anthroposphere was expanded and enlarged to a degree to trigger a question whether the earth itself could survive the pressure of its existence. This has mainly occurred in the 20th century.

After the birth of anthroposphere, nitrogen and carbon cycles became unbalanced and disturbed. The main reason was humans began agricultural production and to enjoy affluent material civilization. There are many reasons the nitrogen and carbon cycles have become out of balance.

ENVIRONMENTAL CHANGES CAUSED BY CHANGES IN NITROGEN AND CARBON CYCLES

Global Warming

Climate change of the earth has occurred as a result of interactions of various factors. The current global warming trend is caused by human activity and is a result of increased concentration of greenhouse gases in the atmosphere. The greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbon (CFCs.) Carbon dioxide produced by the combustion of fossil fuels is the largest contributor to global warming. The second largest contributor is methane emitted by paddy fields, livestock, and others. The third largest contributor is nitrous oxide mainly emitted due to the application of nitrogen fertilizers to farmland.

Effects of global warming have been observed in various places. According to a report by the Worldwatch Institute, the surface of ice covering the Arctic Ocean decreased by about 6 percent in 18 years from 1978 to 1996. The thickness of the ice was an average of 3.1 m in 1970 but the average dropped to 1.8 m in the mid-1990s. At the South Pole, which contains 91 percent of all the ice on the globe, three ice shelves collapsed and huge icebergs have drifted into the ocean over the last 10 years.

In Japan, the average annual temperature continues to rise. In September 1999, the average temperature in Tokyo and Osaka hit an all-time high of 26.2°C and 27.2°C, respectively. Amami-Oshima at 26.6°C and Naha at 27.2°C were almost the same. Japan continues to become warmer and warmer. In most areas in Japan, the average annual temperature has risen by more than 2°C over the last 100 years. In particular, the rate of rise is the highest in Tokyo where the average has risen by 2.9°C.

The Japanese Meteorological Agency makes public such information as average monthly temperature, precipitation, and hours of sunlight of various locations in Japan from Wakkanai to Minami-Daitojima Island. In February 2002, the average temperatures from Wakkanai to Hakodate in Hokkaido varied from 0.1°C to -4.3°C. The gap of the average temperature within that year was quite large ranging from 1.9°C to 4.1°C. The gap of the average temperature with an average year in Irkutsk in Siberia, Yuzhno-Sakhalinsk in Sakhalin, Vladivostok in maritime provinces and Ulaanbaatar in Mongolia was also high at 5.4, 3.7, 4.6 and 3.2°C, respectively.

The average temperature in March 2002 hit a record high in various parts of Japan. For example, the average was 12.2°C in Tokyo, 3.3°C higher than other years. The record high temperature marked in January continued until spring greatly influencing fauna and flora. For example, cherry blossoms bloomed earlier than usual in various places. In the same year, the Meteorological Agency reported that the higher-than-usual temperature would continue for a while even into April.

According to the Office of Statistics of the Observations Division of the Meteorological Agency, the average monthly temperature in March 2002 hit a record high at 95, or nearly two-thirds, of 149 observation points located in Japan. The average was higher by more than 3°C mainly in the Kanto region. The earlier record high in Tokyo was recorded in 1990 at 10.6°C. But the average in March 2002 was higher than that by 1.6°C, hitting a record high since the observation began in 1923. In Osaka, the average was 11.6°C. This was higher by 2.6°C than an average year, marking a new record exceeding the previous record by 1°C. It was the highest since the observation began in 1883.

As global warming continues to advance, it is impossible to avoid serious damages on agricultural production due to such a phenomenon as drought at various places. This raises another concern over insect pests. According to a prediction in 1998 by the Hadley Center for Climate Prediction and Research in the United Kingdom, if global warming continues to advance, food production will drop drastically in Africa and North America due to the abnormal weather.

Ozone Development in Troposphere

Ozone in troposphere greatly contributes to global warming as a greenhouse gas. As the OH radicals generated as a result of its photolytic reaction controls the life of other greenhouse gases including CH₄ and HCFC in troposphere, the ozone is involved in global warming indirectly.

On the other hand, ozone in troposphere helps prevent harmful ultraviolet rays from reaching the surface of earth, which is caused by a decrease in ozone in stratosphere. Ozone in troposphere is beneficial in the sense that it eases effects of harmful ultraviolet rays on the living body and ecosystem.

In recent years, ozone in the troposphere has steadily increased becoming an issue. The Frontier Observational Research System for Global Change announced recently that the ozone of the subtropical westerlies moves between continents and contributes to the promotion of global warming.

It is a widely known fact that artificially generated NO_x has a great effect on the ozone development of troposphere. Of agricultural activities, fertilizers, livestock waste, and biomass combustion are the main sources of NO_x emissions.

Acid Rain

Chemical compounds containing nitrogen, carbon, and sulfur turn into organic acids such as formic and acetic acid and acid substances such as meta-sulfonic acid and nitric acid when combined with oxygen in the air. When about 350 ppm carbon dioxide in the atmosphere is dissolved in deionized water, its pH level is about 5.6 and is considered to be in an equilibrium state. Rain with pH below 5.6 is defined as acid rain.

The pH level of rainwater is decided not only by the concentration level of the acid substances but the levels of basic substances including ammonia, calcium, sodium, and magnesium. About 60 percent of anions in rainwater in Europe are sulfate ions and about 30 percent are nitrate ions. In Japan's rainwater, the concentration of nitrate ions is often higher. In both cases, main causes of acidification of rainwater are sulfate and nitrate. It is fair to say that their precursors are sulfur dioxide and other sulfur compounds as well as nitrogen oxides.

Nitrogen oxides are emitted by the combustion of fossil fuels and biomass as well as the soil itself. Of agricultural practices, combustion of biomass, fertilizers, and livestock waste cause nitrogen oxide emissions.

Destruction of Stratospheric Ozone

Because CFCs are chemically stable, they move to the stratosphere when emitted into the atmosphere. They are broken up in the stratosphere by ultraviolet rays and emit chlorine atoms. The chlorine atoms are combined with oxygen atoms in the ozone and destroy ozone. Nitrous oxide (N₂O) emitted from nitrogen fertilizers and methyl bromide (CH₃Br) also contribute to the destruction of the ozone layer.

In 1982, a British research group reported a decrease in the ozone layer over the South Pole. In 1985, an ozone hole was observed over the South Pole. In 1989, an ozone hole emerged over the North Pole. The Japanese Meteorological Agency reported in September 2000 that the ozone hole over the South Pole grew to its largest since the observation began, reaching a size twice as big as that of Antarctica (29.2 million m²).

What will the destruction of ozone layer and emergence of an ozone hole result in? The ultraviolet rays from the sun are directly exposed to the ground. This destroys the DNA of living things and protein, a component of the living body. Because photo-plankton in the ocean is highly sensitive to ultraviolet rays, the ecology of fish and shellfish is greatly affected through the food chain. There are also concerns about the effects on the yield and quality of agricultural crops as well as the global ecosystem. An even greater concern is the climate change of the earth due to a change in heat balance in the atmosphere, which will be discussed later.

ENVIRONMENTAL PROBLEMS INVOLVING NITROGEN AND CARBON

In addition to environmental problems caused by changes in nitrogen and carbon cycles, the following will be discussed for reference even though they are not so closely related.

Invasion of Exotic Species

The "biological invasion" or the penetration of non-native organisms into ecosystems is probably the least visible and difficult to predict in environmental destruction. It is also one of the most dangerous kinds. Many organisms successfully invade water zones and move inland across borders by natural water current or with shipping containers. Migration of living things far beyond their own habitat as a result of frequent or accidental flow is an unavoidable aspect of basic human and cultural activities.

This "biological invasion" has greatly influenced the ocean, forest and horticultural industries. Such influences are further increasing. As the recent occurrences of foot-and-mouth disease shows, we have entered a new era of the "chaos of the ecosystem", where humans and goods freely flow. Almost all organisms can be brought in anywhere. Who can accurately trace the spread of epidemics and pathogens that cause disease to crops? It is extremely difficult to project the crop production of tomorrow affected by such invaders.

Dioxins

There is a problem of soil and crop pollution by dioxins – polychlorinated dibenzo-p-dioxin, polychlorinated dibenzofurans, and coplanar polychlorinated biphenyl (PCB.) Dioxins are emitted easily when substances that contain chloride are burned. Various materials including chlorine-containing bleached paper, plastics, exhaust, and garbage emit dioxins.

Dioxins emitted from garbage incinerators fall on the ground as flue gas and pollute soil and crops. The pollution further spread from rivers to the ocean. Dioxins emitted at one place travel in the air or on the oceanic current and spread all over the earth. In the end, they enter the human body through the food

chain. Such problems have already been documented in Belgium and other European countries as well as Japan.

Genetically Modified Crops

One of the biggest concerns related to agricultural production in the 21st century is genetically modified crops (GMCs). Over 43 million ha were planted to GMCs around the world in 2000. This was more than a 25-times increase over 1996 levels. The United States of America accounts for three quarters of the planted area of genetically engineered crops. Of soybean yield in the United States in 1998, more than one-third was genetically modified. About one quarter of corn and about one-fifth of cotton was also genetically engineered.

Other than the United States, Argentina and Canada have a high percentage of GMCs. In 2000, more than 50 percent of soybean yield in Argentina and rapeseed yield in Canada were genetically modified. The three countries account for a total of 99 percent of all planted area of GMCs in the world. Of this total, 52 percent is used for soybean production and 30 percent is used for corn production. The rest is mainly for cotton in the United States and rapeseed in Canada.

The safety of genetically engineered crops is sometimes questioned. The Rowett Research Institute in the United Kingdom said in 1998 that the immune systems of rats that were fed GMCs over a long period of time weakened. It has been found that crops with genes to produce a natural pesticide also have an ability to kill creatures other than targeted pests. Because the elements working as pesticides remain in the soil after harvest, soil pollution may be caused. If weeds pollinated by insects are around GMCs, they may become able to kill insects, which may disturb the ecology of insects and animals.

Also, GMCs with resistance to herbicides may cause problems to the ecosystem. In Canada, weeds growing in close proximity to genetically engineered crops were able to gain resistance to the chemicals. They were able to do this only two years after the introduction of GMC production.

As such cases show, we need to closely watch the production trend and future route of GMCs that have been touted as a “savior of food shortage.”

EXAMPLE OF SUSTAINABLE AGRICULTURAL ACTIVITIES

Example of Nitrogen: N₂O Emitted from Nitrogen Fertilizer

Many strategies for reducing N₂O emission have been proposed. They include: 1) match N supply with crop demand; 2) close the N flow cycle; 3) use advanced fertilizer technologies; and 4) optimize tillage, irrigation, and drainage in which gaseous emissions deal primarily with cropping systems could be minimized. A number of field studies have been conducted with nitrification inhibitors that could decrease N₂O emissions when used. There are a few studies in which the potential of using controlled release fertilizer for decreasing N₂O emission was evaluated.

Example of Carbon: CH₄ Emitted from Rice Cultivation

Possible strategies for mitigating CH₄ emission from rice cultivation can be achieved through the controlling of either the production, oxidation, or transport processes. Total emission rate of CH₄ during the cultivation period was reduced by 42-45 percent by short-term drainage practices compared with a continuously flooded treatment. The addition of soil amendments, such as nitrate and iron containing materials, and mineral fertilizers are useful for mitigating CH₄ emission. Mitigation of CH₄ emission requires that the quantities of organic amendments be minimized. Stimulation of composting organic amendments appears to be a promising mitigation option.

INTERACTIONS OF GLOBAL CHANGES UNDERMINING ENVIRONMENT, NITROGEN, AND CARBON: FUTURE RESEARCH

As discussed earlier, there are many environmental problems involving nitrogen and carbon. Considering such pressure on the global environment, the issues of food security and environmental conservation we are facing now are serious. What is more serious is that various phenomena of the environmental deterioration may interact with each other. Of possible combinations of the phenomena of environmental deterioration that will interact with each other and potential results, interactions related to agricultural production will be discussed here.

Global Warming + Ultraviolet Rays + Nitrogen/Carbon

The air of the lower atmosphere is becoming warmer due to global warming, especially the temperature of stratosphere over the South Pole. The decrease in ozone layer is escalated in the cold stratosphere due to the power of chlorine from CFCs. The destroyed ozone layer intensifies as the temperature drops. The ozone layer over the North Pole will become gradually thinner as global warming continues to advance.

Global Warming + Acid Rain + Ultraviolet Rays + Ozone in Troposphere + Nitrogen/Carbon

In the eastern part of Canada, the volume of water flowing into lakes is decreasing due to a mild drought over the last 20 years. Because the volume of organic sediments pushed in by waters decreases as the flow weakens, the clarity of the lakes increase. In addition to a higher amount of ultraviolet rays reaching the surface of a lake due to the depletion of ozone layer, the rays go deeper into the water as the clarity increases. For example, it has been measured that a lake that had penetration of ultraviolet irradiation of 20-30 cm has now reached over 3 m.

Global Warming + Nitrogen

Nitrogen pollution affects the ecology of continental areas, especially that of forests. Because nitrogen pollution weakens the ability of forests to absorb carbon from the air, it contributes to a decrease in temperate forests.

Global Warming + Decrease in Habitat + Invasion of Exotic Species + Nitrogen/Carbon

Nitrogen pollution is causing a decrease in coral reefs all over the world.

Global Warming + Infectious Disease + Nitrogen/Carbon

Even a very small rise in the minimum temperature causes the invasion of pests into a new territory. Seawater of warm coastal areas can be the habitat of cholera especially when the water is contaminated with nitrogen.

Global Warming + Forest Fires + Nitrogen/Carbon

Climate change has caused changes in cycles of forest fires. Frequent occurrences of such fires will emit larger volumes of carbon resulting in a greenhouse effect in the air. It will also cause nitrogen loss. Climate change and forest fires interact with each other and multiply their individual effects.

Global Warming + Water + Nitrogen/Carbon

Conversion of dryland into highly productive agricultural land increases the use of nitrogen fertilizers. Nitrogen oxides run out of the system via water.

Deforestation + Nitrogen/Carbon

Deforestation causes decomposition, emission, and erosion loss of nitrogen and carbon in the soil.

Invasion of Exotic Species + Nitrogen

Nitrogen pollution of grassland promotes the overgrowth of dominant exotic weeds. Nitrogen contamination of forests weakens the resistance of both native and exotic tree species to pests.

CONCLUSION

In 1975, Japanese writer Sawako Ariyoshi wrote “*Multiple Contamination*.” It was 12 years after the publication of “*Silent Spring*” by American writer Rachel Carson. Ariyoshi, from a writer’s perspective, points out the fear of the interactions of individual chemical substances that adversely affect the environment.

Such fears cannot be avoided in the case of changes in the global environment. Global warming primarily due to man’s activities and ultraviolet rays falling naturally but now uninhibited on the earth are good examples of these interactions.

Sound maintenance of the environment should be a priority in planning for all earth’s inhabitants. Estimates show that it takes more than 100 years to lower nitrate-nitrogen rates from 10 ppm in the

groundwater to 1 ppm. Furthermore, the same 100 years are needed to return carbon dioxide of 380 ppm at the current level to 280 ppm, which was the level at the time of the Industrial Revolution.

However, we seem to have begun to find a clue to bring about a decisive change of measures to mitigate the current environmental crisis. For example, although it required 40 years, Carson's "*Silent Spring*" triggered today's activities to protect the environment. Twelve years have passed since we formulated the original draft of the first report (Climate Change, The Scientific Assessment) of Intergovernmental Panel on Climate Change (IPCC) at Harvard University. Since then, the second and third reports have been compiled and international politics can no longer be discussed without discussing environmental problems.

In Japan, there is a similar trend. Measures to promote environment-friendly agriculture started with the "direction of new food, agriculture, and rural policy" in 1992 and the "Basic Law on Food, Agriculture, and Rural Areas" in 1999. In response to such policies, laws were passed focusing on three environmental issues, namely; sustainable agriculture, fertilizer control, and livestock animal waste management. Private corporations began to compete with each other to acquire ISO 14001 and 9000 certification. Active involvement of our country in COP (Conference of Parties to the UN Framework Convention on Climate Change) also reflects the positive trend towards environmental protection.

Further contribution to the discoveries and technological development of environmentally sound practices will heavily depend on the constant and sincere efforts of researchers and individuals. The global environment has no future without such efforts and continuity.

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2. APPROPRIATE AGRICULTURAL PRACTICES FOR ENVIRONMENTAL SUSTAINABILITY: LESSONS FROM THE OIL PALM INDUSTRY

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INTRODUCTION

Improving agricultural productivity was a major focus at the World Summit on Sustainable Development in Johannesburg in 2002. The key concern was the rapid decline in agricultural productivity in rural areas around the world. In many instances, this rapid decline “forced people to encroach on forests, grasslands and wetlands, creating a downward spiral of environmental degradation and poverty” (United Nations, 2002).

In spite of recent progress made in plant breeding to raise the genetic yield potential of many agricultural crops, it is not uncommon to see wide gaps between actual productivity and potential yields. In 1994, the Wuppertal Institute for Climate, Environment and Energy in Germany coined the term *Factor 4* to demonstrate that it is possible to quadruple resource productivity by efficient application of technology presently available. Could this be also applicable to agricultural productivity through the implementation of better agricultural practices (BAPs)?

This paper discusses the application of appropriate practices to improve agricultural performance within the context of sustainable agriculture. Experience from the oil palm industry in Malaysia is used to demonstrate how appropriate practices have contributed towards addressing concerns over air and water pollution as well as pesticide usage.

APPROPRIATE AND INAPPROPRIATE AGRICULTURAL PRACTICES

How does one define appropriate and inappropriate agricultural practices? What is the line that differentiates the “good” from the “bad” practices? Unfortunately, there are no clear definitions or delineations. Use of these terms depends on the context such as the scale and type of agriculture. Traditional small-scale subsistence agriculture has many sound and appropriate practices pertaining to the use of resources that are consistent with what is popularly termed natural or organic farming. But these practices may not be regarded as appropriate for large-scale agriculture. For instance, manual methods of cultivation and harvesting would have to be replaced by mechanized approaches in commercial agriculture as more attention is given to achieving higher land and worker productivity.

In some cases, what has been considered as appropriate agricultural practices may become inappropriate on account of changing circumstances or developments. For instance, fire has been used as a tool in agriculture from time immemorial. It has been used for land clearing in traditional agriculture, shifting cultivation, and also commercial scale agriculture. In oil palm, fire was the prevalent method used by plantations and smallholders to prepare land for replanting an existing crop or planting on new land. Today, this practice is now deemed inappropriate from the point of atmospheric pollution. The adverse impact of this practice became obvious during the forest fires of 1997/98 in Southeast Asia. Rowell and Moore (2000) reported that up to 80 percent of the fires in Sumatra and Kalimantan in Indonesia were started by plantations during land clearing.

Another example is the use of the ‘skull and crossbones’ pictogram on the labels of pesticides. As part of its product stewardship initiatives, ICI voluntarily introduced the ‘skull and crossbones’ sign on the label of its herbicide called Paraquat. This was done in the 1960s with a view of preventing misuse

of the herbicide. However, with this type of labeling, the herbicide was perceived as very toxic and was thus used as a means for committing suicides.

In hindsight, it would have been safer to use the 'St. Andrew's cross' according to the World Health Organization (WHO) classification. In 1989, the Department of Agriculture in Thailand approved a change in the labeling of Paraquat products, from a 'red band with skull and crossbones' pictogram to the WHO classification with a 'yellow band and St Andrew's cross' symbol. A study conducted between 1992 and 1998 showed that while the number of overall suicide cases had almost doubled in the country, the number of cases of ingestion of Paraquat had declined following the change in product labeling (Lim, 2003.)

Various terms have been used to describe appropriate practices. Those relevant to agriculture include 'better (or best) agricultural practices' and 'better (or best) management practices' (BMPs.) What are the attributes of BAPs and BMPs? In general, these practices must support the underlying principles for sustainable development and specifically, sustainable agriculture.

There are countless definitions of sustainable agriculture. The UK Sustainable Development Commission (www.sd-commission.gov.uk) defines it simply as "agriculture that contributes to the overall objectives of sustainable development – to meet the needs in the present without compromising the ability of the future generations to meet their own needs." The United Nations Food and Agriculture Organization adopted the following official definition in 1988:

"Sustainable development (in agriculture, forest and fisheries sectors) should conserve land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable."

The effectiveness of BAPs or BMPs in supporting sustainable agriculture should be quantified against several sustainability indicators covering the economic, social and environmental dimensions. The Ministry of Agriculture, Food and Fisheries in the UK have selected a pilot set of indicators covering the following areas (www.ecifm.rdg.ac.uk/sustainable_agriculture.htm):

- A. Agriculture within the rural economy and society (structure of the industry, financial resources, agricultural productivity and employment)
- B. Farm management systems (management, organic farming, codes of practice)
- C. Input use (pesticides use, nutrients, greenhouse gas emissions and energy)
- D. Resource use (water, soil, agricultural land and non-food crops)
- E. Conservation value of agricultural land (environmental conservation, landscape, habitats and biodiversity.)

Unilever which launched its Sustainable Agriculture Initiative covering major crops including oil palm, tea, tomatoes, peas and spinach in 1998 developed a set of 10 sustainability indicators and parameters, as given in Table 1.

LESSONS FROM THE OIL PALM INDUSTRY

Overview of the Oil Palm Industry

Introduced from Africa, the oil palm, *Elaeis guineensis* Jacq. is the most widely grown industrial agricultural crop in Malaysia and Indonesia, both in plantations and smallholdings. Other producing countries include Thailand, Papua New Guinea, Nigeria, Colombia, Cote d'Ivoire, and Ecuador. In 2001, the world's production of palm oil was 23.18 million mt or 19.8 percent of the total production of 17 oils and fats, making it the second most important oil after soy oil. In terms of exports, palm oil is the most widely traded oil accounting for 45.6 percent of the world's exports of 17 oils and fats (2001) (www.mpob.gov.my/.) Malaysia is the largest producer of palm oil, contributing about 11.80 million mt or 50.9 percent of total production, while Indonesia produced about 7.5 million mt or 32.3 percent. Malaysia is also the world's largest exporter of palm oil, accounting for about 61.1 percent or 10.62 million mt of the total exports of 17.37 million mt in 2001.

Table 1. Unilever's Sustainable Agriculture Indicators

Indicator	Parameters
1. Soil fertility/health	Number of beneficial organisms/microorganisms, number of predatory mites, soil organic carbon, etc.
2. Soil loss	Soil cover index, soil erosion
3. Nutrients	Amount of applied NPK, nitrogen fixation, balance of NPK over crop rotation, emissions of N to air
4. Pest management	Amount and types of pesticides applied, percentage of crop under integrated pest management (IPM)
5. Biodiversity	Level of biodiversity on-site, level of biodiversity off-site
6. Product value	Total value of product/ha, yield/ha of target product, conformance to quality specifications, ratio of solid waste reused or recycled to solid waste disposed to landfill
7. Energy	Energy balance, ratio of renewable energy over non-renewable energy inputs, emissions to air
8. Water	Amount of water used for irrigation, leaching and runoff of pesticides and applied NPK to surface and groundwater
9. Social/human capital	Group dynamics/organizational density, rural community awareness to relevance and benefits to sustainable practices/connectivity to society at large, rate of innovation
10. Local economy	Amount of money/profits reinvested locally, percentage of goods/labor/services sourced locally, employment level in local community.

Source: www.growingforthefuture.com

The oil palm tree typically has an economic life of about 25 years. Harvesting commences about 24-30 months after planting and each palm can produce 8-15 fresh fruit bunches (FFB) per year weighing about 15-25 kg each. This depends on the planting material and age of the palm. Each FFB contains about 1,000-1,300 fruitlets; each fruitlet consists of a fibrous mesocarp layer and the endocarp (shell) containing the kernel. Present day planting materials are capable of producing 39 mt of FFB per hectare and 8.6 mt of palm oil. Actual yields from good commercial plantings are about 30 mt FFB per hectare with 5.0-6.0 mt oil (Henson, 1990.) Among the major vegetable oils, the oil palm has the highest crop productivity, being seven times more productive than soybean and about three times higher yielding than rapeseed.

The oil palm produces two types of oils: palm oil from the fibrous mesocarp and lauric oil from the palm kernel. In the conventional milling process, the FFBs are sterilized and stripped of the fruitlets which are then digested and pressed to extract the crude palm oil (CPO). The nuts are separated from the fiber in the press cake and cracked to obtain palm kernels which are crushed in another plant to obtain crude palm kernel oil (CPKO.) The by-product, palm kernel cake, is used as an animal feed. Fractionation of CPO and CPKO in the refinery produces the liquid stearin fraction and a solid stearin component.

Palm oil and palm kernel oil have a wide range of applications. About 80 percent is used in direct food application while the rest is utilized as a feedstock for a number of non-food applications (Salmiah, 2000.) Among food uses, refined, bleached and deodorized (RBD) olein is used mainly as cooking and frying oils, shortenings and margarine. RBD stearin is used for the production of shortenings and margarine. RBD palm oil (i.e., unfractionated palm oil) is used for producing margarine, shortenings, *vanaspati* (vegetable ghee), frying fats and ice cream. Non-food products of palm oil and palm kernel oil are produced either directly or through the oleo-chemical route. Direct applications include the use of CPO as a diesel fuel substitute, drilling mud, soaps and epoxidized palm oil products (EPOP), polyols, polyurethanes, and polyacrylates (Salmiah, 2000.)

Overview of Appropriate Agricultural Practices

Since the beginning of the industry in the early 1900s, many sound agricultural practices have been developed and implemented. Before formal environmental management came into vogue, these

appropriate practices were regarded as good management practices at various stages of the development and management of the plantation. They generally followed a cycle from planning-planting-production-replanting.

Today, prior to development of a plantation, it is necessary to conduct an environmental appraisal or environmental impact assessment (EIA) to assess the potential environmental impacts of the development and to identify and implement appropriate measures to mitigate any adverse impacts. In Malaysia, an EIA is required if the proposed plantation development involves clearing of more than 500 ha of forestland under the provisions of the Environmental Quality Order 1987.

During land preparation, zero burning practices are usually followed to prevent air pollution. In the immature and mature phases, attention is given to soil and water conservation measures such as construction of contour terraces, conservation terraces, and silt pits and maintenance of acceptable ground covers, particularly leguminous cover crops. Besides providing soil protection, the latter contributes significantly to improvement of soil fertility through return of organic matter and fixation of atmospheric nitrogen. A systematic approach is adopted for assessing site-specific fertilizer requirement of palms based on the soil and foliar nutrient status, climatic factors, and the agronomic history of the field. IPM practices are adopted to manage major pests such as bagworms, nettle caterpillars, and rhinoceros beetle (*Rhinoceros oryctes*) as well as diseases such as *Ganoderma* stem rot.

Processing of FFB at the mill generates a high volume of effluents in the form of palm oil mill effluent (POME.) These are subjected to anaerobic and aerobic digestion in effluent treatment plants located near the mill to ensure that any discharge to waterways meet the regulatory requirements of the Department of Environment (DOE.) Waste and by-products from the palm oil mill are mainly reused or recycled. The empty fruit bunches (EFB) that are obtained after the FFB has been sterilized and stripped of oil bearing fruitlets are widely used as mulch and organic fertilizer while kernel shells and fiber obtained after kernel recovery are used as fuel for generation of energy. The palm oil mill produces more than sufficient energy to meet the oil mill's requirement.

With regard to social aspects, the oil palm plantation supports a community of workers and staff as well as the local community. As a traditional practice, plantations provide housing for workers, staff, and their dependents. They also provide schools, medical facilities, and places of worship. Moreover, through use of local goods and services, the oil palm plantation contributes to the economy of the local community.

A summary of the appropriate or better agricultural practices implemented in the oil palm industry is given in Table 2. These practices have been documented in several publications, the most comprehensive of which is “*Oil Palm and the Environment: A Malaysian Perspective*” (Gurmit, *et al.*, 1999.) Overall, these practices meet guidelines for sustainable agriculture and the recommended indicators for sustainability (Table 1) (www.growingforthefuture.com.) Practices with regard to zero burning, IPM and waste management are discussed in the following sections which highlight measures that had been adopted to promote the adoption of the specific appropriate practice.

Zero Burning

1. Introduction

As discussed earlier, fire has been used as a tool in agriculture from time immemorial. However, within the context of air pollution and the release of greenhouse gases, it is now generally regarded as an inappropriate practice, particularly after the fires of 1997/98 that caused widespread haze and air pollution in South-East Asia. The most important root cause for these fires was the use of open burning techniques for conversion of forestland to other land uses, e.g. estate crops, industrial plantations, and other commercial enterprises; traditional slash-and-burn agriculture; and speculative burning to stake land claims (Tahir, 2001.) Rowell and Moore (2002) reported plantations using fire to clear land started 80 percent of the fires in Sumatra and Kalimantan in Indonesia.

While the clean clearing technique using fire has been the traditional method of land preparation for oil palm cultivation, it is being progressively replaced by non-fire approaches, particularly the ‘zero burning technique.’ Commercial implementation of this method in Malaysia commenced in the late 1980s and today, it is the recommended practice for land preparation by the industry.

Table 2. Appropriate Practices for Sustainable Development in Oil Palm Plantations

Planning Phase	Conduct of preliminary environmental appraisal or formal EIA prior to development of new plantations or change of type of crops.
Development Phase	Conservation of forest areas unsuitable for oil palm cultivation ('forests-in-plantations').
	Retention of riparian reserves or buffer zones to minimize erosion and conserve biodiversity.
	Zero burning during land preparation.
	Establishment of an integrated road and drainage system.
	Construction of contour terraces in undulating to hilly terrain.
Development Phase	Establishment of legume cover crops for ground protection and enhancement of soil fertility.
	Minimizing runoff and soil erosion between land clearing and full ground coverage.
Production Phase	Ground cover management with judicious use of herbicides and maintenance of acceptable ground vegetation, including legume covers.
	Placement of pruned fronds along inter-rows for organic recycling and soil and moisture conservation.
	Application of EFBs for nutrient recycling.
	Land application of treated POME for nutrients and moisture.
	"Discriminatory" application of fertilizer based on nutrient needs assessment by soil and foliar analyses.
	IPM practices: —biological control of rats with barnowls (<i>Tyto alba</i>) —biological control of rhinoceros beetles —biological control of leaf-eating pests; bagworms, nettle caterpillars —planting of beneficial plants to augment populations of bio-control agents.
	Mechanization of field operations such as spraying, fertilizer application and FFB harvesting to increase productivity and reduce physical load on workers.
	Reduction of oil mill smoke emissions to comply with environmental quality (Clean Air Regulations 1978).
	Effective treatment of POME to comply with environmental quality (prescribed premises) (Crude Palm Oil) Regulations 1977.
Social Aspects	Downstream value-added utilization of biomass (EFB, etc.) and waste.
	Provision of housing, medical, educational, welfare and social amenities for workers and their dependants.
	Establishment of practices to ensure the safety and well-being of workers under the provisions of the Occupational Safety and Health Act, 1994.

2. The Practice

The zero burning technique is a method of land clearing whereby the tree stand, either logged over secondary forests or an old area of plantation crop such as oil palm or rubber is felled, shredded, stacked and left *in situ* to decompose naturally. The detailed procedures for applying zero burning in various situations are described in the ASEAN "*Guidelines for the Implementation of the Policy on Zero Burning*" (ASEAN Secretariat, 2003.) Unlike the clean clearing practice, this is an environment-friendly approach that does not cause air pollution. Through recycling of the plant biomass, the zero burning practice improves soil organic matter and soil fertility, thus reducing the overall requirement of inorganic fertilizers. Compared to clean clearing, the zero burning technique is less dependent on weather conditions and has a significantly shorter fallow period between felling of the old vegetation and planting of the new crop. As felling is done progressively, application of the technique to replanting of oil palm would result in additional revenue from continued harvesting of the palms until they are felled. However, these economic gains could be negated by higher costs of controlling pests such as

rhinoceros beetle and basal stem rot disease which can cause serious losses to the new oil palm stand, especially in coastal areas where these problems can be endemic.

3. Measures to Promote Appropriate Practice

The seriousness of the trans-boundary atmospheric pollution caused by fires during 1997/98 has led to various intergovernmental efforts by ASEAN member countries. Key policy measures adopted are a Regional Haze Action Plan (RHAP) and the ASEAN Agreement on Trans-boundary Haze Pollution. The implementation of RHAP is monitored at the ministerial level by the ASEAN Ministerial Meeting on Haze (AMMH) and also the Haze Technical Task Force (HTTF.) At the 6th AMMH meeting, ASEAN Ministers agreed to adopt the policy of zero burning and to promote its application by plantation companies and timber concessionaires in the region. In order to help achieve this objective, “*Guidelines for the Implementation of the Policy on Zero Burning*” has been published by the ASEAN Secretariat (2003.)

At the national level, an analysis of laws related to forest fires within ASEAN showed that none of the ASEAN countries had specific laws dealing with forest fires. Provisions are generally covered under forestry or environment-related laws in some countries (Azrina, 2002.) For instance, in Malaysia, the relevant regulatory provisions come under the National Forestry Act 1984 and the Environmental Quality Act (EQA) 1974. In the wake of the 1997/98 fires, Malaysia amended the EQA in 2000 to address problems related to open burning, which includes the provision for imposing maximum fines of RM500,000 (US\$131,579) and a five-year imprisonment. While abolishing the DOE’s powers to issue contravention licenses for open burning, the amendments to EQA also provided for 14 specific prescribed activities for which open burning is allowed.

Notwithstanding the provisions of the law, adoption of the zero burning by the oil palm industry in Malaysia was driven by the industry itself. In line with its environmental policy, one major plantation company adopted zero burning as a commercial practice beginning in 1989. Its experiences with this technique were shared with the rest of the industry through various publications, particularly stakeholder advisory guidelines “*The Zero Burning Technique for Oil Palm Cultivation*” (Golden Hope Plantations Berhad, 1997.) Today, zero burning is an accepted commercial practice for land clearing in plantations.

Integrated Pest Management

1. Introduction

The oil palm is host to numerous pests, the most serious being bagworms, nettle caterpillars, the rhinoceros beetle and rats. Outbreaks are usually sporadic as natural enemies normally keep the pests in check. But outbreaks can become frequent and recurrent when natural biological control breaks down, as has been observed in the late 1960s and early 1970s. The main cause was the use of broad-spectrum, long-residual, contact organochlorine insecticides (Wood, *et al.*, 1977.) From the 1970s research, development has focused on the search for more sustainable approaches to maintain the natural pest/predator balance. This has led to the development of IPM approaches (Wood, 1979; and Chung and Sharma, 1999.) At present, IPM is widely accepted in the oil palm industry.

2. The Practice

IPM involves a mix of suitable cultural, physical, chemical and biological control approaches to minimize crop losses to pests. Greater emphasis is given to the application of non-chemical interventions, particularly biological control. Examples of biological control measures applied to the oil palm industry include the use of baculovirus and *Metarhizium anisopliae* to control the rhinoceros beetle, control of leaf-eating bagworms and nettle caterpillars by their natural predators and parasitoids, and the use of barn owls (*Tyto alba*) as the biological agent to control rats. In order to enhance the populations of predators of bagworms and nettle caterpillars, beneficial plants such as *Antigonon leptopus* and *Euphorbia heterophylla* are often established in open areas around the oil palm fields. To support an effective ‘resident’ population of barn owls, nesting boxes are erected in the oil palm fields.

Although pesticides continue to play an effective role in IPM, judicious use is advocated so that they do not have adverse effects on the other IPM components and the broader environment. Monitoring of pest population is an important element in IPM. This is done by regular assessments of pest damage or estimation of pest numbers by trapping, etc. For instance, for the control of the rhinoceros beetle, the insect population is assessed by aggregation pheromone trapping while a systematic census of fresh pest damage on palm fronds is undertaken to quantify the extent of damage and the causal insect species in

the management of leaf eating pests. The decision for chemical pesticides intervention will be taken only after the economic threshold level of pest damage has been breached. The choice of pesticides and mode of application must also give due consideration to operator safety and potential impact to the environment. In general, non-persistent and selective pesticides are used. Trunk injection of insecticide is commonly practiced for controlling outbreaks of leaf eating pests ensuring selective control of the target pest as well as minimizing the risk of pesticides exposure to the operators.

3. Measures to Promote Appropriate Practice

Economic consideration is a key driver for adoption of IPM in plantations. Severe pest attacks can cause severe crop loss up to 50 percent or more. In a review of the economics of crop protection in oil palms, Wood (1977) stated that while economic factors are vital for decision-making, measures adopted must fit into the overall picture, particularly the stability of the agro-ecosystem. Past experience has shown that chemical intervention alone is not cost-effective or sustainable and a more holistic approach is essential. Hence, implementation of IPM in oil palm is largely driven by the industry itself and the role of regulatory measures is mainly related to the promotion of safe and appropriate use of pesticides.

In Malaysia, the Pesticides Act of 1974 (Act 149) regulates the importation, manufacture, sale, storage, and use of pesticides. The use of highly toxic pesticides (Paraquat and its mixtures, monocrotophos, and calcium cyanide) is covered under the “Guidelines on Pesticides (Highly Toxic Pesticides) Regulations” which stipulate the duties and responsibilities of employers and workers. Employers using these pesticides have to comply with specific requirements pertaining to record keeping and storage of pesticides, protective clothing, provision of first aid kits, medical surveillance programs, and training of workers.

The safe use of pesticides is also covered under the Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000 of the Occupational Safety and Health Act 1994. Many of the provisions pertaining to the use of highly toxic pesticides under Act 149 are also included in these regulations. In addition, the occupational safety and health regulations require employers to conduct chemical health risk assessments and take action to control hazardous practices identified.

Water Pollution Control

1. Introduction

In a global survey on emerging environmental issues for the 21st century, concern over freshwater pollution was among the four most frequently cited issues by environmental experts around the world (UNEP, 1999.) In Malaysia, monitoring of river water quality by the DOE in 901 stations located in 120 river basins showed that in 2000, 43 percent of the rivers were slightly polluted and 14 percent were polluted (DOE, 2000.) Industries and factories, including palm oil mills located near watercourses, are often sources of water pollution. While the oil palm industry was the main cause of water pollution during the 1970s, implementation of regulatory requirements and development of appropriate effluent treatment systems has enabled the industry to meet stringent water discharge standards.

The processing of FFB to produce CPO generates a large volume of liquid wastes that are collectively termed POME. About 3 mt of POME is generated from the production of every ton of palm oil. In raw state, POME is a thick brownish, non-toxic slurry of water, oil, and cellulosic residues with an average Biological Chemical Demand (BOD) of 25,000 mg/litter. If untreated, POME can cause serious water pollution as its oxygen depleting potential is 100 times that of domestic sewage.

In the 1960s and 1970s, which saw the rapid expansion of the oil palm industry, discharge of raw POME by mills into waterways and rivers was the main cause of water pollution in Malaysia. At its peak in 1975, the POME pollution load, in terms of population equivalent, exceeded 15.9 million people, which was much higher than the total population of the country during that time. This led to the promulgation of the EQA in 1974 and the regulations pertaining to discharge of effluents into waterways or to land.

Effective implementation of these regulations in 1978, along with the development of suitable effluent treatment methods by the industry, resulted in a significant reduction in pollution the following two years. The pollution load declined to a population equivalent of 2.6 million people in spite of a 50-percent increase in CPO production. This was subsequently reduced to an insignificant level of less than 100,000 by the mid-1980s (Vincent and Rozali, 1997.) Under the Environmental Quality

(Prescribed Premises) (Crude Palm Oil) Regulations 1997, it is mandatory for oil mills in Malaysia to treat wastewater to meet the regulatory standards before discharge to waterways is allowed.

2. The Practice

As POME is organic in nature, it is amenable to biodegradation by a mixture of microorganisms that eventually break down the waste into water, solids (sludge), methane, carbon dioxide, and traces of hydrogen sulphide gas. Among the various methods for treatment of POME, more than 85 percent of the oil mills in Malaysia use the ponding system (Ma, 1999) where the effluent is treated in a series of ponds with specific functions and hydraulic retention times. The total treatment cycle is about 65 days, of which about 45 days are required for anaerobic digestion of effluent. The ponding system is relatively cheap to implement but requires a large area.

The other widely used system is the open tank digester with extended aeration where POME is treated in tanks in a two-phase anaerobic digestion process followed by extended aeration in a pond. While both systems are capable of treating POME to meet the regulatory standards for discharge to waterways, they release significant quantities of biogas (mainly methane) during the anaerobic phase. Using a closed tank system with biogas recovery could minimize the latter.

A pollution prevention approach involving the use of a decanter-drier system was introduced in 1981 and has been used in many oil mills. This system effectively reduces the sludge solids that normally forms part of POME by 75 percent. The decanter solids can be dried in a rotary drier using heat from the boiler exhaust gas to produce animal feed and organic fertilizers (Ma, 1999; and Jorgensen and Gurmit, 1984.)

As the law allows for land application of partially treated POME, provided the BOD level does not exceed 5,000 mg/litter, it is common practice for plantations to apply treated POME as a source of plant nutrients as well as for irrigation. Land application systems include:

- the sprinkler irrigation system
- furrow irrigation system
- tractor/tanker/pump system
- the long bed system
- the flatbed system.

3. Measures to Promote Appropriate Practice

Effective pollution abatement in palm oil mills in Malaysia has largely been due to the policy measures introduced by the government coupled with active participation by the industry. When water pollution arising from palm oil mills became a serious national problem in the 1970s, the government realized that urgent action had to be taken. Shutting down the offending mills would not have been a politically or economically correct option, as it would affect economic development. Instead the government took a novel and pragmatic approach combining conventional command/control measures and economic instruments, which in present day terms are based on the 'polluter pays principle.'

In 1974, the government passed the Environment Quality Act, under which the Department of Environment was established. Under the Act, the DOE was empowered to prescribe selected industrial premises and set conditions for them to operate. Palm oil mills, along with rubber factories, were the first to be prescribed by the DOE. With the support of an expert committee comprising members from the public sector and the industry, the DOE established regulations governing the operation of oil mills.

The Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, which came into effect July 1977, required palm oil mills to apply for a license to operate every year. Mills had to put in place effective effluent treatment systems to meet the discharge standards comprising eight parameters (biological oxygen demand – BOD, chemical oxygen demand – COD, total solids, suspended solids, oil and grease, ammoniac nitrogen, total nitrogen, and pH and temperature). Realizing that time was needed to develop and implement appropriate effluent treatment systems, the DOE adopted a phased approach towards complying with standards. Mills were given a one-year grace period to construct treatment systems. Standards would be enforced from the second year and they would become increasingly stringent over a four-year period (Table 3.)

The economic dimension of the regulations is reflected in the structure of the annual license fee that consists of two parts. The first is a flat rate processing fee while the second part is related to the quality of the effluent discharged to the watercourse. The fee for discharge is RM10.00/mt if the discharge meets the DOE standards. The fee is increased tenfold if the discharge exceeds the permissible BOD level. Through this approach, it made economic sense for palm oil mills to put in place systems to

treat effluents and bring them to the required standards rather than pay the high fees for discharge to watercourses.

Table 3. BOD Standards for Discharge to Watercourse

Standard*	Date Effective	Level (mg/litter)
A	1 July 1978	5,000
B	1 July 1979	2,000
C	1 July 1980	1,000
D	1 July 1981	500
E	1 July 1982	200
F	1 July 1984	100

Source: DOE, 1985 (cited by Vincent and Rozali, 1997.)

Note: * Standards A-D were announced in the Crude Palm Oil Regulations in 1997.

Given that the industry had to develop effluent treatment systems from scratch, the DOE recognized the efforts of companies that had contributed research and development efforts in this direction by reducing or even waiving the licensing fees. The regulations also had the element of self-control as oil mills had to monitor their own performance and submit quarterly returns to the DOE detailing the quantity and quality of treated effluents discharged monthly into watercourses. The DOE conducts random visits to mills and non-compliant premises have faced appropriate penalties including withdrawal of the license to operate.

The effectiveness of the regulations to control pollution from palm oil mills is reflected in the dramatic reduction of the pollution load in terms of population equivalent discussed earlier. In their analyses of the approach taken by the Malaysian Government to address water pollution problems with regard to the oil palm industry, Vincent and Rozali (1997) highlighted the following general lessons learned.

- Pollution abatement and industrial expansion can happen simultaneously.
- Research and development efforts by the industry “softened the potential trade-off between pollution abatement and industrial expansion”.
- Industry representation in the expert committee had “helped to ensure that the structure and timing of the regulations took into account the costs the regulations imposed on the industry and offered the industry the flexibility to respond to them”.
- The government’s commitment towards implementation of the regulations was reflected in well-publicized actions of suspending the licenses of non-compliant palm oil mills.

PROMOTING THE ADOPTION OF APPROPRIATE AGRICULTURAL PRACTICES

The above examples of appropriate agricultural practices in the oil palm industry illustrate the key roles played by the government and the industry in developing and implementing appropriate practices. In the case of water pollution control, the Malaysian Government took the lead role in formulating the necessary regulatory framework for control while the industry contributed in the consultative process and research efforts to develop effective effluent treatment systems. The pragmatic and time-phased approach taken by the DOE towards implementation of the regulatory requirements facilitated the effective compliance by the industry. This was in spite of initial reservations that the standards might be too stringent and impose undue economic burden on the industry.

In situations where there is trans-boundary pollution problems, governments of affected countries could act in concert to develop and promote appropriate practices, as seen in the case of the occurrence of fire and haze in some ASEAN countries. Collectively, they have agreed to support the implementation of the policy on zero burning.

In the other two examples discussed, the private sector and regulatory authorities had both contributed significantly towards the adoption of the zero burning practice in Malaysia. In the case of IPM in oil palm, the industry took the lead in undertaking research and promoting IPM practices. The key drivers were economic and ecological considerations as the industry was aware that chemical control alone would not be a sustainable solution in the long run.

In the private sector, industry organizations can play a positive role in promoting better agricultural practices. The Malaysian Palm Oil Association (MPOA) had recently proposed the institution of its 'Sustainable Environmental Charter' in which member companies would pledge to uphold their responsibilities in safeguarding the environment. MPOA has also proposed development and promotion of BMPs on various environmental aspects such as guidelines on land use policy and wildlife conservation and management of human-wildlife conflicts (Khairudin, 2003.)

Ultimately, it is the grower or company that will put appropriate or better agricultural practices into action. The success in implementing these practices depends to a large extent on management, leadership, and commitment coupled with innovation. Benchmark examples include United Plantations Berhad, which in 1984 developed a pollution prevention approach in treating POME using the decanter-drier system (Jorgensen and Gurmit, 1984) while the rest of the industry addressed end-of-pipe systems. In line with its corporate environmental policy, Golden Hope Plantations Berhad adopted the zero burning technique for planting and replanting oil palm throughout the company's plantations in the early 1990s, at a time when there was no regulatory pressure of the industry to do so. Among multi-national companies, Unilever, one of the largest consumers of the world's agricultural crops, launched its Sustainable Agriculture Initiative in 1998 for major food crops such as oil palm, tea, tomatoes, peas, and spinach that it produces or controls through contract growers (Vis, *et al.*, 2001.)

Besides the players, effective enablers are also required for the promotion of appropriate agricultural practices. As introduction of new and better practices may encounter resistance to change, awareness and training programs must be undertaken to ensure that the growers or farmers appreciate the rationale, benefits, and methodology behind the new practices. The better practices should also be implemented in an integrated or holistic manner in line with principles of sustainable agriculture. In this context, application of management systems such as the ISO 14000 environment system or the Green Productivity methodology developed by the Asian Productivity Organization would be relevant. Green Productivity is a strategy for enhancing productivity and environmental performance for overall socio-economic development. Based on the 'Plan-Do-Check-Act' cycle for continuous improvement, the generic Green Productivity methodology is applicable to all sectors, including agriculture and community development (APO, 2000.)

CONCLUSION

While it may be rather difficult to have a precise definition of appropriate agricultural practices, such practices should have attributes that support the underlying principles for sustainable agriculture. Their performance should be measured against indicators that reflect improvements in the economic, social, and environmental dimensions for sustainability. As seen in these selected lessons from the oil palm industry, the government and the private sector are key drivers in promoting the development and adoption of appropriate practices. Their respective contributions vary with individual situations. In the case of addressing water pollution caused by palm oil mills, the government spearheaded the process by putting in place a pragmatic regulatory framework while the industry had the primary role of adoption and implementation of necessary changes.

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3. OVERVIEW OF ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES AND TECHNOLOGIES IN TROPICAL ASIA

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AGRICULTURAL SITUATION IN TROPICAL ASIA (SOUTHEAST ASIA)

Agriculture in Southeast Asia has undergone great changes during the last two or three decades, particularly since the introduction of modern technologies. In addition, economic development has also greatly influenced Southeast Asian agriculture and agrarian structures (Hart, *et al.*, 1989; and Elson, 1997.) Following such economic transformation, a number of issues and problems related to recent agricultural development in Southeast Asia have presented themselves. As usual, they are extremely complicated (Tables 1 and 2.) Crop scientists and specialists from the related fields in agronomy alone are not able to grasp the complexities. For example, under the present agricultural production systems in Southeast Asia, the application of higher inputs of production components generally is the dominant mode of intensified and diversified cropping systems. However, whether this is sustainable would be a major question from the viewpoint of sociocultural and environmental aspects (Tanaka, 1995.)

In the course of recent economic development, it is observed not only in developed countries but also in developing countries like those in Southeast Asia that the agriculture sector has been relegated to the sidelines in national development plans. Agricultural areas have been disregarded to some extent in the face of the spectacular expansion of industrialization and urbanization. Agricultural production systems are also forced to adapt themselves to such things as industrialization and urbanization. Therefore, it is necessary for agriculturalists to develop a methodology that is relevant to such rapid changes in the socioeconomic environment.

SOCIAL AND CULTURAL SCIENCES IN RELATION TO AGRICULTURAL AND AGRARIAN STUDIES

Taking such situations into consideration, it seems to be useful for us to explore relevant methodologies in the social and cultural sciences. These examine social structures, rural communities, and cultural values as well as including methodologies that seem to be potentially useful to developing agricultural sciences and technologies.

Commonly, ethnographers and anthropologists provide detailed descriptions of subsistence economy or agricultural production in their ethnographic monographs, even though their main theoretical interests are focused on more social or cultural affairs like kinship relations, social or political structure, symbolism, etc. Particularly, as was seen in Barrau (1958,) Conklin (1980,) Izikowitz (1951,) Leach (1954,) or Nash (1965,) these materials provide plenty of information on subsistence agricultural systems and their transformation in tropical regions.

Table 1. Characteristics of Agriculture in Southeast Asia

Agricultural Systems		Characteristics of Agricultural Techniques	Regions
I.	Subsistence agriculture	Low, but stable productivity combined with many kinds of crops	Intermountain regions in Myanmar, Lao PDR, Vietnam, and Outer Islands of Indonesia
II.	Small-scale agriculture directed to yield increase	Middle/high and stable productivity of major crop (e.g., rice, maize, etc.)	Deltaic regions, rainfed terraces and lowlands I Northeast Thailand, Cambodia, and lowlands of insular Southeast Asia
III.	Land-use intensive and diversified small-scale agriculture under commercialization	Further intensification of land use Diversification of crops and cropping pattern	Chao Phraya Delta, Mekong Delta, highland in Java, Bali, Central Sumatra, and the Philippines
IV.	Labor-saving/capital-intensive agriculture under urbanization	Intensification of productivity per unit labor	Chao Phraya Delta, Mekong Delta, Malaysia

Table 2. Major Technical Issues and Problems in Agricultural Systems in Southeast Asia

Agricultural Systems	Issues and Problems related to Agricultural Technology
Subsistence agriculture	<ul style="list-style-type: none"> ● Maintenance of soil fertility ● Improvement of farming techniques and crop rotation ● Conversion of shifting cultivation to sedentary agriculture ● Reclamation of paddy fields ● Reforestation ● Sustainable use of natural resources ● Prevention of soil erosion ● Agro-forestry
Small-scale agriculture directed to yield increase	<ul style="list-style-type: none"> ● Improvement and enhancement of soil productivity ● Improvement of problem soils ● Improvement of farming techniques and cropping patterns ● Intensification of cropping ● Plant protection technology ● Pest-tolerant varieties ● High-yielding production systems ● Developing extension services
Land-use intensive and diversified small-scale agriculture under commercialization	<ul style="list-style-type: none"> ● Land consolidation ● Improvement for higher productivity ● Integrated crop management ● Introduction of high-valued crops ● Integrated pest management ● Postharvest technology ● Crop quality management ● Environmentally-sound technology ● Watershed management
Labor-saving/capital-intensive agriculture under urbanization	<ul style="list-style-type: none"> ● Intensified cropping with broadcast rice ● Introduction of high-valued crops ● Crop diversification ● Higher-level mechanization ● Export-oriented farming systems ● Organization of production units

Apart from these, official reports like regional gazetteers and settlement reports and travelers accounts published in colonial periods also contain a variety of information related to cropping systems

and their historical development. Therefore, it is useful and significant for us to examine such information in order to obtain general backgrounds for understanding issues and problems broadly and specifically related to agricultural and rural development in a region or area.

Recent social and cultural studies also provide basic knowledge on the transformation of rural societies and agrarian structures. Socioeconomic studies carried out by agricultural economists or rural sociologists, for example, have paid keen attention to households' and communities' economic activities. They have provided useful information on agricultural production and technologies, although they usually specify their particular purpose in understanding the mechanism of these activities.

In particular, with regard to the transformation of rural societies, there are many studies that examine the shift from traditional to modern agriculture under the influence or introduction of modern technologies (Fujimoto, *et al.*, 1990; and Fukui, 1993.) These look at changes in cropping systems and land-use developments and show them to be directly related.

In these studies, various types of research methods have been developed, such as demographic analysis, community approaches, long-term participatory observation, discourse analysis, life-history approach, etc. Such community- or human-oriented approaches seem to have been rarely utilized or adopted by agricultural studies. They have been concerned mainly with the physiological/ecological production processes of crops grown in experimental plots.

Another aspect on which cultural studies focus is the re-evaluation of traditional/indigenous knowledge and technologies in subsistence agricultural systems. They have analyzed the significance and role of traditional knowledge and technologies in farmers' practices. It seems to be very useful to utilize these sources when we try to reconsider the sustainability of present agricultural systems.

AGRICULTURAL TECHNOLOGY AND ECOSYSTEM

In addition to social and cultural studies, environmental and biological studies also illuminate and expand upon agricultural affairs. Although it has been widely accepted that viable alternatives to highly mechanized and "chemicalized" agricultural technologies should be developed (National Research Council, 1989,) intensification of cropping systems through increasing inputs of materials like chemical fertilizers, insecticides, etc. is still the dominant reality in tropical agriculture. In farming systems research, not only the intensification of crop management but also its diversification through combining livestock or freshwater-fish raising has caused concern. However, all these attempts to increase productivity through the intensification and diversification of cropping systems inevitably demand the higher input of materials into agricultural fields. If all these inputs are provided in the form of chemical or synthesized materials, the sustainability of present agriculture may increasingly become unstable.

Such technological changes call ecologists' attention to the sustainability of modern-day agriculture. Ecologists are usually interested in natural ecosystems and their succession, but some of them have begun to carry out research especially on artificially sustained environments like agricultural fields or areas. Their attention is directed not only to weeds and pests or their natural enemies, which are directly related to agricultural production, but also to many "ordinary" forms of life that are not visibly related to the production systems. They not only realize that agricultural fields and areas have long been the "natural" ecosystems for "ordinary" creatures but also evaluate the importance of farmers' roles in having sustained this "natural" (or, more correctly, "artificial") ecosystems for a long time (Moriyama, 1997.)

These ecological studies suggest that agricultural studies also have to explore alternative ways of leading us in developing more environmentally-sound cropping and farming systems.

NEED FOR AREA-ORIENTED OR AREA-SPECIFIC APPROACHES

It is conventional for agricultural studies to practice field experiments either in experimental plots or in farmers' plots. Even if an experiment is set in the farmers' fields locally, it is not common for agronomists to extend their research interests into the area's social or cultural affairs. "Area" is the complex interaction of nature, society, and human beings. The cropping and farming systems are the reflection of the area. Therefore, I urgently call for the establishment of more intensified and diversified collaborative efforts between agricultural sciences and other relevant studies.

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4. CASE STUDY ON FARM/HOUSEHOLD LEVEL ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICE: ORGANIC FARMING

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INTRODUCTION

This is the case study of organic farming in Japan by Mr. Michio Uozumi. Mr. Uozumi has been a farmer for 33 years and most of this has been in organic farming. He is not only a farmer, but also the Director of Japan Organic Agriculture Association (OAA, an incorporated nonprofit organization) and the Vice Chairman of Organic Agriculture Promotion Association (OAPA, an incorporated nonprofit organization.)

MANAGEMENT SIZE AND DESCRIPTION OF UOZUMI FARM

Mr. Uozumi's farm has a total of 31,500 ha. Fifteen *are* are in rice paddies and are for self-consumption. His upland fields consist of 30,000 ha where he cultivates 50-60 types of vegetables and grains year-round. He also has poultry farming in a flat-feeding style. He raises about 600 chickens mainly for eggs and meat. He has three colonies of bees in his apiary portion. He cultivates *shiitake* mushrooms. He also raises fruits such as Japanese plum and persimmon.

Mr. Uozumi is engaged in combined stockholding agriculture and organic farming managing the farm described above. His labor force is support from consumers and one or two short-term interns in addition to his family members (himself, his wife, and son.)

Product Sales

All of Mr. Uozumi's products are sold directly to consumers in partnership relationship. Mr. Uozumi delivers the products by driving by himself. He delivers to 35 consumers in the neighboring area in the prefecture every week. Using a professional delivery service, 30 consumers in the neighboring prefectures in the Kanto region receive his products every other week. There also is a bulk shipping to consumer's group outside the local area. The products are shipped to a consumers' group in Matsudo, Chiba prefecture, twice a week. A private driver comes to get them. To date, all of the products are shipped out all year round without interruption. Mr. Uozumi works carefully to ship an average of 12-15 items every week.

Price Decision

The producer helps decides prices in accordance with the crop situation in the year with slight fluctuations. Although general market prices are taken into consideration, the products are not necessarily expensive just because they are organically grown. The farm works hard not to be influenced by market prices so much when they nosedive or skyrocket. The farm decides prices that can satisfy consumers.

Farm Machines and Facility

The farm has a wide variety of farm machines to enable year-round cultivation of many kinds of crop. The farm is equipped with the following machines and facilities for tilling, management work, and storage.

- Tractors: 1 large-, middle- and small-sized tractor each
- Combine harvester and thresher: to harvest rice and wheat
- Management machine: 3 small tillers
- Drier machine: thermal power drier machine for rice and wheat
- Harvester: to harvest grains
- Manual spreader: 1
- Forklift: 1
- Refrigerator: 6.6 m2 (to store grains, vegetables and seeds)
- Barn: place for distribution, year-round storage of potatoes
- Farmyard manure storage: 29.7 m2
- Greenhouse: weather protection for tomato cultivation.

Farmland

Mr. Uozumi owns approximately 1 ha of farmland. An additional 2 ha is leased land at the average rent of ¥10,000/1,000 ha/year.

Fertilizers

Organic fertilizers are produced on-farm by fermenting for 2-3 months a mixture of chicken manure from 600 chickens at the flat-feeding-style farm with rice bran and mountain soil. Thirty to 40 mt of organic fertilizers can be produced annually from the Uozumi farm.

Fossil seashells and leaf mold are used for some kinds of crops. Some of this has to be purchased from off-farm sources.

Weeds are returned to upland field as green manure.

Materials Used at Farm

No agricultural chemicals, including specified agricultural chemicals, are used. Even agricultural chemicals approved for Japanese Agricultural Standard (JAS) organic are not used. Polyethylene film is used for the roof of the greenhouse for weather protection.

Polyethylene film mulch is used for some kinds of crops in the upland field for heat retention and weed prevention. Non-woven fabric (product name *Paslite*) is used to prevent frost damage on leafy vegetables in winter. Carp is used to tackle weeds in rice paddies. Ten to 15 kg of carp is released into every 1,000 ha of rice paddies for about two months after rice is planted.

Seeds

Although about 70-80 percent of the seeds are still purchased, some seeds have been acquired from the farm recently. Although genetically modified seeds are developed at private and national research institutes, Uozumi believes that such seeds should not be developed to protect biodiversity and thus does not use them on his farm. After the incident of pollution of genetically modified seeds of Starlink corn, Uozumi produces his own seed corn on-farm.

5. VILLAGE LEVEL ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICE: THE SLOPING AGRICULTURAL LAND TECHNOLOGIES (SALT) OF THE SOUTHERN PHILIPPINES AND ASIA

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INTRODUCTION

In September 2000, the Asian Productivity Organization (APO) organized the first seminar on the Impact of Agricultural Practices on Environmental Sustainability. It was held in Tokyo and hosted by the Government of Japan. The objectives were to discuss current measures adopted to minimize the negative impact of agricultural practices on environmental sustainability as well as to propose strategic methods that could be undertaken by participating countries to counteract these negative impacts.

A review of the proceedings from that meeting shows that the topics were well discussed especially at a macro level. The resource papers described in an excellent way the problems facing environment-friendly agricultural practices and each country paper represented specific country issues. The workshop participants themselves formulated and adopted 18 separate recommendations during the plenary session attesting to the seminars success.

Recommendation No. 17 states, "Prevalence of poverty in developing countries was pointed out to be the primary cause of environmental degradation in the region." Furthermore, the recommendation went on to suggest the implementation of "massive effective poverty alleviation programs in the developing countries in order to ease pressure on the natural resources of the region" (APO, 2002.)

Thus, this paper is an attempt to examine environment-friendly agricultural practices from the eyes of the poorest of the poor in Asia. It will try to accurately depict the situation of poverty-stricken farm families and communities as well as discuss their views of sustainable agricultural practices. It will also discuss one environment-friendly agricultural practice developed in the southern Philippines alongside poor farmers known as the Sloping Agricultural Land Technology (SALT.) It then will present a short case study of two different poor villages and their efforts to implement environment-friendly agricultural practices. Finally, it will try to give some general guidelines and insights to those of us in decision-making roles as to how to empower the poorest of the poor and the small farmers and communities to implement environment-friendly farming systems.

DEFINITIONS

We do not need to go into many technical definitions at this point. However, for the sake of continuity and understanding, I would like to give the following definitions below as a framework for those reading this paper.

1. *Sustainability*

It literally comes from a Latin word meaning "to hold up from under." This implies the "supporting" of a thing such as a system, program, etc., by making sure that there is an adequate "holding up" of resources.

2. *Sustainable Agriculture*

It is food and income generation from the land in a way which "holds up from under" the necessary production. It is agriculture that produces acceptable outputs without depleting the things that the outputs depend upon (e.g., soil, nutrients, etc.) Anthony Young (1989) describes this as "sustainable

land use (agriculture) equals acceptable production plus conserving of resources upon which production depends.”

3. *Environment-Friendly*

It is safe and non-threatening practices to the ecosystem which includes all the animal and plant kingdom (including the human realm) within that ecosystem.

4. *SALT*

This stands for “Sloping Agricultural Land Technology.” The SALT technology was developed in the late 1970s in the southern Philippines for sustainable farming of the uplands of the tropics.

5. *Poverty*

It comes from the Latin root word “pauper” or poor. It is taken as a state of lacking the means of providing materials needs or comforts for ones self or family. It is relative depending on the individual situation and conditions but about 40 percent of the people in the world are said to live in some form of poverty.

6. *Absolute Poverty*

It is a condition characterized by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information. It depends not only on income but also on access to social services (United Nations, 1995 cited in Gordon and Spicker, 1999.) About 20 percent of the people of the world are said to be here.

7. *Organic Farming*

It is a farming without the use of chemical or inorganic inputs. Sometimes this is called “natural” farming.

8. *Subsistence Farmer*

It is a farmer and/or farm family whose basic concern is food production that is adequate for meeting his/her family needs. The income from a subsistence farm family is usually derived from “excess” food that is not consumed but rather sold on the open market. The family may have “other sources” of income such as sporadic off-farm labor and non-farm products (e.g., forest products.)

9. *Food Security*

According to USAID, food security is achieved when all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life. But the World Vision team in Africa defines it as the ability of households to sustainably meet their own food needs (Flaten, 2002.)

ENVIRONMENT-FRIENDLY AND POVERTY SITUATIONS

Environment-friendly agricultural farming systems are a worthy goal of all countries of the world. Some of the more developed countries have instituted good laws and programs to accomplish this ideal. The United States of America in the 1980s implemented the landmark 1985 Food Security Act and its corresponding program called the Conservation Reserve Program (CRP) in a largely successful effort to “set aside” and take out of production the majority of highly erodible lands (HEL) in the U.S.A. Likewise, Japan in the same time frame began implementing exemplary forestry conservation programs.

However, it has been much harder for the lesser-developed countries to afford the “luxury” of environment-friendly agricultural programs. Generally, due to high populations and growth rates, limited resources, and a large percentage of the countries’ people living or existing at or below the poverty line, many “subsistence” farmers have found it hard to afford these environment-friendly systems. Therefore, any agricultural practice desiring to be “environment-friendly” must take into account the people included in that environment: their needs, their resources, their knowledge level, their hopes and their dreams.

SLOPING AGRICULTURAL LAND TECHNOLOGY

The Mindanao Baptist Rural Life Center (MBRLC) has years of experience in working alongside poor farmers and farming communities in developing environment-friendly farming systems. The MBRLC is a rural development program began in September 1971 by agriculturist Harold R. Watson. It is still operating today and located in *barangay* Kinuskusan, Bansalan, Davao del Sur on the island of

Mindanao, Philippines. The Center sets on a 19-ha demonstration farm and is dedicated to the upliftment of poor farmers and farming communities in the Philippines as well as the rest of Asia.

From the very beginning, a high emphasis has been given to helping upland farmers find sustainable farming systems fitting their situations and meeting their needs. The upland farming systems developed and promoted by the Center has intensive soil conservation components and is environment-friendly. To date, a number of internationally known technologies and demonstrations utilizing agro-forestry for soil conservation as their base have been developed by the MBRLC. These are primarily the Sloping Agricultural Land Technologies known generally as SALT. All of these technologies are “environment-friendly” in that they model no external inorganic inputs plus being sociocultural and environmentally sound practices.

For reference purposes, a brief description of the MBRLC SALT technologies follows:

1. *Sloping Agriculture Land Technology* (SALT 1)

The SALT 1 technology utilizes a number of fast growing nitrogen-fixing trees and shrubs (NFT/S) for soil conservation in the uplands. These NFT/S are planted in double hedgerows every 3-5 m apart along the contour of the sloping area. These nitrogen-rich fixing hedges act as a physical barrier to soil erosion as well as giving a rich NPK mulch which enhances the soil erosion control potential for the system as well as providing a good source of organic nutrients for the system. The alleys or strips in between the double contour hedges are planted to seasonal and permanent crops to give a balance of food and income generation. The original SALT 1 model is situated on a 1-ha plot. The major NFT hedgerow species selected for the southern Philippines includes *Flemingia macrophylla*, *Desmodium rensonii*, *Gliricidia sepium*, *Leucaena* spp., *Indigofera tyesmani* (anil,) and *Calliandra* spp., among others.

2. *Simple Agro-Livestock Technology* (SALT 2)

This technology is a variation of the SALT 1 technology with a heavy emphasis being placed on an animal component. In the SALT 2 model at MBRLC, the main demonstration makes use of an integrated goat dairy on a 0.5-ha of land. Half of the land area is dedicated to agro-forestry trees (mainly NFT/S) dedicated to use solely as forage/fodder for the goats while the other half is dedicated to food and income for the farm family. Again, the main agro-forestry species mentioned above for SALT 1 are primarily used in this system.

3. *Sustainable Agro-forest Land Technology* (SALT 3)

Another variation of the SALT 1 technology is SALT 3 where a heavier emphasis is placed on small-scale reforestation for the farm family. This is a 2-ha model where 1 ha is utilized to a regular SALT 1 project while the remaining 1 ha is planted into a small, farmer-managed forest. The majority of the agro-forestry species utilized in the reforestation aspect are again NFT/S such as *Albizia saman*, *Pterocarpus indicus*, *Acacia auriculiformis*, *A. mangium*, and *Leucaena diversifolia*. However, a number of non-NFT/S are also used in this agro-forestry model including *Swetinia macrophylla*, *Gmelina arborea*, and *Eucalyptus* spp.

4. *Small Agro-fruit Livelihood Technology* (SALT 4)

A classification of trees which often escape the attention of agro-foresters are the fruit trees which are the building block of the SALT 4 technology. Working from the idea that some farmers would prefer fruit production over other commodities, SALT 4 integrates durian (*Durio zibethinus*,) lansones (*Lansium domesticum*,) rambutan (*Nephelium lappaceum*,) mango (*Mangifera indica*,) jackfruit (*Artocarpus heterophyllus*,) coffee (*Coffea* spp.,) and calamansi (*Citrus madurensis*) into a 0.5-ha demonstration with high returns on investment. The majority of agro-forestry fruit trees utilized here are non-NFT/S but are supported by the presence of N-fixing hedgerows for erosion control and soil fertility management.

With the SALT technologies, farmers, technicians as well as researchers worked together along with MBRLC staff to help come up with practical solutions for local farmers and their struggle with dwindling production in their upland farms. Moreover, the local people who were the first adopters of SALT came from a specific profile fitting a number of upland families and communities not only throughout the Philippines but the rest of Asia (Table 1).

Table 1. The Typical SALT Farmer/Participant of the MBRLC Programs,
Based Upon Actual Baseline Data (15,000 + surveyed)

1.	A tribal minority (Bagobo, T'boli, Manobo, B'laan, Tagakuolo, etc.) or a low-lander (Cebuano, Illongo) living in the marginal uplands.
2.	Living in the uplands (greater than 18 percent slope)
3.	Staple food – upland corn/rice
4.	Living in “forestland” of <i>Imperata cylindrica</i>
5.	Average grade 4 education
6.	Has access to 1-2 ha of land
7.	Slash-and-burn farmer
8.	Has “dreams” in life
a.	provide food/income for family
b.	provide housing/clothing
c.	provide education for children

The principles adhered to in developing the SALT technologies were very simple, fourfold and designed to be applicable to the above-described end user. It was felt that any sustainable upland system must meet four criteria, which has now become the MBRLC basis for evaluating any new farming system for the tropical uplands:

- 1) Control soil erosion;
- 2) Rebuild/improve the soil structure and fertility;
- 3) Provide adequate food and income for the farm family implementing the system; and
- 4) Culturally acceptable.

SALT has become a widely used conservation model for sustainable upland farming throughout Asia. It is impossible to estimate how many hectares in Asia have been “SALT-ed” but it is safe to say that it would be in the tens of thousands. In 2000 alone, the MBRLC extension program accounted for over 1,000 ha of SALT-based conservation systems in the uplands of the southern Philippines. Outside the Philippines, the countries of Vietnam, Sri Lanka, and Myanmar, among others, have significant SALT programs.

As early as the mid-1980s, Laquihon (1987) studied the determinants of SALT adoption in the Philippines. Interviewing 71 SALT adopters from the 16 provinces throughout the Philippines, Laquihon recorded some determining factors as to why farmers adopted an environment-friendly technology such as SALT and classified them according to type (Table 2.)

Table 2. Determinants of SALT Adoption and Type

Determinant of Adoption	Classification
They had training and exposure to SALT	Sociocultural
They anticipated benefits from the technology	Sociocultural
Planting materials were made available	Biotic
Sponsoring organization was sincere and capable	Sociocultural
They had a source of outside income	Sociocultural
Their land was sloping	Physical
They were leaders in the project	Sociocultural
Sunlight direction	Physical
Religious beliefs	Sociocultural
Credit availability	Sociocultural

Source: Laquihon, 1987.

Laquihon's conclusions indicated that exposure to a conservation technology in itself was not enough to influence most people to adopt the technology. Many sociocultural, physical, and biological factors have to be favorable for adoption with the most influential being sociocultural.

In an unrelated study, 150 SALT farmers across southern Mindanao were interviewed for the Southern Mindanao Agriculture Program (SMAP) and asked about their reasons for adoption of the SALT technology (Guliban, 1993). The condensed results are listed below (Table 3.)

Table 3. Farmers' Reasons Given as to Why They Adopted SALT

1	Those farmers with land tenure were more likely to be SALT adopters than those without tenure (112 respondents had land tenure out of 150 interviewees or 75 percent adopters with tenure).
2	When asked about whether they needed support in SALT implementation, 95 percent responded positively. The type of support cited to SALT their farms was mainly hedgerow seeds (28 percent giving this response) and fruit tree seedlings (26 percent giving this response). Other needed support cited by SALT farmers included commercial fertilizers (11 percent), livestock (6 percent), technical advice (6 percent), and financial assistance (3 percent).
3	When asked what the overriding determinant was in their adoption of SALT, the farmers responded: <ul style="list-style-type: none"> a. training (24 percent) b. anticipated benefits of the technology <ul style="list-style-type: none"> i. oil erosion control (25 percent) ii. restoration of soil fertility (21 percent) iii. increased farm income (17 percent) iv. forage for animals (2 percent) v. convinced of benefits (1 percent) vi. fruit trees from sponsor (1 percent)

Source: Guliban, 1993.

MBRLC EXPERIENCE ON SALT ADOPTION

From the MBRLC experience, farmers and farming communities adopt SALT (as well as other environment-friendly farming systems) for multiple and varied reasons. One could classify these "reasons" as "incentives" to adopt. The major incentives to adopt SALT and other environment-friendly technologies by upland farmers/communities can be classified into two types: micro level (grassroots) and macro level (national.)

Micro Level

These are incentives, which are grassroots in nature and immediately felt by the farmers themselves. They do much to get local adoption but do not address the large issues of government policies, etc., addressing the overall upland degradation problem.

1. Proven System/Working Model

One of the responses MBRLC gets as to "why do farmers apply SALT" is that they have seen the technology work and are convinced in its potential. This was seen in the SMAP survey of farmer adoption of SALT. The original MBRLC SALT demonstration is still functioning today. It is a 25-year old project on a 35-percent slope and is about as productive today as it was in the beginning. Over 20,000 visitors a year come to the MBRLC to see the original SALT project and can visually see the sustainability of the system.

2. Available Planting Materials/Starter Inputs

People who choose to apply environment-friendly farming systems need an immediate way to apply what they have learned or chosen. Since the SALT technologies heavily rely on vegetative barriers of the NFT/S, a priority of MBRLC, which has helped spread conservation in the southern Philippines, has been the provision of planting materials through its Seed/Plant Propagation Department. Over 30 mt of agro-forestry seeds and 100,000 agro-forest seedlings have been produced and distributed to local people over the past few years. Most of these dispersals complimented the MBRLC extension program. Again it should be stressed that no monetary incentives are used to apply conservation only payment "in kind" which would assist the farmer in applying the particular conservation measure.

3. *Education About Conservation*

Not enough can be said about awareness, training and education in giving people an incentive to apply soil conservation technologies and/or other environment-friendly farming systems. Again, over 20,000 visitors a year come to see the original SALT 1 model as well as the other SALT models at MBRLC with about 1,500 plus of those being one-week trainees. Over 20,000 published training manuals on the SALT technologies are produced and distributed each year. For many years, the MBRLC ran a radio program focusing on sustainable upland farming called “Back to the Farm.” Also, numerous newspaper articles and journal publications were published on the SALT technology. Even though it is hard to measure this item as a conservation incentive, it is believed by MBRLC that the focus on this aspect of the program may have helped acclimatized a whole nation to become aware about the need for conservation in the uplands.

4. *On-farm Follow-up/Good Extension Techniques*

Perhaps the key incentive in all that MBRLC does to get people to adopt environment-friendly measures such as SALT is to provide in-village extensionists to work with and follow up on farmers who have had exposure to the technology. The MBRLC has about 45 full-time agriculture extensionists in the field, living and working in small villages across southern and eastern Mindanao. The program is built upon good community development principles, is community-based, and relies heavily on capability and skills improvement where the villagers themselves can come to deal with erosion and declining yields in their respective areas. An effective extension and follow program may be the most significant factor in application/adoption of soil and water conservation measures.

5. *Support Group Formation*

This is a community organizing and/or strengthening program tying in heavily to the extension program. Where people are aware, well organized, discussing options, and working together, a positive atmosphere is created for implementation of desired measures.

6. *The Dedication and Sincerity of the Extension Organization and Extensionist*

Often overlooked, this one subtle incentive may bring about many adoptions of conservation/environment-friendly measures than most would like to admit. Assuming Laquihon’s conclusion citing the overwhelming influence of sociocultural determinants to SALT adoption, the human factor and caring in the technology dissemination may be of utmost importance. MBRLC has found this to be true in its extension program to the point that potential extensionists are hired more for attitude and character than they are for specific skills.

Macro Level

These are incentives and decisions usually made on a regional or national level and are eventually felt by the small farmers. However, they should never be ignored because in the long run, they are necessary for a sustainable soil conservation movement.

1. *Government Laws Affecting Adoption*

Favorable government mandated laws and incentives provide a macro-climate conducive to environment-friendly farming systems. For instance, House Bill 9820 sponsored by the Philippine Government House of Representatives is a bill providing for a sustainable soil and water conservation movement for the Philippines. Benefits contained therein include land tenure for SALT adopters, tax breaks and technical assistance to farmers wishing to apply conservation technologies. Moreover, the Law mandates conservation farming for the uplands. It is respectfully called the “SALT” Bill.

2. *Overall/Comprehensive Awareness Program*

Again, this one is hard to measure as an incentive but should be a priority for any country undertaking an environment-friendly farming system program. Mass media such as radio and television, appropriate training of all levels of people, mandatory conservation taught within the school systems, research institutions focusing on conservation needs, etc., should be a major strategy in convincing people and whole nations to join the conservation movement. MBRLC has seen the definite benefit of this strategy as an incentive on a micro level.

CASE STUDY NUMBER 1 – UPPER VALLEY WATERSHED PROJECT, NINOY AQUINO, COTABATO

In 1996, the MBRLC was asked by the Asian Development Bank (ADB) to consider taking the social component of a rather large irrigation project in western Mindanao. The total project was under the Autonomous Region for Muslim Mindanao (ARMM.)

The “social component” consisted of the watershed protection and management of the irrigation project’s water collection area. The area consisted of a total of 30,000 ha and it was to be a four-year program that goaled at least 1,500 ha of conservation applied.

With over 10 Philippines Government line-agencies and another 10 – plus people’s organizations and NGOs, the MBRLC accepted the program for watershed protection and conservation. However, MBRLC stipulated that the program must be done in a way to truly involve the people of the watershed as well as to channel at least 90 percent of the funds (in the form of planting materials, training, village organizing, etc.) to the watershed dwellers. The primary strategies included a community awareness campaign, the formation of conservation-awareness groups among farmers, communities and school children, an intensive on-site as well as off-site farmer training program, and the actual implementation of the SALT farming systems via direct extension assistance, farmer-to-farmer adoption, and village “radiation.”

Six full-time extension workers were dedicated to this four-year project (1996-2000.) Working in teams of two, they were able to accomplish the following within the project time frame.

The numbers in Table 4 are shown to give the idea that people working together can be much more effective than working apart. It also is a good example of helping people accept and even embrace environment-friendly technologies such as the SALT system.

Table 4. Accomplishments of the MBRLC Kabulnan Watershed Program,
Social Component, FY 1996-2000

Area of SALT applied directly (ha)	1,044
Area of SALT by farmer-to-farmer (ha)	289
Area of SALT by “radiation” (ha)	46
Conservation awareness groups formed (number)	72
Publicity materials distributed (number)	3,000+
Radio programs aired (number)	98
Farmers trained (number)	1,567
Tree nurseries established (number)	57
Seed nurseries established (number)	22

In the beginning of the project, the foreign advisors wanted MBRLC to plan from a technical perspective the whole project. However, MBRLC’s position that watershed management is not done by remote sensing or even good aerial photographs; rather, it is done by people. Therefore, the whole watershed program designed and implemented by MBRLC focused heavily on enlisting the local people of the watershed to see the real benefits of conservation farming systems such as SALT and then helping them to apply those systems. As a follow-up comment to the above, even after the official watershed program “ended” and the ADB funding was stopped in mid-2000, the MBRLC continued its own funded programs of upland development, privately-funded and continuing to work alongside the people of the Kabulnan watershed. We now estimate over 2,000 ha of conservation applied.

CASE STUDY NUMBER 2 – MAGSAYSAY, DAVAO DEL SUR

Magsaysay is a municipality of Davao del Sur with 22 villages or *barangays*. The 1995 census puts the total population at 41,979 people making up 8,224 families for an average of 5.1 persons per household. Half of Magsaysay’s *barangays* are lowland irrigated with the other half being upland communities ranging from moderate to steep slopes. The whole of Magsaysay is in a dry zone with a pronounced six-month wet and six-month dry season (National Statistics Office, 1995.)

As MBRLC moved into the area for community development work, the Local Government Unit’s (LGU) Municipal Development Council (MDC) steered the MBRLC to work in the most critically

impoverished areas of the municipality. These areas were narrowed to basically four *barangays*: Bacungan (1,764,) Balnate (979,) Malawanit (1,365,) and San Miguel (1,290) or 13 percent of the total population of Magsaysay. These areas were chosen by the LGU-MDC and MBRLC as primary targets because of their isolation, limited access to basic services, extremely steep topography, and high incidence of poverty. The majority of people living in these villages are Visayans (lowlanders) who have migrated into the uplands and mixed-tribal peoples of B'laan heritage.

The MBRLC entered into the area in 1991. From 1991 to 1992, MBRLC community development work was conducted with groups in Balnate and San Miguel. Work was later on expanded to include Bacungan (1993-95), Malawanit and Asbangilok (1995-97.) Initial contact in the area was made by MBRLC by Mr. Rod Calixtro, Base Project Division Leader, and the first MBRLC extensionist assigned to the area was Mr. Noel Elmundo. Other extension workers for the life of the project included Mr. Ramonito Solana and Mr. Jun Elegio.

The MBRLC project was heavily linked to the LGU through the MDC and more pointedly through relationships with the *Barangay* Councils, captains and the *Barangay* Development Councils (BDCs.) Also, a good linkage was made with the European Union (EU) project known as the SMAP through the Department of Agriculture (DA), which provided most of the monetary inputs into the initial projects.

Overall, there were over 200 SALT farmer adopters in the larger area. In Malawanit alone, there were 60 SALT 1 adopters and 50 SALT 2 adopters. San Miguel had over 60 SALT 1 adopters and another 20 SALT 2 adopters. Balnate had 30 SALT 1 adopters whereas Asbangilok had 30 SALT 1 and two SALT 2 adopters. The village of Bacungan, "*purok*" 1, had 15 SALT 1 adopters and 10 SALT 2 adopters.

It should also be noted that a number of "other" development projects relating to infrastructure, healthcare, community organizing, water development, etc., were explored and implemented by the community. This was done as a comprehensive community development project with moderate leadership by the on-site MBRLC extensionist. In other words, the development work actually carried out in the village was more holistic than what is focused on in this particular paper.

Lessons Learned (from the above and other cases)

1. *Stress Production*

Production, not environment-friendly, will be the selling point to farmers in terms of trying new farming methods. Therefore, we must find technologies and methods that are not only environmentally sound but also productive in the eyes of local people. Whatever we are promoting to local people as "environment-friendly" must also be proven as productive in order for local people to consider it a viable system.

2. *Give True Assistance and Incentives to Those Wanting to Apply Environment-Friendly Agricultural Practices*

Environment-friendly approaches to agriculture can have extra "costs" to production especially for the poorest of the poor farmers. For instance, when conservation measures are applied to upland farming systems such as terraces, vegetative barriers, soil traps, etc., those whose livelihood is dependent on subsistent agriculture have little or no resources to apply such measures even if there are perceived long-term benefits. Even the retooling of poor farmers to think "environment-friendly" will have costs such as training, information dissemination, etc. Basically, costs to environment-friendly agriculture, from the community's perspective, can be broken down into two categories: intrinsic and extrinsic. Intrinsic costs are those that the farmers and farm communities actually have to invest out of their own pockets and are the main costs felt by the local community. They can be physical structures for conservation, planting materials, information, tools for organic farming, etc. Extrinsic costs are generally those outside of the community that are borne by society as a whole and these are manifested in government conservation programs, NGO/people's organization programs, general education, etc. For instance, the intrinsic costs for a SALT system to a local farmer/community might be the cost in seeds for the hedgerows, time of the farmer/family set aside for training, and labor to implement the system. The extrinsic cost to SALT might be the government programs that are sponsoring the farmer trainings, the time, effort and costs put into SALT by an NGO such as the MBRLC, and broad-based education programs. The bottom line is that true incentives, especially in the area of soil and water conservation

for the uplands for the poorest of the poor, must be given to the farmers and farm communities in order for them to see these environment-friendly approaches as a viable option. The “best” incentives that we have found (from experience) is education, training, initial planting materials, and possible animal dispersals as “starter” projects, and good, in-village organization. Other possible real incentives for impoverished farmers and communities might be land tenureship, tax breaks or exemptions, etc. We highly discourage cash incentives to poorer farmers.

3. *Include People in Your Consideration of “Environment-Friendly”*

Sometimes, we inadvertently pit the human race against the environment. However, we humans are just as much a part of our environment as the earth, plants, and animals and thus should be viewed as “allies” and not enemies in the efforts towards environment-friendly practices. Environment-friendly approaches must focus on the whole environment and not just “nature.” The people of an ecosystem are the major determinant in the sustainability and environment-friendliness of any agricultural practice. Agriculture by definition is “man cultivating the land”. If we are to have truly “environment-friendly” systems, we must involve people from the ground-up in the process.

4. *Education about Environment-Friendly Agricultural Practices Must Be at All Levels But Especially at the Most Basic: the Farm and Farm Community Level*

Good laws and good government can provide excellent frameworks for encouraging environment-friendly practices. However, there must be education (preferably non-formal) at all levels of society in order for “environment-friendly” to become the accepted “norm” for an area. MBRLC/ARLDF has found in the rural Philippines that there is a critical mass of about 30 percent which is the “tipping point” for making villagers accept or reject a practice. This is not a set law, but awareness is an important part in getting people to participate in projects/programs. Non-formal education promoting environment-friendly agricultural practices should be formed, encouraged, and supported.

5. *Design and Implement Participatory Approaches to Get Communities “On Board” with Environment-Friendly Approaches to agriculture*

In order for wide-scale adoption, environment-friendly agriculture practices must be entered into in a participative way by most of the poorer farming communities. We can “force” people with decrees, laws, etc., but we have found that when we “join together” in programs of this type and are sincere as an organization, there is a much higher participation rate.

6. *Keep the Technology/Program Simple*

Environment-friendly agricultural practices hoping for rapid adoption and dissemination must be simple and easily reproducible. This includes taking into account the limited resources available to many local farming communities.

CONCLUSION

I would like to thank the APO for the opportunity to participate as a resource person in the conference. The ideas and observations presented here are solely mine and based on the experiences of development work in the southern Philippines as well as other Asian countries. I take full responsibility for the data and interpretations thereof.

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6. NATIONAL AND REGIONAL LEVEL ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES: INTEGRATED WATERSHED MANAGEMENT IN INDIA

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INTRODUCTION

In most developing countries of Asia, agriculture – including crop and animal husbandry, forestry and fisheries – constitutes the backbone of environmental security on which rural livelihood depends. The latest report on Global Assessment of Soil Degradation (GLASOD) estimated a total of degraded land in Asia at 1,200 million ha (Oldeman, *et al.*, 1992.) Soil erosion accounts for 60 percent of the total land degradation and is the most extensive factor of lowering environmental quality. Erosion rates of 10-500 mt/ha/year have been estimated for countries of the region (Eswaran, *et al.*, 1995.) This land degradation at a regional scale manifests itself in increased sedimentation, reduced farm production, diminishing livestock-carrying capacity, and deforestation with consequent loss of biodiversity. In that context, the status of watersheds as natural management units often indicates the environmental health of a nation.

In India, the agriculture sector plays a vital role in economic development as it contributes 29.4 percent of GDP and employs about 64 percent of the workforce. The majority of small and marginal farmers as well as landless poor depend on agriculture. Much of this is practiced in the unfavorable marginal lands. Because of soil erosion, deforestation, overgrazing, and unscientific methods of cultivation, a large portion of that land area has been rendered barren. Over 173 million ha, covering slightly half of the country, are threatened by various types of degradation such as rill and gully erosion, salinity, water-logging, shifting cultivation, etc. It is estimated that an average 16.75 mt/ha/year of soil are lost through erosion in India (FAO, 1983.) This translates to more than 5,000 million mt of topsoil eroded annually.

It has been realized that adopting an integrated watershed management approach can contain deterioration of natural resources. Aiming at minimizing the intensity of ecological degradation and improvement in the living standards of the local population through soil and water conservation measures and other approaches like reforestation, improvements can be made to the productivity of soil, water, animal, and human resources. These Integrated Watershed Management Programs (IWMPs) involve long-term environmental rehabilitation measures to check further erosion and reduce downstream flooding. In addition, the projects focus on reducing the current gap between local demand and supply of fuel wood and fodder for the benefit of the rural communities. The IWMP has thus become an important strategy for development of environment-friendly agriculture in India. The government accordingly has taken up many watershed projects and most of the experiences have been found highly encouraging in the contexts of environment and development. An attempt has been made in this paper to highlight the state-of-the-art environment-friendly agricultural practices adopted under IWMPs in India.

NEED FOR INTEGRATED WATERSHED MANAGEMENT PROGRAMS

Agriculture in India is still a gamble with agro-environmental resources. Some of the trends of agricultural development in India can be summarized as follows:

1. Growth of irrigated area and increased crop yield attained during the initial phase of the Green Revolution has come to pretty much a halt. Hence, the future growth of agricultural production will have to increasingly come from rainfed regions at least till another flux of large-scale investment in irrigation takes place.
2. Frequent, erratic rainfall patterns, especially after the 1980s, have resulted in highly fluctuating agricultural productivity making it difficult to sustain the population on farming systems alone.
3. The tapping of groundwater has also reached alarming levels of depletion causing serious environmental problems.
4. Increased utilization of inorganic fertilizers and pesticides has brought in chemical deterioration in the form of nutrient loss and leaching.
5. Increasing human and livestock population combined with uncertain crop yield has reduced availability of the common property resources such as community forests and biomass.

Under these circumstances, the IWMP has become the major policy instrument for achieving environmental sustainability, mainly in rainfed areas.

Basically, a watershed is a piece of land that drains at a defined outlet. This natural hydro-environment unit evolves through the interaction of rainwater and landmass, which normally comprises arable and non-agricultural lands, and drainage systems. Typically, watershed areas are delineated on the basis of the distribution and flow of rainwater up to the defined outlet. Until recently, a village/block/district was considered as a basic unit for developmental activities. However, since these are only administrative units, the importance of environmental resources is often ignored or neglected which results in under- or over-utilization of natural resources. In view of this, the concept of the watershed as a development unit has evolved since it is a unit in which all the agro-environmental resources like soil, water, geomorphology, and land use are in harmony, thereby facilitating adoption of integrated and holistic approaches to problem-solving.

The main ethos of an integrated approach in watershed management is:

1. simultaneous development of land and biomass resources in the light of their symbiotic relationship.
2. ensuring environmental sustainability along with economic viability by promoting low cost, innovative conservation technologies.
3. meeting food, fodder, and fuel requirements of human and livestock population, which depend on these resources.
4. improving land productivity by promoting better environment-friendly agronomic practices.
5. integrated farming systems and alternate land-use approaches.
6. development of local institutions for future management through participatory approaches.

Essentially, a watershed is made up of the natural resources, water, soil, and vegetative factors in a basin. Integrated management will bring into account the productive use of all the natural resources. IWMP essentially includes land improvements, water harvesting, and other conservation works as well as the human consideration. It involves the following operating principles:

1. Land and water resources are interactive parts of natural ecosystems and should be managed based on this point.
2. Watersheds are continually changing and need to be managed by considering these changes.
3. Management of land and water resources must be coordinated, with decisions based on the best available information that are cost-effective, environment-friendly technologies.
4. Sound watershed management is best achieved through the action of individual users who also become the managers of these resources.

Since the 1980s, greater emphasis has been placed on IWMP and about 42 operational research watersheds in different agro-ecological zones have been established. Subsequently, in India, watershed-based development spread at a tremendous rate. During the Ninth Plan period from 1997 to 2002, more sustainable watershed based eco-system development was promoted and realized by creating village

level institutions with active involvement of NGOs. More than 2,500 small watersheds have been developed in an integrated manner during the last 10 years.

DELINEATION, CODIFICATION AND PRIORITIZATION OF WATERSHED DEVELOPMENT PROGRAMS

As physical and hydro-environmental status of watersheds vary greatly, it is necessary to develop a suitable terminology to define them. A system delineating region, basin catchment, sub-catchment, and watershed in descending order of areas is followed in order to label a watershed (All India Soil and Land Use Survey [AISLUS], 2001.) Thus, a combination of alternating Arabic numbers and English alphabet is used in coding watersheds (Table 1.) A sample watershed code would be 4B1A3.

Table 1. Distribution and Codification of Different Hydro-Environmental Units

Hydro Unit	Number	Code Specification	Remarks
Region	6	Arabic numbers	Based on <i>geographic</i> and <i>topographic</i>
Basin	35	Letters	All big river basins
Catchment	112	Arabic numbers	Major tributaries to big rivers
Sub-catchment	500	Letters	Small tributaries and streams
Watershed	5,000	Arabic numbers	Small hydrological units

In 1990, the National Watershed Atlas on 1:1 million scale was published. In this atlas, the delineation of watershed size ranging between 500-800 km² was recorded. Generally, each of these watersheds can then be further subdivided with the smallest watershed in the context of agricultural hydrology being the farm field or plot.

Considering the massive investment in the integrated watershed development program, it is important to plan the activities on a priority basis for achieving fruitful results, which also facilitate addressing the most problematic areas and arrive at suitable solutions. In order to do that, the priority classes are designated based on the prevailing resource situations as depicted from the theme maps such as land use/land cover, soil erosion, physiography, geomorphology, and slope. These thematic maps are then integrated to prioritize the watershed.

With the advent of Geographical Information System (GIS) and Remote Sensing (RS) techniques, it is possible to generate, store, and integrate all the data for assessing the distinct characteristics such as erodibility of each sub-unit of a watershed and assess the aggregate importance of each unit. Working out weighted averages to find the environmental rating of a watershed can then normalize these.

Accordingly, for a typical watershed the anticipated highest erodibility index is set at 6 while the lowest index is 1. Considering this, the cut-off point of 4 is taken for deciding the priority watersheds. In other words, watersheds with weighted indexes more than 4 have been classified as priority watersheds, while watersheds with weighted indexes lower than 4 were classified as least priority watersheds. The prioritized watersheds are then again classified into sub-groups of high, medium and low priorities. Subsequently, successive watershed development programs, primarily aimed at reducing soil erosion by way of appropriate structures like check dams, gully plugs, and afforestation of wastelands, are planned in a participatory way.

COMPONENTS OF AN INTEGRATED WATERSHED MANAGEMENT PROGRAM

A typical IWMP covers the following components that are usually aimed at land-based activities and are relevant to the conservation of the natural resources base.

1. Agriculture: Support Irrigation and Soil Conservation

This component aims to increase agricultural productivity in a sustained manner and to diversify crop production. The field activities include: construction of check dams, water harvesting structures, water storage tanks and channels, rehabilitation of old infrastructure, implementing new measures to check soil erosion and conserve moisture, field trials of high-yielding drought-resistant crop varieties, and distribution of improved seeds and improved farm implements. This is being achieved through organizing farmers' training camps and exposure visits.

2. Forestry

The basic objective of this component is to halt deforestation, provide vegetative cover on degraded land, and supplement the fodder and fuel-wood resources available to the rural communities. These activities are labor-intensive and generate considerable employment opportunities for the local people. The main elements of this component are establishing plantations with contour hedges, protection/improvement of existing vegetative cover, and rehabilitation of degraded areas.

3. Animal Husbandry

The objective of this component is to improve the productivity of livestock through breed improvement programs, reduction in the number of unproductive cattle, and to ensure maximum utilization of fodder resources. Key activities involved are establishment of natural breeding centers, distribution of fodder seeds, pasture improvement, animal healthcare, and efficient fodder utilization.

4. Horticulture

The activities under this component aim to raise fruit production, diversify production, and to conserve soil and moisture through establishing perennial tree crops with appropriate ground cover on steep land that is unsuitable for arable production. The main activities included are establishment of private orchards, top working of wild trees, rejuvenation of existing orchards, and distribution of horticulture plants for homestead planting.

5. Energy Conservation

The main objective here is to reduce the pressure on forests for fuel-wood by introducing energy-efficient cooking equipment (pressure cookers, wood stoves) and encouraging the use of alternative energy sources (biogas, solar.)

6. Community Participation

Community participation is the key to ensuring success of convergent planning and joint project implementation with the village communities. The project interventions are accompanied by reciprocal obligations by the beneficiaries under which they agree to contribute in cash, kind, or labor, or to implement associated activities. The strategy of IWMP is to involve local people, NGOs, and other volunteer organizations in planning, implementation, and subsequent maintenance of the developed assets by the beneficiary communities with a view to gradually make it a people's program in place of government-sponsored projects.

Soil and Water Conservation Measures

1. Bunding

Contour bunding is practiced to intercept runoff, reduce soil loss, and to provide increased opportunity time for water intake. This measure was found to be useful in low rainfall areas (<600 mm) and in soils having high infiltration and permeability rates. Generally, it is recommended for up to 6 percent slope and for soils having a depth of more than 7.5 cm. Extensive studies (Samra, 1997) showed that 1.3 m² bunds spaced at a 1.83-m vertical interval are suitable for lands having a slope between 6-12 percent. For slopes less than 6 percent, contour bunds with cross section of 0.9-1.3 m² spaced at 0.9-1.2 m vertical intervals are found to be effective.

2. Conservation Ditching

Conservation ditches of 1.58 m² cross-section, 30 m length (u/s side slope 5:1, d/s side slope 1.5:1 and depth 0.61 m) are constructed at 75 m spacing on land with slope of about 1 percent. Results of four-year monitoring study (Palaniappan, 1985) indicated that on an average, the ditch retained 91.6 percent of the annual runoff and saved 100 percent of the soil loss of 2.6 mt/ha. In order to minimize scouring of ditch sides, vegetative strips are planted as barriers in order to prevent rill damage on the upstream edge of the ditches.

3. Bench Terraces

Bench terraces are usually practiced on slopes from 6 to 33 percent. This conservation technique has been observed to reduce runoff of by 50 percent and soil loss by 98 percent (Somani, 1992.) Besides conserving soil moisture, the terraces significantly helped reduce the nutrient loss in runoff water. The bund height may be kept from 0.5 to 0.75 m with side slopes of 5:1 or greater. The height of bund is decided by the degree of slope. The bunds are sometime made of loose boulders supported by grasses. The roots of the grasses help in binding and keeping the boulders intact and in place. Terracing along with the provision of runoff disposal can enhance agricultural production.

4. Boulder Diversion Dam with Spillway

This practice is very common in lower areas of mountain watersheds. These structures are constructed across the streams for controlling soil loss and diverting water. In this practice, local vegetation, bamboo pieces, and loose boulders are used for controlling sediment flow.

Water Harvesting Techniques

1. Ponds

Surface water ponds are typical water harvesting structures constructed in order to catch runoff. In relatively flat topography situations, dug ponds are constructed as excavated pits. In most of these “pit” ponds, the sides as well as the bottom are lined with suitable sealants due to the porosity and light nature of the soils. In some places grass is used as the inner lining of ponds for checking percolation losses.

2. Minor Irrigation Tanks

Low earthen dams are constructed across main streams for creating water storage units forming irrigation resources. Assessment of runoff and storage capacity and information on soil and geology are prerequisites in designing such structures. The difference between the ponds and the tanks are that ponds do not have an extensive water distribution system.

3. Percolation Ponds

Percolation ponds are constructed across the slope for reducing velocity of runoff, increasing water percolation, improving soil moisture regime, and recharging the groundwater table. These structures are also used to check the silt load entering the multipurpose reservoirs located downstream. For construction of these structures, the site selected is relatively flat with a catchment area not less than 40 ha.

4. Drainage and Conjunctive Use

Vegetable crops such as cabbage, capsicum, and tomato are very sensitive to water-logging. Permanent grassed waterways are kept in order to help in drainage. Channels and grassed waterways are positioned in such a way that they do not hinder any agricultural activity such as plowing, hoeing, and harvesting. It is a fact that water-logging has been observed in some of the downstream watersheds. Gradual rise in the water table and related problems of water-logging and soil salinity/alkalinity have surfaced mainly because of the lack of drainage provisions, etc. Considering the problem, since 1996, reclamation of waterlogged areas has been included as a new component of IWMP.

Such conjunctive use is brought about in the following ways: (i) conjunctive in space: some parts of the command may be irrigated exclusively by surface water and other parts by groundwater; (ii) conjunctive in time: parts of the command may be irrigated alternatively by surface and groundwater during the growing period/crop season; and (iii) conjunctive by augmentation: supplies from one source are augmented by those from other sources (e.g., augmentation via tube-wells.)

Improved Agronomic Conservation Practices

1. Broad Bed and Furrow System

This is a practice in which cultivated land is converted into alternate beds and furrows. The broad beds are used for cultivation and the furrows are formed for handling the runoff water to safely return it to the watercourse. The depth of each furrow is usually 15 cm and the spacing between two consecutive furrows is 1.5 m (Virmani, 1990.) The length of furrows is decided considering the peak rate of runoff and soil infiltration rate.

2. Tillage

Tillage plays an important role in keeping the soil surface receptive to rainfall for better infiltration and thus encouraging moisture conservation. Shallow tillage effectively reduces runoff both in flat and broad bed and furrow configurations. It also reduces soil loss in broad bed and furrow configurations (5.9 mt/ha) as against no cultivation (8.8 mt/ha.) A result of various studies demonstrates that deep tillage was found advantageous in most situations.

3. Mulching

Mulching protects the soil against the impact of raindrops and thus reduces initiation of the erosion process. Surface mulching immediately after sowing is one of the effective means of controlling runoff and soil loss on cultivated lands. In order to cut down the evaporation of moisture from the soil

surface, a dry soil mulch is formed by stirring the soil. In low permeable soils, vertical mulching is done by opening trenches across the slope at about 4-6 m intervals and then back filling with crop residues plus soil.

4. *Vegetative Cover*

Vegetation is a natural means of protecting lands against soil erosion. Recommended vegetative measures include the use of natural grasses and legumes raised on bunds or strips across the slope. Sometimes, particular grass species like vetiver grass are specifically adopted for this purpose. The width of vetiver grass buffer strips is usually 30-40 cm and it has been reported that soil was trapped in front of the vetiver grass buffer strips up to a depth of 15 cm (Samra, *et al.*, 1996.)

5. *Integrated Pest Management (IPM)*

To alleviate the potential adverse effects of pesticides, IWMP has officially adopted IPM as its operational guideline for Best Management Practices (BMP.) The essential element for IPM includes one or more management activities that are carried out by farmers. This results in the density of potential pest populations being maintained below levels at which they become destructive. This is done without endangering the productivity and profitability of the farming system as a whole, the health of the farm family and its livestock, and the quality of the adjacent and downstream environments.

Alternate Environment-Friendly Land-use Systems

1. *Agro-forestry*

In order to achieve efficient and environment-friendly utilization of resources, lands in marginal areas are brought under alternate land-use systems. Currently, agro-forestry has started attracting many farmers as these marginal lands have the capacity to support growing of suitable fodder, trees for fuel, grasses, and even timber species according to the needs of villagers and capabilities of soils. Keeping in view the land situations, different silvi-pastoral systems are developed by raising trees on the contour and planting grasses and legumes in the inter-row spacing. Recently, different fruit trees such as custard apple, pomegranate, guava, and mango have also been cultivated in an agro-horticultural system. These plants, besides having economic value, conserve soil and lessen erosion. Different combinations of crops, trees, and grasses are also being tried for optimizing the returns from alternate land-use systems for a specific watershed (Srivastava and Rao, 1989.)

2. *Crop Rotation*

In the upper reaches of watersheds, most of the area is rainfed except for a few pockets in valleys where small irrigation exists. The choice of crops for rotation completely depends on crops that require less volume of water. For rotation, legumes are important as a mixed crop. During the rotation, when rainy season erosion permits, crops such as cowpea are grown, forming an integral part of the mixed cropping system. As crops are chosen for nutritional purposes (e.g., protein-rich pulses as a part of cropping pattern,) there are chances of sheet erosion. Ideally, crop rotation is adopted in such a way that during peak runoff periods sowing of close growing crops provides protection to the soil.

3. *Grazing Lands and Aquaculture*

The traditional practice of keeping a maximum surface cover using grasses, shrubs, etc., is promoted in IWMP. Grazing is encouraged in rotation and is allowed only during certain times. It is avoided during the flowering and seed setting stages of grasses. Fodder shrubs and grasses planted as hedges along the contour of the land slow the runoff, weaken the erosive power of water, and cause it to deposit its load of valuable soil behind the hedgerows. Moreover, in the downstream water storage tanks and wetland paddy fields, integrated fish cultivation and/or aquaculture is often introduced as a component of IWMP for additional income-generating activity and also as a risk-aversion strategy.

INNOVATIVE APPROACHES IN IWMP FOR AUGMENTING ENVIRONMENTAL SUSTAINABILITY

Progressive adoption of above environment-friendly agricultural practices and the importance of watershed as a unit for integrated environmental resource management have been recognized in recent years. Management is now not merely of land, water, and biomass, but rather integrates self-reliance and holistic development of the rural poor. From an operational context, this would mean integrating:

(i) different uses and management of watershed resources; (ii) different departments with sectoral interest through interdisciplinary approaches; and (iii) poverty alleviation. Thus IWMP becomes more "anthropo-eco-centric" and community-based than just technology-oriented. This leads to empowerment and self-reliance of the farmers.

INSTITUTIONALIZING MULTIPLE DEPARTMENTS FOR SYNERGETIC IMPACTS

Since the preparation of overall plans for IWMP in the 1980s, the following four types of management committees are progressively established in order to take up various activities required to control the serious problem of eco-degradation in an integrated manner through a multidisciplinary force working under a single administrative authority. These include: National Watershed Council, State Watershed Committees, District Watershed Committee, and Watershed Associations.

The significance of IWMP has been an establishment of the Watershed Implementing Agency (WIA) in many states that acts as a co-coordinating unit at the project level. An existing lead department is selected for implementing watershed management progressively. In some States, the lead department is the Department of Forest, when more than 50 percent of the watershed area is under their jurisdiction. In other States it is the Department of Agriculture/Rural Development. The choice is kept flexible and practical. In each case, since the lead department dominates in the region in terms of land ownership, it would be expected that other departments fall in-line.

By having a unified line of command, under the Project Director of the WIA, IWMP gets its synergy from multidisciplinary field staff deputed from various line departments, namely; from minor irrigation, agriculture, soil conservation, social forestry, horticulture, livestock, and energy conservation for an interdisciplinary approach (Figure 1.) Continuous attempts to restructure the WIA to have better representation of beneficiaries offers innovation among the respective state governments and multilateral donor agencies towards community based IWMPs. This type of setup is expected to sustain and strengthen the inter-departmental coordination and become ready responsive to peoples needs.

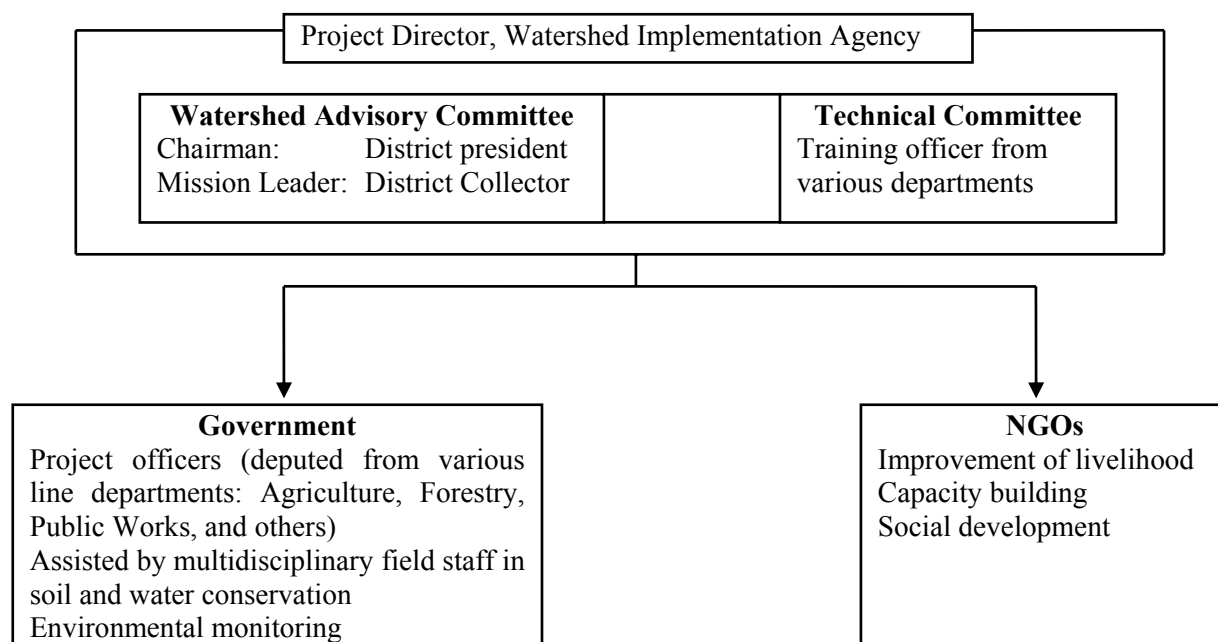


Figure 1. Multi Institutional, Interdisciplinary, Participatory Arrangement for IWMP

Community-based Participatory Approach for Sustainability

The community-based approach has been an important component in the new generation of IWMP. To ensure people's participation, Village Watershed Development Committees (VWDC) have been created to identify problems, prepare plans, implement them and maintain the created assets. The VWDCs are empowered to execute the activities under IWMP, resolve problems within the community

to fulfill their needs, and enable government to play a facilitator role. They usually consist of the multiple users' committee such as water users' committee, forest protection committee, fodder development committee, seed distribution committee, self-help groups, and social-cultural committee. They usually comprise a group of about five farmers elected or selected from each of the villages in a watershed. They are further linked in a network at district level and watershed level (Saravanan, 1998.)

These associations review the progress of the watershed project, assist in resolving management and administrative problems, guide in implementation, and identify policy issues, if any, for reference to State and national committees. Essentially, the watershed committees act as an executive body of the watershed association and carry out the activities of the watershed plan through paid employees. Under ideal conditions, the watershed association is the final decision-making body for any activity under watershed development programs.

Funding, Subsidies, and Incentives for Watershed Management Activities

Under the participatory approach of IWMP, the watershed community implements development activities within a selected watershed and funds for such activities are released directly to the community for execution of works. The IWMP is categorized into two major components: 1) the Development Component, to be executed through the watershed association; and 2) the Management Component, to be undertaken by the project implementing agency.

The development component consists of two sub-components, namely; natural resource management and production system management. The natural resource management sub-component includes management of private land, common land, and rainwater based on the scientific ridge-to-valley approach. The production system management sub-component includes on-farm production systems for land-owning families and household livelihood support systems for landless families.

The management component consists of three sub-components, namely; administration, community organization, and training. The sub-component of community organization includes activities not only related to organization of institutional set-up at the village level but also items such as entry point activities, infrastructure development, preparation of project proposal, adaptive research, etc. A typical allocation of funds for various categories of work under IWMP is presented in Table 2.

Table 2. Allocation of Funds by Components in An IWMP

Component	Fund Allocation (percent)
Management Component:	
Administration cost	10.0
Community organization	7.5
Training program	5.0
Development Component	
Natural resource management	50.0
Farm production system for land-owning families	20.0
Livelihood support system for landless families	7.5
Total	100.0

Source: Lakshmikanthamma, 1997.

In order to win the confidence of villagers, funds are provided in the IWMP allowing entry point activities to be decided in consultation with the community. In the second stage, villagers are involved in agro-eco-analysis during participatory rural appraisal (PRA) exercises. They are expected to contribute 10 percent of the cost of the project, which they generally do in the form of labor, collection of local materials, etc. Subsidies or incentives for activities which are not part of the traditional day-to-day farming activities or which represent a change from the traditional activities of farmers towards more environment-friendly practices are also included in the IWMP. A good example of this can be seen in the Katteri watershed where a series of ponds and check dams have helped to recharge their only source of water (Indo-German Bilateral Project [IGBP], 2001). The IWMP provides a maximum of US\$75/ha in lowland (defined as less than 8 percent slope) and about US\$125/ha in upland (more than 8 percent slope) areas for income-generating activities. For landless or very marginal farmers, the program

provides up to US\$25 per family for income-generating activities. For participation in activities like afforestation, US\$1 per plant (about US\$500/ha) is provided to beneficiaries in order to motivate them into adopting more environment-friendly practices (APO, 2002.)

REGIONAL EXPERIENCES FROM MODEL INTEGRATED WATERSHED MANAGEMENT PROGRAMS

Case 1: Katteri Watershed Project (1,750 ha), Ooty, Tamil Nadu, South India

(Development Partner: Germany-Gesellschaft für Technische Zusammenarbeit [GTZ], 1996-2000)

1. The Problem

- Large-scale deforestation, with severe effects in the ecosystem, climate and populations.
- Widespread soil erosion, overgrazing, and inappropriate land-use resulting in barren landscapes.
- Breakdown of self-sufficient autonomous lifestyles with forest clearance.
- Seasonal migration of men in search of employment.

2. The Solution

- Development of an integrated approach to the problems based on community needs.
- Soil and water conservation.
- Water harvesting.
- Protected afforestation on community land.
- Pasture improvement through planting pasture grasses.
- Distribution of subsidized fuel and energy-saving devices.
- Distribution of seedlings to encourage planting on private land.
- Integration of land-use innovations with measures to improve community livelihoods.
- Promotion of income-generating activities to reduce poverty and discourage seasonal migration.

3. The Project achievements

- Control of soil erosion.
- Substantial afforestation of 247 ha.
- Rehabilitation of degraded communal pastures, giving better yields and economic returns.
- Access to irrigation allowing double-cropping and increased cultivation of cash crops.
- Increased incomes from sales of vegetables, fodder grass, bamboo and eucalyptus poles.
- Increased water supplies from water harvesting and raised groundwater levels.
- More local income-generating possibilities reflected in greater prosperity and less migration.
- Improved environment including the regeneration of indigenous trees and grasses.
- Distribution of local fuel-efficient stoves, halving fuel requirements.

4. The Overall achievements

- A marked increase in groundwater recharge.
- Development of a very adoptable system for neighboring states.
- Ongoing community motivation to maintain and expand the improvement.
- Replication by private farmers in neighboring states.

Case 2: Fakot Watershed Project (1,200 ha), Dehradun, Uttar Pradesh

(Development Partner: Ford Foundation/World Bank, 1983-89)

1. The Problem

- Soil erosion resulting in a reduction of cultivable land and the abandonment of eroded areas.
- Low erratic rainfall averaging 460 mm per year with recurrent droughts.
- Infertile sandy soils with very low water retention and storage capacity.
- Lowered water table because of overexploitation.
- Low crop yields and frequent failure due to drought.
- Degraded communal grazing land due to overstocking.
- Acute scarcity of fodder and fuel wood.
- Seasonal migration of human and livestock populations.
- Change from mix cropping to single crop system.

2. The Solution

- Introducing the management of natural resources – soil, water, vegetation and animals for increased production through an integrated sustainable production system over the whole watershed.
- Field-testing of nationally developed dry land farming technologies.
- Increasing awareness among rural people to encourage participation in the new system.

3. The Project Achievements

- Land protection and increased agricultural production.
- Reclamation of 120 ha of wasteland through gully rehabilitation.
- Improved and sustainable source of fuel wood from shelter-belt pruning.
- Increased yields from intercropping drought-tolerant crops with fast-growing, multipurpose trees.
- Increased acreage (3-4 times) and double-cropping because of improved water harvesting.
- Improved dairy output resultant on increased fodder availability.
- Higher incomes through produce, sales, and employment opportunities – poverty alleviation.
- Improved vegetation cover and biodiversity.

4. The Overall Achievements

- A rise in groundwater level.
- Recognition of the value of the integrated management of natural resources widely recognized by government ministries with the consequent policy that dryland areas be based on watershed-based integrated management.
- Replication in neighboring watersheds and States of Rajasthan, Gujarat, Punjab and Haryana.
- Development of an instruction manual for other users.

CONCLUSION

The demand for food grains in India is estimated to grow to 265 mt by 2030 (ADB, 1997.) The primary task before the agriculture sector is fulfilling the food needs of the growing population. Agricultural production (2.5 percent) has kept ahead of population growth (2.1 percent) thereby maintaining a tenuous food security. However, such exploitation is likely to bring increased pressures on land productivity that eventually may result in accelerated degradation of environmental resources.

In the past two decades, the integrated watershed management approach has been a vehicle for achieving the twin objectives of enhancing production while simultaneously preserving the environmental resource base. The thrust in such an integrated approach is low-cost, location-specific conservation technologies that can provide opportunity for local innovations rather than capital and chemical intensive farming. Hence a new approach for IWMP has been formulated (Ministry of Agriculture, 2001) incorporating the strength of the earlier first generation projects. The restructured watershed programs provide flexibility in choice of technology with active involvement of local communities in planning, execution, and monitoring so as to make it sustainable. The main elements and the guiding principles of the new IWMP are: conservation of environmental resources; sustainable farming systems; due emphasis on production enhancement activities for land owners; livelihood support for landless families; mobilization of communities at village and watershed levels; and emphasis on 'Government Participation' in 'Community Plans'.

Nevertheless, government/donor support for watershed development projects is not infinite. Impact evaluation studies in different agro-ecological regions over the past two decades demonstrated increased and sustained land productivity until the local project implementing agencies were functioning. Though quality of agro-environmental resources were highly enhanced through IWMP, the watershed management activities were usually sustained effectively only for a period of 5-10 years and non-availability of appropriate strategy to upkeep the conservation infrastructures and eco-friendly production systems led to damages after withdrawal of support by the project implementing agencies. Hence, there is an urgent need to evolve suitable withdrawal strategies to maintain and sustain watershed management activities particularly after withdrawal of financial support. In IWMP, there is a whole range of stakeholders who are directly or indirectly involved in the sustainability of watersheds. Sustainability only results when all these stakeholders are motivated not only in managing the watersheds for income generation but also contributing to its environmental integrity with intergenerational equity in mind.

Swaminathan (1986) summarized the status quo in India, which is applicable to most of Asian countries in general:

“We now have technical capability to build enduring national food security based on sound environmental principles, but what we often lack is the requisite blend of political will, professional skill, and farmers’ participation. We live in this world as guests of green plants and of farmers who cultivate them. If farmers are helped to adopt more environment-friendly practices, agriculture will not go wrong. If agriculture goes right, everything else will have a chance for success.”

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7. SUSTAINABLE AGRICULTURAL PRACTICES AND FARMING SYSTEMS: COMPREHENSIVE UNDERSTANDING AND FUTURE DIRECTIONS

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INTRODUCTION

The demand for food, feed, fiber, and forests is increasing as world population continues to expand and is expected to double in the next 25-50 years. Despite billions of dollars that donor agencies have spent on world poverty reduction and food security, the United Nations estimates that there are still about 800 million persons every day going to bed hungry. To meet requirements for sufficient, safe, and nutritious food for these people poses a great threat to the environment. At the World Summit on the Environment in Rio de Janeiro in 1992, Agenda 21 declared:

“Major adjustments are needed in agricultural, environmental and macro-economic policy, at both national and international levels, in developed as well as developing countries, to create the conditions for sustainable agriculture and rural development. The major objective of sustainable agriculture and rural development is to increase food production in a sustainable way and enhance food security. This will involve education initiatives, utilization of economic incentives and the development of appropriate and new technologies, thus ensuring stable supplies of nutritionally adequate food, access to those supplies by vulnerable groups, and production for markets; employment and income generation to alleviate poverty; and natural resource management and environmental protection” (Agenda 21, 1992.)

Yet our conventional natural resources are on the decline:

- C Degrading soil resources, particularly in steep and sloping land agriculture. Soil erosion in both arid and humid tropical zones is largely the result of: (a) unavailability of appropriate farming systems to maintain soil fertility and productivity; and (b) overstocking of grazing animals. Deforestation in the Amazon and in other tropical regions of Latin America and Africa is closely linked with expansion of cattle ranching on open access land.
- C Growing concern in the industrialized countries for animal welfare and sanitation is a reaction to the stress caused by intensification of housing and management.
- C Consumer preference for “naturally” produced food can be partially interpreted as an expression of dissatisfaction with production systems which require excessive use of chemical additives such as antibiotics and hormones in animals and of chemicals in crop production.
- C Limited water resources due to reducing reserves and competing uses.
- C Reduced biodiversity (plants, crops, animals) as consequences of selfish common resource exploitation.

The poorer farmers in remote regions mainly have the natural resources to make their ends meet. This alarming trend prompted the United Nations to call the 2002 Earth Summit in Johannesburg devoted to sustainable agriculture. World experts in all specialized fields have discussed future directions for research and development in order to assist the poor to gain better livelihood while they

themselves act as guardians of their own environment. Future farmers should possess a basic understanding of sustainable development so that they can appropriately select and adopt farming systems that fit their environment. These farming systems result from the careful application of advanced approaches in integrated natural resource management (INRM.) It is imperative for every development expert to be able to participate in this mainstream activity in order to help design effective sustainable agricultural development programs addressing poverty reduction in a country.

In this document, we will be discussing:

- the concept of sustainability and the circumstances that lead to a new direction of sustainable agricultural development;
- activities on sustainable development: the appropriate technology movement, the Low External Input Sustainable Agriculture (LEISA) movement, and the Sustainable Agriculture Rural Development (SARD) program;
- a scientific approach that leads to sustainable farming systems: the INRM approach; and
- examples of proven farming systems that ensure sustainable agricultural development.

THE CONCEPT OF SUSTAINABILITY

Professor Yoshiaki Ishizuka, a famous Japanese plant physiologist, once said at a scientific meeting concerning environment protection, that in the western world, several hundred years ago people cut down their forests in order to have food and capital to invest in development. Now living in prosperity, they are conscious about the environment; they have replanted their forests and ask other people not to cut forests. Imagine how would a poor man choose to remain poor to safeguard the environment for the world? Thus we should find ways to help him richer while he conserves nature.

Attitudes and needs such as this have led to the concept of “sustainability” which was put forward in the early 1980s. The Asian Development Bank published a policy document to guide planners and the Bank’s staff taking into account the sustainable management aspects of all agricultural projects. The Technical Advisory Group (TAG) of the Food and Agriculture Organization (FAO) in 1988 formulated a set of criteria for the evaluation of sustainability. Later, in launching the campaign for the 1990 World Food Day, the FAO itself proposed its own definition for sustainability.

For development to be sustainable, it must integrate environmental stewardship, economic development, and the well-being of all people for generations to come. This is a challenge facing governments, NGOs, private enterprises, communities, and individuals (Conway and Barbier, 1990.) Francis (1990) made a global review of the concepts concerning sustainable agriculture in the temperate zones. Definitions of sustainable agriculture are generally concerned with the need for agricultural practices to be economically viable, to meet human needs for food, to be environmentally positive, and to be concerned with quality of life. Since these objectives can be achieved in a number of different ways, sustainable agriculture is not linked to any particular technological practice. Nor is sustainable agriculture the exclusive domain of organic farming. Rather, sustainable agriculture is thought of in terms of its adaptability and flexibility over time to respond to the demands for food and fiber (both high and low,) its demands on natural resources for production, and its ability to protect the soil and the resources. This goal requires an efficient use of technology in a manner conducive to sustainability.

Finally, because agriculture is affected by changes in market and resource decisions in other sectors and regions, it is important that these changes do not provide a rationale for depleting the local agricultural resource base (Wilson and Tyrczniewicz, 1995.) For the tropical ecosystems, particularly in the zones where rice production prevails, I think that the main elements of sustainability should include:

a. Conservation of Land, Water, and Plant and animal Genetic Resources

An acceptable technological change must maintain the long-term productivity of the land and at the same time must not pollute the water system of the area. A common mistake very often committed by irrigation projects is that while the new irrigation scheme helps increase crop production in one area, it creates polluted water harmful to the crops grown downstream. As new plant varieties or new high-yielding animal breeds are introduced, traditional ones tend to be overlooked and forgotten by most farmers, especially in regions having a complete water control facility. A diversified genetic background should always be maintained by carefully designed cropping patterns. To safeguard the farmer’s

production, when new varieties and breeds are introduced, try to use several ones at any time, so there would be no abrupt outbreak of any harmful pest.

b. *Environmentally Non-degrading*

The technological change will be in harmony with the environment where it is introduced. It should minimize the emission of carbon dioxide and methane gases into the atmosphere, the contamination of toxic chemicals into the land and water systems, etc.

c. *Technologically Appropriate*

The degree of sophistication of the technology should not surpass the capacity of absorption by the users in terms of educational level, physical infrastructures, financial status, etc.

d. *Economically Viable*

The introduced change should involve minimum financial risk to the users. Occasional failures would not offset per capita income dramatically, yet still enable farmers to start anew. In addition, it should create more employment, first within the household – particularly jobs for women – and the surrounding communities.

e. *Socially Acceptable*

The technological change usually should not be in conflict with the norms, belief, and customs of the users. It suits the manpower capacity of the household or the community.

The above concept fits quite well with many farmers' experiences derived from trial and error practices on various agro-ecosystems in Vietnam. They have been enjoying better livelihood and yet their environment remains very supportive. These sustainable farming systems seem to gain more ground as government policy tends to favor comparative advantage of each region.

SCIENTIFIC ACTIVITIES PERTAINING TO SUSTAINABLE AGRICULTURAL DEVELOPMENT

Sustainable development is a popular theme for hundreds of research projects conducted by scientists of various universities and research institutions. I shall present some typical results from the pioneers of this field:

The Alternative Technology Movement

It was initiated by a research project funded under the Economic and Social Research Council's Sustainable Technologies Program (<http://www.sustainabletechnologies.ac.uk/home.htm>). By looking at three examples in the UK (organic food, eco-housing, and wind energy schemes,) this project has been seeking to understand how experiments with alternative technologies come to have more widespread influence. The project, which is being carried out by Dr. Adrian Smith at Science and Technology Policy Research at the University of Sussex (SPRU) (<http://www.sussex.ac.uk/spru/environment/at>), aims to develop historical and conceptual insights on sustainable environment management that can be applied to policy.

1. *Local Organic Food*

There are over 100 community-supported agriculture initiatives and over 400 farmers markets in the UK. Is this a successful example of 'system building': creating a network that effectively connects the science of organic farming to local consumers?

2. *Low Impact Eco-housing*

A recent survey found 400 low impact eco-housing initiatives in the UK. Projects in this niche all use innovative, greener building techniques, and renewable resources to minimize impacts. How easily are such techniques transferred into larger-scale developments?

3. *Wind Energy Schemes*

The UK currently has around 950 wind turbines. The expansion of wind energy is set to accelerate after many years of slow growth, thanks to new policy initiatives. It is a niche activity that has a mix of commercial wind farms and smaller community turbines. Did the appropriate technology movement play a pioneering role in the early years?

Simultaneously, the Center for Alternative Technologies (CAT, founded by Gerard Morgan-Grenville in Britain, <http://www.cat.org.uk/>) was pioneering in the field of sustainable development. CAT is an environmental charity aiming to ‘inspire, inform, and enable’ people to live more sustainably. A solution-driven organization, offering practical solutions to environmental problems, CAT’s key areas of work since 1977 are renewable energy, environmental building, energy efficiency, organic growing and alternative sewage systems. Their services include a visitor center open seven days a week, practical and informative publications, a mail-order service of ‘green’ books and products, educational services for schools, consultancy for individuals and businesses, residential courses, membership, and a free information service. The role of CAT is to explore and demonstrate a wide range of alternatives, communicating to other people the options for them to achieve positive change in their own lives. This communication involves:

- C Inspiring: instilling the desire to change by practical example
- C Informing: feeding the desire to change by providing the most appropriate information
- C Enabling: providing effective and continuing support to put the change into practice.

CAT takes a holistic approach to its work, integrating ideas and practices relating to land use, shelter, energy conservation and use, diet and health, waste management, and recycling. Through its resident community and work organization, CAT is also committed to the implementation of cooperative principles and best achievable environmental practices. They demonstrate ways in which people, nature, and technology can live together successfully by working with, or living with, instead of conquering nature. This includes environment-friendly sewage systems, generators that obtain free power from the sun, rain, and wind, and chemical-free gardening.

The LEISA Movement

A group of European researchers in response to a concern that mainstream agricultural development in the early 1980s – particularly the Green Revolution – was bypassing the small and marginal farmers was formed. They feared the eroding of their small farmers’ livelihoods, affecting the environment adversely, and leading to widespread losses of agro-biodiversity.

In 1984 they founded ILEIA, a Center for Information on Low External Input and Sustainable Agriculture, and an independent organization with the mandate to contribute to poverty alleviation through the promotion of agro-ecological approaches. ILEIA started to identify promising technologies involving no or only marginal external inputs, but building on local knowledge and traditional technologies, where these still existed, and the involvement of the farmers themselves in development. This is called LEISA or ‘Low External Input Sustainable Agriculture’.

LEISA enables the creation of viable small-scale farming, which is a major part of rural livelihoods and thus contributes significantly to developing economies. LEISA is about finding technical and social options open to farmers who seek to improve productivity and income in an ecologically sound way. LEISA is about optimal use of local resources and natural processes and, if necessary, safe and efficient use of external inputs. It is about empowerment of farmers, both men and women, and communities, who endeavor to build their future on their own knowledge, skills, values, culture, and institutions. LEISA is also about participatory methodologies to strengthen the capacity of farmers and other actors, to improve their livelihoods, and adapt to changing needs and conditions. LEISA also seeks to influence policy formulation in a manner conducive to its further development. Information about these technologies was exchanged mainly through the *ILEIA Newsletter* (<http://www.ileia.org/>). ILEIA’s target groups include:

- a. field-level development workers working directly with farmers.
- b. academics and researchers in universities and national, (sub-)regional and international research and information centers on rural and agricultural development.
- c. policymakers of national governmental organizations, of private, voluntary organizations and NGOs and of bi- and multilateral donor organizations.

Some of the corner stones of LEISA are:

- **agro-ecology**: the knowledge base to apply ecological concepts and principles (for example, synergy, biodiversity, nutrient recycling, natural pest management, complementarity, and resilience) to the design and management of sustainable agro-ecosystems.
- **optimal and low-cost use of local and external resources**: making best use of available local resources and, if necessary, efficient use of modest amounts of modern external inputs.
- **indigenous knowledge**: the knowledge of farmers generated by their own and their ancestors' experiences combined with knowledge originating from elsewhere, which has been internalized. Indigenous knowledge is holistic and encompasses all aspects of rural life.
- **participatory learning, planning and action**: participation of development supporters in the farmers' development process to strengthen the latter and their own capacity to adapt agriculture to changing needs and conditions and towards sustainability.
- **social justice and cultural integrity**: economic development respecting cultural and social values of those segments of society that have little influence on economic and political decision-making. Special attention is given to specific gender issues, such as access to and control over information, resources, and production outputs.
- **stakeholder concerted action**: building platforms of consultation with the various stakeholders in sustainable agricultural development in order to share information, learn from experiences, and for joint action. Accountability of stakeholders for the development process, a prerequisite for the sustainable building of civil society, is thus enhanced.

The SARD program

Created by the FAO, SARD was initiated as a process which meets the following criteria:

- Ensures that the basic nutritional requirements of present and future generations, qualitatively and quantitatively, are met while providing a number of other agricultural products.
- Provides durable employment, sufficient income, and decent living and working conditions for all those engaged in agricultural production.
- Maintains and, where possible, enhances the productive capacity of the natural resource base as a whole and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the sociocultural attributes of rural communities, or causing contamination of the environment.
- Reduces the vulnerability of the agriculture sector to adverse natural and socioeconomic factors and other risks, and strengthens self-reliance.

(From FAO Trainer's Manual, Vol. 1, *"Sustainability Issues in agricultural and Rural Development Policies,"* 1995.)

1. *What is SARD?*

Agriculture and rural development are sustainable when they are ecologically sound, economically viable, socially just, culturally appropriate and humane, and based on a holistic scientific approach. SARD inherently addresses multiple sectors encompassing not just agriculture, but also water, energy, health and biodiversity. In the 10-years since Rio, when SARD Chapter 14 of Agenda 21 first outlined programs and actions to enhance food security in a sustainable way, the concept of SARD has evolved to include social, institutional, and economic sustainability, as well as environmental sustainability. This means that sustainable agriculture and rural development, including forestry and fisheries, must meet the nutritional requirements and other human needs of present and future generations, provide durable and decent employment, maintain and, where possible, enhance the productive and regenerative capacity of the natural resource base, reduce vulnerability, and strengthen self-reliance.

2. *What is the SARD Initiative?*

The SARD initiative is a multi-stakeholder umbrella framework designed to support the transition to people-centered sustainable agriculture and rural development and to strengthen participation in program and policy development. The Initiative helps to achieve SARD by supporting pilot efforts and building the capacity of rural communities, disadvantaged groups, and other stakeholders to improve access to resources (e.g., genetic, technological, land, water, markets and information,) promote good

practices for SARD, and foster fairer conditions of employment in agriculture. The initiative is expected to result in concrete and measurable improvements in the livelihoods and living conditions of the rural poor over the next five years, thus contributing to the implementation of Chapter 14 of Agenda 21 and achievement of the Millennium Declaration goals.

3. *Who is Involved in the Initiative?*

This is a civil society-led, government-supported and FAO-facilitated initiative. Some 55 organizations of farmers, indigenous peoples, workers and trade unions, women, youth, NGOs, the scientific and technological community, business and industry, interested consumer and media groups, along with governments and inter-governmental organizations have already voiced interest in and support for the initiative.

4. *Why do We Need an Initiative for SARD?*

Poverty, limited resources and political and social constraints have restricted the ability of rural people; in particular disadvantaged groups, to exchange and learn about, test, adapt, and replicate environmentally and socially appropriate approaches of sustainable agriculture and rural development. Disadvantaged groups, including small farmers/producers, agricultural workers, and indigenous peoples, are often unable to secure or improve their own livelihoods due to resource constraints or lack of influence over the policies, processes, and institutions that affect them such as in the context of globalization. Nevertheless, since Rio, significant progress has been made in the development of more equitable and effective policies, approaches, methods, and technologies for SARD, resulting in successful experiences in rural communities. This initiative offers all stakeholders, particularly governments, an opportunity to reinvest in rural development to promote more equal benefit-sharing, reduce poverty, enhance livelihoods, and promote sustainable development.

FAO is now implementing the SARD initiative after the 2002 WSSD (World Summit for Social Development) Johannesburg declaration. A valuable compilation of SARD cases around the world has been published in 2002 for the Johannesburg WSSD (Pretty, 2002.)

THE INTEGRATED NATURAL RESOURCE MANAGEMENT APPROACH

Using standards prescribed by the Technical Advisory Committee (TAC, 1995) of the FAO in classifying natural resource capital, most of our data thus far has firsthand assessment of the human and social capital required and expended. This has been accomplished through numerous socioeconomic surveys. Moreover, it has confirmed that although farm productivity did increase, generating more public goods for society, it was accomplished at the expense of farm income.

This can be illustrated by the cases of China and Vietnam where rice production has increased many fold making these two countries not only self-sufficient but also having rice surplus to export. Even as an exporter, the income of rice farmers is still way below the average of industrial workers. Indeed, the income of farming households is generally low and its most immediate consequence is rural poverty and hence food insecurity as pointed out at the 1997 World Food Summit. Thus, human and social capitals are being degraded.

In separate studies, researchers looked into the degradation aspect of other capital, namely; soil and water. Today's standard ongoing practices of farm productivity will eventually lead to a degradation of natural resources. Aside from being a consequence of a state of inadequate infrastructure, unfavorable marketing system, and insufficient farm credit, the prevailing low farm income in the rural areas of the Third World may be further attributed to:

- C low level of technological skills among the poor and remote farmers to apply technologies that are designed mostly for better-off farmers, or farmers who have access to irrigation and production capital; and hence,
- C inadequate knowledge on NRM.

As one unit of the entire complex resources system, the farm households are unable to give weight to each production enterprise to reach a total balance of the specific ecosystem they live in, particularly when their natural resources are fragile. In other words, *a farmer's inadequate technical level does not facilitate a sustainable integration of the appropriate technologies to suit their larger specific ecosystem.*

Furthermore *they can be confused by a single commodity or single enterprise approach* that most departmental sectors in most scientific organizations still prefer. From the above observations, we see that one of the better solutions to reverse the trend is to move beyond the farm household boundary and even beyond its farming system to follow a sustainable INRM approach with more emphasis on underutilized natural resources that are more easily available to poor farming households in poor rural areas.

The Consultative Group on International Agricultural Research (CGIAR), composed of 16 agricultural research centers around the globe, and the TAC have organized several reviews to set strategic guidelines to the CG centers in pursuing this INRM approach. The most comprehensive are two task forces led by Rabbinge (1995) and N'diritu (1995) and a major position paper in 1997 by TAC. The latter is a resulting analysis of two important reviews: *A Strategic Review of Natural Resources Management Research on Soil and Water* (SDR/TAC.IAR/96/9) and *A Synthesis of Current Activities in Soil and Water Research in the CGIAR* (SDR/TAC.IAR/96/10.)

The Rabbinge report recommended strongly a coordinated effort of research capacities at local, regional, national, and international levels. This would require a readjustment in the way most agricultural research institutions conduct research. It requires a departure from the traditional working mode of most institutions that is away from a self-contained, narrowly specialized disciplinary/departmental approach, towards one in which departments increasingly collaborate with each others on a peer basis and operate “without walls”. The scientific departments must recognize the specific characteristics of various eco-regions, or even eco-subregions, and tailor their research approach to take such differences into account. While it is reasonable for TAC to observe that all NRM research is location-specific, hence the CG centers should not concentrate on specific sites but instead concentrate on NRM studies that have international dimension. We believe that it will be difficult to find such general NRM situations.

To adopt a NRM approach in agricultural research using the best scientific tools for thorough site characterization in a typical site within a major agro-ecosystem will ensure good extrapolation of the developed technology to other sites. Given these fundamental challenges, this new approach to international agricultural research builds upon the results of the Green Revolution (i.e., does not reinvent the wheel,) targets the poorest of the poor and heterogeneous environments (because these are the most at risk of undernourishment and of resource depletion), and builds upon the roles which natural capital fulfills in agriculture in order to further increase productivity and, at the same time, ensure the longevity (or sustainability) of these increases.

Since the mid-1980s the CGIAR has had interest in productivity-increasing (conventional,) resource-conserving technologies. This direction was pushed strongly during the International Centers Week in 1995 with the following **three** important guidelines:

- a. To consider ‘natural resources’ as four major categories of capital (natural, physical [manmade,] human, and social.) They are substitutable over a wide range. Strategies should be designed to increase the total stock of capital.
- b. To center on people, particularly the poor, thus the balance of the research budget between high and low potential environments should be observed.
- c. To take care of the off-site effects of on-site practices. A watershed-based, integrated approach to NRM research is needed.

TAC reiterated the approach in its major position paper issued in June 1997 entitled “*Priorities and Strategies for Soil and Water Aspects of Natural Resources Management Research in the CGIAR.*” After thorough analysis of the ongoing research programs by the CG centers (through April 1996) examined against seven system-wide and 16 eco-regional proposals by TAC (October 1994,) and eight topics formulated by the Zschortau plan (September 1994,) TAC has recommended to the system to “develop improved mechanism(s) by which the Centers, collectively, can be involved with other partners in generating and interpreting improved scientific evidence on the extent and magnitude of the impacts of agriculture, forestry and fisheries, on the degradation or enhancement of natural resources and the impacts of such degradation or enhancement on agriculture, forestry and fisheries production and food security.” To do so the system will need an INRM framework for research, which calls for a broad spectrum of disciplines (water, soil, and genetic resources including plants, animals, and forestry.)

Although the CG centers have generated a wealth of data from various system-wide and eco-regional initiatives, networking or consortium activities, generally most centers – except for a few such as International Centre for Research in Agroforestry (ICRAF,) International Centre for Tropical Agriculture (CIAT) – still have looked more at the individual enterprises that form various components of a farming system within farm households and much less at the community level or at watershed level. Furthermore, most of the CG centers’ research so far has failed to recognize the importance of underutilized natural resources. Observations by the Rabbinge and N’diritu Report have pointed out the shortcoming of the CG centers:

- C The present focus of sustainability research appears too narrow;
- C Research problems are mostly scientist-driven, less demand-driven;
- C International public goods are mostly food crops, not cash crops or fruit trees;
- C The present structure and funding arrangements for the CGIAR are not well adapted to research on sustainability issues;
- C Present capacity in soil, water, and nutrient research, and in integrated pest management (IPM) research is still limited;
- C Research programs are fragmented;
- C With few exceptions, only weakly linked to National Agricultural Research System (NARS), Agriculture Research Organizations (AROs) and NGOs; and
- C Consortia establishment and implementation need improvement.

Box 1. An Example of a NRM Approach in a Poor Rural Setting

The overall philosophy is to demonstrate ways in which small changes in management of natural resources can improve the output of the system and/or lead to improvements in human welfare. In almost all farm households the installation of **bio-digestors** can be justified in terms of immediate impact and low cost. The digester is also a means of bring about other improvements such as growing of **duck weed** (*Lemna* spp.) which can be used to supplement the traditional diet of pigs, ducks and chickens. When linked with the household toilet, can be a means of fertilizing the **fish** pond without the contamination risk of the toilet discharging straight onto the pond. In a similar way the **multipurpose tree** (*Tricanthera gigantea*) (an indigenous tree from Latin America) can be grown in association with food crops such as bananas, with synergistic effects on the yield of bananas and the trees (which prefer to be grown in partial shade). The foliage from this tree can complement the traditional green vegetable (**sweet potato vines** and **water spinach**) used by farmers to supplement the typical rice bran/broken rice diet of their pigs and ducks.

Natural resource capital plays a key role in the process of agricultural intensification. Indeed, intensification can be defined as a process of deliberate simplification of natural ecosystems through a decrease of biological diversity in order to enable one species to become dominant and high yielding. This simplification is maintained over time by replacing various functions of renewable natural capital (e.g., nutrient cycling, biodiversity, water cycle) by manufactured capital (e.g., machinery) and non-renewable natural capital (e.g., petro-chemicals.) The long-term environmental costs of such a substitution are significant. It is therefore essential to take natural resource capital into consideration when developing sustainable agricultural intensification pathways in tropical countries.

An INRM approach will involve the following steps:

Step 1

Identify the extent (quantify whenever possible) of the resource degradation and rural poverty problems to be addressed. Place these problems into their relevant spatial and temporal scales and identify their driving forces. Predict their future trends and patterns. Involve the farmers and other local stakeholders from the beginning of the process. The research questions to be answered are:

1. what is the overall importance of the problem we are trying to address relative to other problems within our domain of expertise, mandate, or comparative advantage?
2. where in space and time does the problem occur, what is its relative magnitude, and if and where is it likely to become a problem over the planning horizon considered?

3. what are the foreseeable options/strategies/solutions (on offer by the CGIAR centers and partners) for solving the problem in the context of number 2?
4. what would be the expected relative efficiencies and net benefits (including potential “spin-offs”) should various options/strategies be implemented at specific places and at specific points in time?

These questions lead to an identification of priority research themes (including priorities for policy research), priority geographical areas for the work, and priority target groups of stakeholders for interventions. A team of biophysical and social scientists working in an interdisciplinary relationship does such work.

Depending upon the types of problems identified, more focus might be placed on step 2.

Step 2

Undertake research activities to enhance the food and raw materials production services of existing land-use systems through appropriate forms of natural resource capital. The questions to be addressed include: which crop/tree species; which animal or fish species; which cultural technique should be the focus of the work (and why); how should they be spatially organized through the farm, landscape, and region to assure the continuous improvement of the regulation of the externalities generated by these systems; and what are the prerequisites for successful adoption. This leads to the identification of a range of resource management options that would increase food production and farmers' incomes.

Those activities are led by interdisciplinary biophysical workgroups with a strong ecological dimension including social scientists, in particular policy specialists. They capture the indigenous knowledge on resource utilization, marketing issues related to new products, and policy research.

Step 3

Undertake research activities to assess trade-offs among the options arrived at in step 2. The objective is to optimize these trade-offs. This leads to the identification of options to be handled by various disciplines and centers.

Clearly, the implementation of the INRM approach necessitates the establishment of partnerships with concerned stakeholders (e.g., policymakers at different levels from the village to the international sphere) as well as new collaborative modes among the national and international research centers and NGOs. The emphasis is no longer on large-scale adoption of a single solution (i.e., an improved crop variety) by one category of stakeholders (farmers) but on ensuring that a given problem which occurs in a variety of environments is solved in a sustainable manner through the adoption of ranges of options by farmers, regional bodies (including NGOs), and policymakers at the national and international levels. In this approach, we can clearly distinguish a substantial shift in research paradigm:

<u>Old Paradigm</u>	<u>New Paradigm</u>
Centralized, top-down	Farmer-centered, participatory systems approach
Mono-disciplinary	Reduced and balanced/efficient input use
Input-intensive	Regenerative diversified farming
Maximization of food crop yields	Gender-sensitive focus
Disregard of gender	Networked partnerships of agencies with common
Isolated research and development agencies	interest

The success of the INRM approach depends on the degree of integration of inter-disciplinary sectors in rural development: consolidating several sources of development budget; combining extension effort; and providing credit to certified farming households. This is indeed an approach requiring holistic, participatory, gender- and farmer-sensitive perspectives and respect for indigenous knowledge and practices.

Let us take some examples in Vietnam to illustrate. After the de-collectivization of cooperatives in 1988, the farmers have been on their own in production. Most services provided to them by the former cooperatives were discontinued. They seemed to be free in choosing their destiny. However, top-down approach in extension work is still imposed by local leadership.

This has now brought about the failure of production or marketing of farm products in some areas. The latest example of this is sugarcane production. Many provinces have been competing in cane sugar production. They took soft loans in order to construct sugar mills in their province. Farmers were told to plant sugarcane as much as they could.

Suddenly, the central government allowed large importations of refined sugar. The price of imported sugar was cheaper than that produced locally, making the price of sugarcane cheaper than firewood. In the last quarter of 1995, many farmers cut down their sugarcane to be used as firewood.

Another example is the case of livestock raised in the central coastal region. Children handle herding of cattle and buffalo while their parents are busy fishing in the sea. A program of schooling for the children will mean a cessation of cattle production here. Thus rural development under Vietnamese situations needs a holistic view of the circumstances where farming households should be encouraged to participate in decision-making so that indigenous knowledge and practices may have an opportunity to play a major role.

Over the next 25 years, food security in developing countries will require systems that sustains the fertility of the land to support man, animal and crops. Thus various integrated crop-livestock-aquaculture farming systems need to be developed for each agro-ecosystem. In increasing farm income, we may consider the following system components:

- Perennial crops of high biomass-producing capability for transformation into food, feed and fuel, which helps to restore soil fertility and act as sinks for the greenhouse gases, carbon dioxide and methane.
- Multipurpose livestock, which recycle crop residues and by-products, produce cash income and fertilizer (manure), contribute to food and economic security, and provide employment for women and children.
- Technologies for on-farm fuel production using low-cost bio-digesters and gasifiers.

The crop component will be centered around the research on better rice varieties that can yield 12-15 mt/ha with a good eating quality and resistance to major insects and diseases. As we are expanding rice production into problem soil areas, rice varietal improvement will be focused on acid, drought, and P deficiency tolerance. As much as possible, the taste of these rice cultivars should be acceptable to the local people. In rainfed rice-farming systems, more attention will be given to crop stand establishment and efficient integrated nutrient management using direct seeding as a main technology.

The livestock component will be concentrated on new breeds of animal, either local or improved breeds. It is noted that when farmer's capital investment is small, local breeds will be most likely appropriate. Improved breeds will need higher investments. Also, within this component, improved feed usage from farm by-products in order to feed the livestock should be studied extensively to keep the cycle of the system as closed as possible.

Organic fertilizers will play an important role in healthy food production. These fertilizers, both from animal and plant sources, should be studied and transferred to farmers in order to reduce the amount of chemical fertilizer used.

The fish component of these farming systems will be developed. Attention should be given to the improvement of local breeds of fish, their cultural techniques, and processing.

Technology for minimizing postharvest losses of crops will be developed and successfully accepted by farmers.

1. Important Linkage Among the Market, Credit, Input Supply and Extension and Training Systems

A comprehensive INRM approach should be as holistic as possible. It should combine or coordinate the activities of various actors particularly the credit component, input supply, and extension and training systems. When analyzing the data from PRA (Participatory Rural Appraisal) surveys, resource management guidelines (RMG) should be formulated. This then calls for appropriate technologies to be applied.

The farmer must have some credit to implement the technologies and simultaneously he must have some guidance, through some kind of training by an extension agent, in order to be able to use the technologies properly. Of course, the RMG should be arrived at only after a careful consideration for the

marketing of the farm outputs. It is most preferable when farmers stand together in some form of organization to increase their bargaining power against the market.

2. Policies in Support of the Requirements of INRM for SARD

At the present time, the sectors that play major roles in INRM are operating separately in Vietnam. The Vietnam Agricultural Bank has their own agenda and their own clientele being the richer farmers who have collateral and can borrow money. Most Vietnamese farmers have no collateral and need money, but alas, cannot borrow. The extension programs are working solely as technology transfer programs without any assurance of farmers adopting the technology since they may not have the capital or input into the process of adoption. Therefore, it is time that a national policy for linking research-extension-credit should be approved by the government.

ILLUSTRATIONS OF SUSTAINABLE FARMING SYSTEMS

Sustainability in the Mekong Delta

1. Rice-Freshwater Prawn (*Macro brachium rosenbergii*) Systems

They were established mostly in low-lying areas of the Mekong Delta. Freshwater prawns were raised in the rice fields simultaneously. On the surrounding dike, fruit trees and cash crops were planted. Livestock was raised on the dike, also. Income from rice was reduced, but those from shrimp, fruits, cash crops, and livestock increased remarkably. Results showed that the optimum land use for rice-freshwater prawn system was from 60 to 70 percent of total area reserved for rice field, 15 to 20 percent for trenches, and 15 to 20 percent for dikes. Maximum return above variable cost (RAVC) was US\$7,900/ha/season.

2. Rice-Fish Farming Systems

These systems have been practiced at various sites in the Mekong Delta using the most common species: common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*), silver barb (*Puntius gonionotus*), rohu (*Labeo rohita*), and Nile tilapia (*Oreochromis niloticus*) in the rice fields.

The total farm household income from practicing rice-fish systems could reach US\$1,428/ha compared to US\$800 for double-cropping rice. Income from rice alone seems to be the same while those from fish, fruits, and other crops increased significantly. Integration of fish into rice fields can make better use of farm resources, thus increasing farm income.

In general, when introducing fish or shrimp to the rice field, the net farm income increased as compared to rice monoculture. They also help keep clean the environment by reducing application of chemicals in the rice field in combination with the IPM practices.

3. Livestock-Fish Farming System

Experiments with stocking density of 7 fish/m² is applied with Nile tilapia (*Oreochromis niloticus*) occupying from 41 to 60 percent of the water area. The rest are silver carp (*Hypophthalmichthys molitrix*), rohu (*Labeo rohita*), common carp (*Cyprinus carpio*), silver barb (*Puntius gonionotus*), and catfish (*Pangasius micronemus*). All the fish are fed on pig excreta and waste feed which is washed out daily into the ponds. After 300 days, the fish yield 14.2-15.8 mt/ha, of which marketable size are 283, 225, and 1,340 g for Nile tilapia, silver barb, and catfish. Silver carp, common carp, and rohu have the size of 353, 373, and 366 g. Total pig production is 1,673 to 2,493 kg after 10 months of raising.

Sustainability in the Red River Delta

1. Testing Various Cropping Patterns in the Intensive Cultivation Areas

Evaluation of the economic profitability of the intensive rice-farming households in the Red River Delta showed that rice monoculture does not bring sufficient income to families. Farmers practicing diversification received higher incomes. Potato, soybean, and vegetables tested to replace maize in the winter crop season showed higher gross returns.

2. Diversification of Agricultural Production in the Red River Depression

The rice-fish systems give higher economic profitability in areas where the main season rice is unreliable. Pigs are the main component of livestock production in this area. Introducing fruit crops such

as longan, orange, and apricot have been successful, especially on the base of the hills. This model will be extended in the following years.

3. Rice-Fish Farming Systems in the Deepwater Area of the Red River Delta

The majority of the total of 55,000 ha low-lying lands in the Red River Delta have not been amended yet. Rice production is still unstable, and farmers' living standards remain very low. Experiments comparing the rice yield of the two dominant systems; rice-rice and rice-fish systems showed that the main wet season rice-fish system can give an income equivalent to 1,654 kg paddy/ha. Application of inorganic fertilizer to the main wet season rice crop can be considerably reduced. In addition, the rice fields can absorb the surplus of water if heavy rains occur. It is estimated that one ha reserved for fish culture can yield 10 mt of fish, which is equivalent to 40 mt of rice.

Sustainability in the Rainfed Lowland Rice Farming Systems

For the sake of stabilizing the natural environment across land units, irrigation systems need to stop where additional extraction of freshwater from rivers or the ground may endanger the downstream areas. Hence, rainfed farming continues to dominate large rice regions in the world.

Rainfed agriculture exists from the hillside to the plain. Rainfed lowland rice farming is a practice of rice growing with impounded water in the field for part of the growth cycle. Traditionally, water is collected early in the cropping season to facilitate land preparation before transplanting. Traditional farmers have utilized such wetland preparation, called puddling, for centuries. But since no one can predict precisely at what day and with what volume rains will bring, puddling is not the optimum way to establish a rice stand in the rainfed areas.

Drought damage to transplanted seedlings is a very common problem in Asia. Studies showed that dryland cultivation followed by direct dry seeding (DDS) reduced the risk of drought damage. Using very short duration modern variety (MV) rice, DDS technique enables an extra rice crop per year even under total rainfed conditions. In order to switch to a more successful DDS-based rainfed lowland farming system, it is essential that the following factors be perfected:

- a. Technique of early plowing in preparation of the dry fallow period: This operation is a "must," particularly with heavy clay soils. Delayed plowing can be permitted for soils high in organic matter. To many farming communities, early plowing is considered abnormal, but once farmers realize its value, they will switch.
- b. Regenerating soil granulated structure before DDS: Appropriate machinery is needed for heavy clay soils. Less sophisticated machinery is required for soils high in organic matter. The degree of granulation has to be studied in order to determine the machinery requirement.
- c. Preventing early flooding of DDS fields: Early rainwater is good for flushing away toxic substances accumulated on the soil surface during the dry fallow. Impounding water in the field may submerge the young seedlings.
- d. Management of the sown seeds: Appropriate means to cover the dry seeds helps protect the seeds from bird and rat damage.
- e. Weed control for DDS: This is one of the major constraints to the quick adoption of DDS.
- f. Fertilization of DDS remains an important research issue for rain fed agriculture: How to minimize losses of nutrients and optimize yield will depend on the timing of fertilizer application and the kind of fertilizer materials.
- g. What crops other than rice can be planted by DDS during the early part of the rainy season?: And what crops can be planted after harvesting the main rice crop, provided some way of on-farm ponding to conserve rainwater can be applied.

Sustainability in the Upland Rice-based Farming Systems

The uplands remain a great national concern due to: (a) equity for the least privileged part of the population; and (b) the disappearance of natural and well-protected watersheds. In many Asian countries, infrastructure (roads, bridges, schools, hospitals, communications, etc.) is neglected by governments due to inadequate funds. Therefore food security is a real issue for the upland people. Likewise, products from the uplands cannot get to the market easily. Therefore, the rainfed upland farming system must see rice as a small component of the whole agro-ecosystem, which requires in the first place measures/

technology for conserving land, and stabilize food and other crop production. The following are constant issues regarding sustainable upland development:

- a. Appropriate sloping land technology.
- b. Contour line and erosion protection measures: by hedgerows of what leguminous species, or by rock walls?
- c. What improved upland rice varieties are to be used that have the taste characteristics preferred by the local community?
- d. What sequence of crop rotation?
- e. What is the most appropriate animal component that can be integrated into the farming system?
- f. What measures can be taken to conserve part of the rainfall for use in irrigation for dry season crop production?

Sustainability in the Northern Mountainous Highlands

1. Screening Upland Crops and Leguminous Species for the Northern Mountainous Highlands

- ★ Rice varieties: San Hoa, Lun 32, and Namkhang are three rice varieties selected and suitable to this area. They give a higher yield (from 40 to 70 percent) as compared to the local rice varieties.
- ★ Bean varieties: There are six soybean varieties (AK03, AK04, AK05, DT92, V74 and VN1), one ground nut (V79) and one mung bean (044) that performed well in both research sites as mentioned above.
- ★ Maize varieties: The Q2, CV1, LS6, LS8, DK888, and DK222 maize varieties are suitable to local conditions and give a higher yield compared to the local check.
- ★ Root crop varieties: There are sweet potatoes (V15-70,) cassava (KM-60,) and taro (*khoai tau baccan*) selected to cultivate on unfertile soil conditions.
- ★ Leguminous species: From many leguminous species tested, the *Thephrosia candida* (cot khi,) *Flemingia macrophylla*, and ipil-ipil (*Leucaena* sp.) are suitable to the local conditions. *Thephrosia candida* is the best species to improve soil fertility and to prevent soil erosion through the SALT model in this region.

2. Farming Systems on the Unfertile Hilly Soil

This area is poor in terms of natural resources and economic activities, in spite of an abundance of labor. Using Rapid Rural Appraisal (RRA) and cessionaries methods on 96 farm households, it was shown that the average farm size is only 692 m². Average income per capita is less than US\$88 per year of which 56 percent comes from crop production, 37 percent from animal production and 7 percent for other activities. Food for family consumption was lacking from 2-3 months per year.

In the rice field, the three main farming systems consisted of: (1) spring and seasonal rice; (2) mung bean-early seasonal rice-winter sweet potato; and (3) spring groundnut-early seasonal rice-winter sweet potato. Due to the low yield of local varieties, the RAVC of each of these systems was very low ranging from US\$100 to \$140 per ha per year.

In the homestead and garden, livestock production was not developed and fish ponds were not used efficiently. The wild trees in home garden did not give much cash value.

A study of technology components showed that three improved rice varieties, two newly introduced soybean varieties, one groundnut variety, and one sweet potato variety resulted in significantly higher yields than the commonly used local varieties. Introduction of these varieties in the main farming systems resulted in a considerable increase of RAVC compared to the local varieties. The spring soybean (AK04 variety,) early seasonal rice (Sanhoa/Lun32 variety,) and winter sweet potato (V15-70 variety) gave the best system-variety combination in terms of MBCR (marginal benefit to cost ratio.) Additionally, the dapog seedbed method with seedlings of 20-22 days old in spring season and with 12-15 days old in summer season was used to replace the traditional seeding method. As a result, the new cropping pattern establishment is more suitable to the local condition.

After improving the cropping patterns, the RAVC increased rapidly to more than US\$400 per ha per year. In addition to improving food security, the farm household still had surplus income for improving livestock production. Integrating an egg-type breed of duck (Khaki Campbell) to the system, farm households further gained up to a total of US\$70 per flock consisting of 10-12 ducks. The low-

lying part of the farm was converted into fish ponds. Roho, common carp, grass carp and silver carp were fed with by-products from crops and manure from livestock.

Fruit trees are also important for household income. However, the average horticulture land per family of about 2,000-3,000 m² was usually left fallow or being used on a very low scale. Fruit trees such as apple, lemon, orange, and apricot were introduced to the research site and results showed that after three years, the farm household could get the first harvest. This will surely further improve family income in the future.

In conclusion, after three years of applying the farming systems research and extension approach, we were able to help the cooperating farm households double their gross income from US\$400 in 1992 to US\$800 in 1994 while the ecosystem balance seems to be stable.

Sustainability in the Central Highlands

Application of Some Variations of SALT Model in the Ethnic Farmers' Slash-and-Burn Areas

Farmers in an on-farm research to test the SALT model were chosen to participate in a local study. They were all slash-and-burn farmers and had farms with sloping lands ranging from 2 to 20°. Annual incomes in the SALT tests reached an average of VND (Vietnamese dong) 1.6 million. More importantly, soil erosion was significantly reduced. Several varieties of upland rice, corn, and mung bean were grown in conjunction with *Tephrosia*. Several adaptations were made to different SALT models based upon local growing conditions.

Sustainability in the Deepwater and Tidal Zones

1. The Deepwater Rice (DWR) Farming Systems for DWR Areas

In regions where water depth is greater than 100 cm, floating rice used to dominate. Virtually all floating rice areas in Vietnam have now been transformed into double-cropping with short duration MV rice allowing a flood fallow in between. Another large part of the rainfed areas in Asia is under 50-cm depth during the height of the rainy season. Rice growing is still the main occupation of the farmers here. Traditionally, single and double transplanting of long duration rice varieties are used. The ingenuity of some DWR farmers shows that DDS with very early MV rice can also be applied in these areas during the early rainy season followed by transplanted traditional 2-month-old rice seedlings. Some farmers found growing rice in a shallow drainage system to be a method of increasing rice yield by three or four times the normal (natural) methods. The integration of an upland crop during the early rainy season, or of fish or shrimp into the rice system, has been proven an environmentally sound and economically advantageous method. However, the sustainability of the systems is questionable due to the following main factors:

- a. Higher yielding (greater than 5 mt/ha) rice varieties with tall stature are not yet available;
- b. Fertilization of DWR, especially in the shallow drainage system, needs an in-depth study on its efficiency;
- c. Integrated pest control methods need further study for deep-water areas;
- d. Production of shrimp fries as feed for the rice shrimp system is difficult; and
- e. Production of shrimp feed using locally available materials is also difficult.

2. Tidal Rice Farming Systems

The coastal land of Asia is flooded daily at a depth from 30 cm to 4 m depending upon tidal movement. In these areas, wetland rice can be transplanted but only during the rainy season when there is a source of freshwater. The rice-shrimp system was accidentally found by one farmer and then spread widely.

- a. Saline tolerant, short duration, tall stature MV rice varieties are much needed.
- b. With appropriate seeds, direct wet seeding should be experimented with to reduce labor costs for production and management of seed sowing.
- c. Production of shrimp fries (as above.)

Illustrations from the works of the Vietnam Farming Systems Network indicate that it is possible to improve farmer's income while the tidal zone is restored to a safe state:

Rice-saline shrimp farming systems: The combination with traditional rice in the wet season in coastal areas where tiger prawn (*Penaeus monodon*) and banana prawn (*Penaeus merguensis*) are

raised in saline and brackish water in the dry season is feasible. The results show that the high value shrimp can increase farm income substantially. The net income from these integrated farming systems was very high due to high income from natural tiger shrimp culture. However, the constraints to rice production were the use of low-yielding and brown planthopper (BPH) susceptible traditional rice varieties.

Agro-forestry and agro-forestry-fish/brackish water shrimp systems: The reports show that on saline or salino-acidic soils, the woody plants *Melaleuca leucadendron* and *Rhizophora* spp. grow very well. Local fish like snakehead (*Channa striata*), snakeskin gourami (*Trichogaster pectoralis*), and walking catfish (*Clarias* sp.) are harvested after the flooding period and give additional income to farmers. The brackish water shrimp, *P. merguensis*, can grow well in *Rhizophora* mangroves and can be harvested every fortnight with the moon cycle. Reforestation can be done with the recovery of some natural species while farm resources are utilized in better ways.

3. **The Degraded Sandy Coastal Areas**

The Vietnam Farming Systems Network research in coastal sandy zones has shown encouraging progress.

Integrated farming systems in the coastal sandy area: A system of peanut/chili and rice are planted on poor sandy coastal soils. High peanut yields of 2.9-3.0 mt/ha are obtained with proper application of P_2O_5 . Rice yield increased from 3.0 to 4.2 mt/ha when super-phosphate doses were increased from 200 to 400 kg/ha. Macro-elements positively influenced growth and yield of chili. Integration with pig (local breed Mong cai) in the system readily increased income further as well as providing more organic manure for the light soils. Farm income improved when there was some investment for raising shrimp in the system.

Also, on coastal sandy ridges, the farming systems integrating forestry (pine, acacia, eucalyptus) with fruit trees (guava, jujube, sapodilla, banana) and upland crops (cassava, sweet potato, chili, vegetables) resulted in an increase of farmers' income by not only providing extra goods to market but, more importantly, providing cover to conserve soil moisture and check erosion.

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1. INDIA

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INTRODUCTION

Agriculture is the main sector of development in many countries of Asia and the Pacific region. Looking at its broader sense, agriculture includes all land-based and biomass-producing activities such as cropping, animal husbandry, grasslands, forestry, horticulture, and fisheries. With only 2 percent of the world's land (329 million ha) and 4 percent of its freshwater resources, India sustains 16 percent of the world's human population and 18 percent of its cattle population. Agriculture is the dominant land use and the mainstay of Indian economy. At around 24 percent, agriculture and allied activities continue to be the single largest contributor to India's GDP and also employ nearly two-thirds of the country's workforce.

India has made much progress in agriculture since independence in terms of growth in output, yields and area under various crops. It has gone through a Green Revolution, a White Revolution, a Yellow Revolution, and a Blue Revolution. The net cultivated area has stabilized at around 143 million ha of land and accounts for 47 percent of the reported area of the country. Around 84 percent of the country's total water consumption is accounted for by agriculture. Only one-third of the cultivated land is under irrigation, which accounts for 55 percent of total food grain production. The other two-thirds of the cropped area, comprising primarily of the arid, semiarid, and the drought-prone areas, contributes to only 45 percent of the production.

The annual production of food grains has jumped from 51 million mt in the early 1950s to 130 million mt in late 1980s. Furthermore, India's production has reached 210 million mt in 2000. Agricultural growth has always had a perceptible impact on food security and poverty alleviation. Therefore, agriculture is and will continue to be central to all strategies for planned economic development of the country.

In India, different ministries deal with agricultural issues. These are mainly the Ministry of Agriculture, the Ministry of Food Processing Industries, Ministry of Chemicals and Fertilizers, and Ministry of Water Resources. The Ministry of Agriculture comprises three departments: Department of Agriculture and Cooperation (responsible for land management, food grain production, horticulture and agro-forestry,) Department of Animal Husbandry and Dairying (responsible for promotion of animal husbandry, dairying, poultry, aquaculture and fisheries) and the Indian Council of Agricultural Research (ICAR) (responsible for agricultural research and education.)

THE GREEN REVOLUTION AND ITS ENVIRONMENTAL FALLOUTS

Intensive mechanization, high irrigation, improved high-yielding varieties, inorganic fertilizers, and agrochemicals fueled the Green Revolution of the 1970s. This strategy has, however, encountered various economic and environmental problems.

- C **Intensification of agriculture** has created problems of water-logging, salinity, decreasing water table, and diminishing soil fertility, etc. Productivity of food grains has accordingly shown a stagnation or decline.
- C **Costs of production** are rising as returns to the application of fertilizers and agrochemicals are diminishing, sometimes sharply.
- C **Water supplies** for agriculture are declining in many key production areas as water tables are dropping and as competing demands for domestic and industrial uses grow.

- C **Human and environmental health** is being compromised by the use of pesticides and fertilizers that can cause illness and groundwater pollution.

In the post-Green Revolution period, the thrust of Indian agriculture is on the enhancement of agricultural productivity through sustainable practices and technologies.

CONCERNS FOR SUSTAINABLE AGRICULTURE AND THE NATIONAL AGRICULTURAL POLICY

Sustainable agriculture will provide the answer to our food security problems in the context of globalization and liberalization of our economy. Development of key sectors such as water, energy, health, agriculture and biodiversity on a sustained basis has been well highlighted in the World Summit on Sustainable Development (WSSD) held at Johannesburg in 2002. The plan of implementation adopted by WSSD fully incorporates issues of environmental security and sustainability of agricultural production.

The Ministry of Environment and Forests (MOEF) of the Indian Government conducted a review of the Agenda 21 on the eve of WSSD, Johannesburg. This included the review of sustainable development programs and policies of the agriculture sector. The findings indicated that India is well on its way towards the path of sustainability. However, an integrated vision to facilitate inter-ministerial coordination and the mechanisms to involve voluntary organizations and the private sector in developmental efforts could perhaps accelerate the process of sustainable development.

The National Agriculture Policy of India (2000) aims at promoting technically sound, economically viable, environmentally non-degrading, and socially acceptable use of the country's natural resources – land, water, and genetic endowment – to promote sustainable development in agriculture. It seeks to actualize the fast untapped growth potential of Indian agriculture, strengthen rural infrastructure to support faster agricultural development, promote value addition, accelerate the growth of agro-business, create employment in rural areas, discourage migration to urban areas, and face the challenges arising out of economic liberalization.

PROGRAMS/SCHEMES PROMOTING ENVIRONMENTAL SUSTAINABILITY

The Ministry of Agriculture has been implementing various resource conservation programs and schemes to promote efficient utilization of water, land, nutrients and pesticides for sustainable food production in the country. These programs will be discussed under four broad headings:

- C Land Management
- C Water Management
- C Plant Management
- C Management for Adaptation to Climate Change.

Land Management

India ranks very high among the developing countries in respect of both the extent and severity of land degradation. The National Commission on Agriculture (1976) reported that out of the total geographical area of 329 million ha, 173.6 million ha (52.8 percent) are affected by different kinds and varying degrees of degradation. Per capita arable land in India is declining rapidly, as shown in Table 1, due to demographic pressure, soil degradation, urbanization, erosion and conversion into non-agricultural land use.

Table 1. Per Capita Land Availability by Year; Actual and Projections

Year	Per Capita Availability (ha)
1990	0.195
2000	0.163
2025	0.121*
2025	0.087*

Note: * Projected.

The Ministry of Agriculture has formulated a National Land Use Policy Outline to ensure intensive utilization of land, create widespread productive employment, and reduce disparity. Land Resources Management Policy is identified as a primary focus area of the Ministry of Agriculture. The existing land-use policy outline is being revised in consultation with all stakeholders to strengthen elements of dynamic land use, environmental sustainability, and equity.

1. Remote Sensing and GIS (Geographical Information system)-based Natural Resource Mapping

Remote sensing is playing an important role in regular forest cover assessments, mapping of wastelands, land-use planning, mapping of coastal regulation zones, environmental impact assessments, groundwater prospects zone mapping and detection and monitoring of natural disasters. The Ministry of Agriculture's two premier organizations, All India Soil and Land Use Survey and National Bureau of Soil Survey and Land Use Planning, have been providing detailed scientific database to user agencies on soil and land characteristics using remote sensing techniques and GIS. A scheme for GIS-based Natural Resource Mapping, proposed to cover an area of 290 million ha of the country in a "Mission Mode," has been conceptualized in consultation with the Department of Space and related ministries.

The MOEF has formulated a National Action Plan for Desertification Control under the United Nations Convention to Combat Desertification (UNCCD.) Soil and land degradation mapping constitute an important activity of this plan.

2. Promotion of Resource Conserving Technologies (RCTs)

– Experiences in the Rice-Wheat Systems

RCTs, such as zero-tillage, surface seeding, bed planting, and the associated agronomic practices are being increasingly used in rice-wheat systems of the Indo-Gangetic belt. These help in timely farming operations and save on inputs like water and fertilizers, improve soil health, and bring significant environmental benefits. The zero-tillage also helps to reduce the burning of crop residues and therefore improve air quality and reduce greenhouse gas emissions.

A major bottleneck in large-scale adoption of RCTs is due to the mindset of the stakeholders and the age-old practice of excessive tillage for establishment of rice and wheat. The shift to RCTs requires a reorientation and training of farmers and extension workers. The Ministry of Agriculture provides for demonstration of zero-till seed-cum-fertilizer drill in farmers' fields and makes available these equipments to the farmers on subsidy basis.

3. Reclamation of Alkali Soils

It is estimated that about 7.0 million ha land is affected by salt in the country out of which 3.6 million ha suffers from alkalinity. A centrally-sponsored scheme of reclamation of alkali soils is being implemented in 11 States of the country. Major components of the scheme are soil amendments, drainage and crop management, and diversification through horticulture and agro-forestry. An area of 0.6 million ha has been reclaimed so far and brought under productive use. Under this scheme, farmers were given subsidy on soil amendment to the extent of 75 percent during the Ninth Five-Year Plan. In the 10th Five-Year Plan, the subsidy has been reduced to 25 percent. Farmers are finding it difficult to afford the cost of soil amendment without the higher subsidy.

Water Management

As stated earlier, agriculture is the single largest user of water in India. Increasing dependence on water for irrigation depletes aquifers and watercourses and inefficient use of irrigation water puts pressure on other users and imposes environmental costs. Present level of water availability is comfortable. Future projections as indicated in Table 2 show a grim scenario.

Table 2. Per Capita Availability of Water; Actual and Projections

Year	Per Capita Availability (m ³)
2000	2,100 (comfortable)
2025	1,700 (stress level)
2050	1,236 (scarcity level)

This macro statistic conceals the highly uneven spatial and temporal nature of water resource distribution in the country. Over 90 percent of the runoff in Indian rivers occurs in the four monsoon months of the year. Regions of harmful abundance coexist with areas of acute scarcity. Since water

resources are finite and demand from the various sectoral users is rapidly increasing, prudent management of water resources are required to overcome the inefficiencies that currently plague the water sector. For efficient use of water, India is implementing one of the largest watershed development programs in the world.

1. Watershed Development of Degraded Lands for Sustaining Productivity

The agriculture sector has to produce more food with less water or “more crop for every drop.” The Government of India has accorded a high priority to the holistic and sustainable development of rainfed areas through integrated watershed development. This has emerged as an effective approach in augmenting water supply through conservation of rainwater in dry and arid (rainfed) farming systems. This is also taking into account various kinds of land use based on crops, horticulture, agro-forestry, silvi-pasture, forests, and livestock development as well as alternate income-generation opportunities for the landless and near-landless.

The farming systems approach adopted in integrated watershed projects addresses multifarious objectives such as increased drinking water supply and improvement in food, fodder, fuel and fiber. The key attributes of watershed development are *in-situ* conservation of water and optimization of soil and water resources in a sustainable and cost-effective mode.

Various central ministries/departments, institutions, state governments, banks (like National Bank for Agriculture and Rural Development [NABARD],) NGOs, watershed associations, water user associations, Joint Forest Management (JFM) committees, self-help groups, corporate, and private sectors are implementing land-based programs. Together, these all help to develop the wastelands of the country. Some 28 M ha of degraded lands have been treated so far under the integrated watershed approach. In view of the multiplicity of watershed development programs being implemented by various ministries, areas of convergence and commonalities in this approach have been identified and common guidelines followed for treatment of watersheds. Major watershed development schemes/programs are as below:

Ministry of Agriculture:

- i. National Watershed Development Project in Rainfed Areas (NWDPR)
- ii. Soil conservation for enhancing productivity of degraded lands in the catchments of River Valley Projects and Flood-prone Rivers (RVP and FPR)
- iii. Watershed Development Project in shifting cultivation areas
- iv. Watershed Development Fund of NABARD
- v. Internationally-aided Watershed Projects.

Ministry of Rural Development:

- i. Integrated Wastelands Development Program
- ii. Drought-prone Area Program
- iii. Desert Development Program
- iv. Grant in aid to NGOs/voluntary organizations.

Ministry of Environment and Forests:

- i. National Aforestation Program
- ii. Grant in aid to NGOs/voluntary organizations.

2. Impact Assessment of Watershed Programs

Impact assessment studies conducted in treated watersheds have revealed that there has been: (1) recharge of groundwater aquifers as evidenced by increase in water tables and rise in number of wells; (2) reduction in soil erosion; (3) increase in cropping intensity; (4) change in cropping pattern; (5) enhancement of crop productivity; (6) increase in household income; (7) reduction in rural urban migration; and (8) rise in overall biomass in the watershed.

3. From “Jhumming” (slash-and-burn) to Settled Agriculture:

Watershed Development of Shifting Cultivation Areas

Shifting cultivation, regarded as the first step in transition from food gathering and hunting to food production, is a primitive practice of cultivation. Some 2.28 million ha of land in the country, mostly in northeastern States, is affected by this problem. The Ministry of Agriculture is implementing a watershed development project in shifting cultivation areas with the objectives of protecting the hill slopes of *jhum* areas by introducing appropriate land use practices and improved technologies as per land capability and to improve the socioeconomic status of *jhumia* families through household/

land-based activities. This will hopefully encourage them to opt for settled agriculture. If successful, it is proposed to extend to other States like Orissa, Andhra Pradesh and Chattisgarh.

Plant Management

There are three main cropping seasons in India, namely; *kharif*, *rabi* and summer. Major *kharif* crops are rice, jowar, bajra, maize, cotton, sugarcane, soybean, and groundnut. Major *rabi* crops are wheat, barley, gram, linseed, rapeseed, and mustard. Rice, maize, and groundnut are grown in summer season also. The growth under agriculture and allied sector was estimated at 5.7 percent during 2001-02, which is attributed to a rise in food grains produced to 211.32 million mt compared to 195.92 million mt achieved during 2000-01.

Since no single discipline can address the entire gamut of issues related to food security, a holistic-farming systems approach is needed. The Ministry of Agriculture implements various crops production schemes duly supported by inputs like high-yielding varieties, fertilizers, pesticides, subsidies, minimum support prices, credit, insurance cover, technology, and extension support to achieve best possible results.

1. Management of Nutrients

In the Green Revolution era, doubling of cereal production required a quadrupling in N fertilizer application. Further increases in production will require even larger increases in fertilizer use, with comparable increases needed in the application of pesticides and other agrochemicals. Overuse of fertilizers and insecticides have serious implications for long-term soil productivity, environment, and human health. The Indian Government has taken several measures to promote balanced use of nutrients.

2. National Project on Development and Use of Bio-fertilizers

The importance of bio-fertilizers in sustainable agriculture is now well established. The Ministry of Agriculture is implementing a National Project on Development and Use of Bio-fertilizers to promote cheaper and eco-friendly plant nutrient supplements. The main components of the scheme are providing financial assistance to agro-industries, farmers, cooperatives, and the public sector for fertilizer undertakings; NGOs for production and distribution of bio-fertilizers (e.g., *Rhizobium*, *Azotobacter*, *Azospirillum*, Phosphate-solubilizing microorganisms, etc.); and field demonstrations, farmers' fairs, training, and extension. So far some 122 production units of bio-fertilizers have been established with an estimated production of 10,000 mt per year.

3. National Project on Organic Farming

The concept of organic farming is gaining importance world over for developing an eco-friendly organic agriculture. The Ministry of Agriculture is in the process of launching a national project on organic farming. Main components of the scheme are setting up a National Institute of Organic Farming, financial support to commercial production units (of fruits and vegetables, waste compost units, bio-fertilizers and vermi-culture units, etc.), capacity building, field demonstrations, and putting in place a system of certification of organic produce prescribing national standards of organic farming.

4. Balanced and Integrated Use of Fertilizers

This scheme is being implemented with the objective of promoting balanced use of fertilizers along with conjunctive use of organic manures, compost, and green manures. Main components of the scheme are providing financial support to municipal bodies for establishment of mechanized compost plants, strengthening/setting up of soil testing laboratories and training and awareness.

5. Systems of Rice Intensification (SRI)

The SRI, developed in Madagascar, is now being tried in a growing number of countries like Indonesia, Sri Lanka, Philippines, and China. This system is reported to have raised average rice yields to twice the present world average without relying on new seeds or chemical inputs. Mainly changing certain plant, soil, water, and nutrient management practices that have prevailed for centuries does this. Contrary to popular thinking, rice is not an aquatic plant. Thus using only half as much water per season can significantly increase the yields. Current trials in India at Tamil Nadu Agricultural University are reported to be confirming water use reductions in rice cultivation of up to over 50 percent. SRI is being examined in the National Research System of ICAR before recommending to farmers.

6. Food Security through Diversification

Agricultural growth with diversification is the stated policy of the Government of India. A bold initiative has been taken to launch a regionally differentiated strategy for promotion of crops, oilseeds, millets, cotton, horticulture, agro-forestry, vegetables, and animal husbandry. The diversification

strategy takes into account the agronomic, climatic, and environmental conditions to realize the full potential of growth in every region and to narrow down regional and crop imbalances and thus ensure food and nutritional security.

7. *Diversification through Horticulture*

A technology mission has been launched for the Integrated Development of Horticulture in the Northeastern region of the country. The program will establish effective linkages between research, production, extension, postharvest management, processing, marketing, and exports bringing about a rapid development of agriculture in the region.

With the increasing thrust for horticulture and vegetable programs, the Ministry has given priority to precision farming for efficient utilization of scarce water. Under the Centrally-sponsored Scheme on Use of Plastics in Agriculture, the government provides assistance to farmers for drip/micro irrigation in horticultural crops.

8. *On-farm Water Management for Increasing Crop Production*

This program seeks to augment the exploitation of ground/surface water and efficient utilization of water for increasing crop productivity in the eastern region. Under this scheme assistance is provided for following activities:

- i. Construction of shallow tube-wells with pumping sets to individuals/group farmers;
- ii. Community lift irrigation points to a group of farmers;
- iii. Electricity/diesel water pumping sets to individual farmers; and
- iv. Dug wells in the plateau region.

9. *Promotion of Forestry and Agro-forestry*

The social, economic, and ecological contributions of forest/tree cover are well recognized. Recorded forest area of the country is 76.8 million ha. The State of Forest Report (2003,) through its remote sensing studies, indicates that India has 67.55 million ha (20.55 percent) forest cover, of which dense forest is 41.68 million ha (12.68 percent) and open forest is 25.87 million ha (7.87 percent.) India's National Forest Policy of 1988 seeks to achieve 33 percent forest/tree cover in the country within a time bound frame.

Our government is making all efforts to regenerate the degraded forests on the watershed basis through the JFM program, which is a major policy shift towards a participatory and less centralized management of forests. 72,711 JFM committees involving 4,641,000 families are currently managing some 16.66 million ha of forests in 27 States on usufruct sharing basis.

Greening India Task Force Report of the Planning Commission seeks to bring 28 million ha under agro-forestry over a period of 10 years through active involvement of farmers, NGOs, private sector, and institutions. The government is providing financial, technological, institutional, legal, and extension support to achieve this target. Use of quality planting material raised through improved nursery techniques, tissue culture, and clonal propagation is emphasized in the plantation programs.

Carbon sequestration potential of soil organic carbon, agro-forestry, energy plantations, and resource conservation technologies are being currently examined to seek possible funding support from the developed countries under the Clean Development Mechanism (CDM) of the Kyoto Protocol. The Planning Commission of India is in the process of formulating guidelines for operationalization of the CDM. This includes market-based mechanisms for carbon sequestration projects under the Land Use, Land Use Change and Forestry (LULUCF.)

10. *Drought Management*

Droughts, which have been frequent in different parts of India throughout history, have been responsible for many famines, rural poverty and migration despite the development of irrigation potentials. The Ministry of Agriculture has been implementing "Drought Management Strategies" for combating the adverse impacts of drought under varying agro-ecological conditions. The concepts like deficit irrigation/supplemental irrigation, efficient utilization of harvested water, zero-tillage and furrow irrigated raised bed planting are being popularized under the Integrated Watershed Management Approach.

In drought-declared States, farmers are given relief through financial assistance under the Calamity Relief Fund, National Calamity Contingency Fund and Food for Work Program. Other steps taken to mitigate drought include free transportation of fodder and drinking water by rail, allocation of cattle grade feed, assistance for drinking water supply, and provision of mid-day meals for school children.

A Task Force under the Chairmanship of the Deputy Prime Minister deals with policy issues and allocation of food grains for relief employment. The Task Force ensures close coordination with the Indian Meteorological Department, Planning Commission, Ministries of Finance, Railways, Water Resources, Rural Development, Drinking Water Supply, Land Resources, Women and Child Development, Animal Husbandry and Dairying, and Food and Public Distribution.

11. *Increasing Application of Biotechnology*

There is currently much optimism that various innovations achieved through crop biotechnology will contribute to enhancing inbuilt resistance to pests and diseases and developing cultivars that require less water. Thus they will be more drought-tolerant and require less agrochemical protection with potentially more nutritional value. But, it is not certain that these technologies will be widely applicable (in technical terms) or widely accessible to the farmers given their high cost.

In policy terms, it will be prudent to seek whatever gains are possible through biotechnology. At the same time, it is advisable to examine other options relying not too heavily on biotechnology as its indiscriminate application could have serious environmental implications. India is at a preliminary stage in the introduction of agricultural biotechnology. The Genetically Modified (GM) seeds are not to be introduced without adequate studies of their impact on health, environment, and livelihoods of people, especially the farmers and the long-term social and economic impact. The Genetic Engineering Approval Committee (GEAC) of the MOEF considers such introduction proposals. The Indian Government has given a selective clearance to BT cotton. Its performance is being assessed. Introduction of GM mustard has been deferred till more studies are conducted about its impact on human health and environment.

12. *Biological Control through Integrated Pest Management (IPM)*

Plant protection is essential for increasing productivity and production of various crops. Indiscriminate and overuse of pesticides for control of insects, pests, and diseases have adverse affects on environment and human health. IPM, which includes the use of bio-pesticides, bio-control agents, pheromones, resistant crop varieties, and adoption of cultural and mechanical methods, is being promoted in the country through a network of 26 central IPM centers. The State Departments of Agriculture and Horticulture, agriculture universities, and *Krishi Vigyan Kendras* (KVKs) are also promoting IPM through farmers' field schools. IPM has helped to reduce the consumption of pesticides from 61 million mt during 1994-95 to 43 million mt during 2000-01.

Management of Agricultural Practices for adaptation to Climate Change

The Inter-governmental Panel on Climate Change (IPCC,) jointly established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP,) in its Third Assessment Report (2001) has projected that global average surface temperature may increase by 1.4-5.8°C from 1990 to 2100. The IPCC Report specifically considers agriculture as highly vulnerable to impacts of climate change in the South Asian region.

There is considerable uncertainty in the magnitude of global warming and its impact on agricultural production. The specific effect of global warming on Indian agriculture would depend upon the actual change in temperature and other climatic features together with adaptation and mitigation strategies.

Ministry of Agriculture has been adopting various resource conservation programs and schemes to promote efficient utilization of water, land, nutrients and pesticides for sustainable farm development in the country. These practices and technologies help in mitigation and adaptation to climate change.

Some studies conducted by the ICAR have indicated that the direct effects of climate change on Indian crop production would be small in the short run provided pests could be controlled. In the long run, however, the production of different crops may be seriously effected depending upon the season, level of management, and the magnitude of climate change. ICAR is in the process of launching a Network Project for comprehensive understanding of impacts of climate change and adaptation on soils, agriculture, horticulture, forestry, agro-forestry, livestock, and fisheries.

CONSTRAINTS IN EXPANDING ENVIRONMENT-FRIENDLY PRACTICES AND TECHNOLOGIES

Despite good successes in implementation of some selected environment-friendly practices and technologies, their extent, coverage, and distribution of benefits remain a matter of concern. There are

technical, economic, social, and political factors responsible for success or otherwise of such programs and policies. Major constraints in their widespread application are lack of awareness and resources (particularly with the small and marginal farmers), inadequate public research and extension system, inadequate arrangements of coordination, lack of convergence of technologies and inputs, inadequate opportunities for capacity building, indifferent or inadequate mechanisms of monitoring and evaluation, equity and gender implications in sharing the benefits of interventions, and, above all, the natural tendency of farmers to look at short-term production rather than long-term conservation priorities.

The constraints referred to above could best be explained through the experiences gained in managing watershed development programs in India, which have evolved through various stages. The first generation projects and programs were highly centralized with sole emphasis on technical aspects implemented primarily through public functionaries. Scant regard was given to local technologies and practices with little or any involvement of the watershed community except as passive recipients. Such an approach suffered from major constraints in terms of sustainability of the project. It was clear that watershed management is as much organizational and social as it is technical. The second-generation projects were redesigned with community participation as the central theme, together with major decentralization of procedures and emphasis on local technologies. While the restructured second-generation projects are resolving the sustainability concerns to a large extent, they have begun to throw up a host of other policy, institutional, and technology issues related to efficient management of water and its demand.

Resource mobilization is a major challenge in implementing the programs and policies. It may be seen that despite the impressive success of watershed programs in India, only 28 million ha, constituting one-third of the total rainfed area, has been treated so far with a total investment of over Rs.100.1 billion (about US\$2,000 million.) It is proposed to address 88 million ha by 2022. This will require a mobilization of some US\$15,000 million and simultaneously a massive awareness generation and capacity building effort.

POLICY SUPPORT AND REFORMS TO ACCELERATE IMPLEMENTATION OF BETTER PRACTICES

The National Agriculture Policy of India has all the necessary ingredients to support sustainable food grain production. Consistent with the policy, the management regimes are being strengthened through various measures like regular interface between the research and extension set-up of the agriculture sector, constant interaction with the State governments through *kharif* (post summer) and *rabi* (winter) conferences, or through theme-based interactions with State governments. These help ensure decentralization of program implementation, putting in place participatory planning and implementation, enhance coordination and convergence of inputs and technologies, and, above all, lead to reforms in public extension systems to achieve the desired convergence.

The Ministry of Agriculture took a bold step in the year 2000 to decentralize agricultural planning, fund allocation, and program implementation. This was through a macro-management mode to operationalize the regionally differentiated strategies and to ensure that limited allocations to this sector find timely and effective application in the intended areas. This new arrangement has evolved by integrating 27 centrally-sponsored schemes and provides flexibility to States to develop and pursue activities on the basis of their regional priorities, including new interventions in the local work plans.

Public research and extension played a major role in bringing about the Green Revolution. The changing economic scenario in the post-green era and the need for appropriate agricultural technology has posed new challenges to the government system of extension. The Ministry of Agriculture has undertaken massive reforms in extension by making use of information technology and development of supporting infrastructure. The new extension system is more innovative, decentralized, participatory, demand-driven, farmer accountable, and ensures public-private partnerships.

It is also increasingly aimed to bring convergence of information technology, biotechnology, remote sensing applications, pre-/postharvest technology, trade and marketing, energy saving and environment-friendly technologies for sustainable farm production. These “drivers” of globalization and economic liberalization duly supported by adequate resource mobilization, capacity building and proper addressal of issues of equity, gender, and ethics will help India take a big leap towards sustainable agriculture in the 21st century.

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2. REPUBLIC OF KOREA

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INTRODUCTION

In the Republic of Korea during the last three decades, the first Green Revolution has been successful in meeting the growing demand for food. The rate of increase in food supply, domestic or imported, has generally exceeded the rate of consumption. Consequently, food production policy has been shifted from a maximum input and output basis to an environment-friendly one with various programs to enhance environmental sustainability.

Korea has limited resources for agriculture, especially in terms of land. A large portion of the land is mountainous. The cultivated land area is estimated at 1.8 million ha with 3.6 million people producing food on that area for the total population of 47.6 million. Rice as the staple food is one of the most important agricultural products. Vegetables, fruits, livestock products, and some specialty crops for spices and medicinal purposes follow. Rice farming systems are highly developed and mechanized. However, labor and fuel expenses are the major direct expenses in rice production while land services are the major indirect expense.

In this paper, the prevailing agricultural practices are closely observed with a particular interest in the uses of inorganic fertilizers and agricultural chemicals for pest and weed control, increased farmers' interest in certified organic food production, and farmers' motives in conversion from conventional agricultural practices to certified organic food production. The features and the major problems of a few organic farming practices adopted by Korean farmers are discussed.

PREVAILING AGRICULTURAL PRACTICES AND ENVIRONMENTAL IMPACT

In Korea, rice farming is the focal point in food production systems and it is highly mechanized. Over 90 percent of paddy rice is machine-transplanted. Major direct rice production expenses are labor, farm machinery, inorganic fertilizers, and agricultural chemicals. Major indirect expenses for rice production are land services. Therefore, labor-saving farming practices are of great importance. Prevailing agricultural practices depend on inorganic fertilizers and fertilizer consumption has been steadily increasing in the last three decades. However, in the last few years there has been a decrease.

Farmers are dependent on agricultural chemicals for pest and weed control. Due to concerns on environmental pollution and food safety, consumers are keen on purchasing labeled/certified organic foods even at higher prices. The demand for organic food has increased, but for the time being, the market share of organic food is still only about 3 percent (Table 1.)

Table 1. Changes in Farm Households Engaged in Organic Farming

	1999	2000	2001	2002
Number of households (000)	14	19	27	31
Area (000 ha)	10	15	25	28
Production (000 mt)	209	305	526	594

As can be seen from the information, certified organic food production has steadily increased during the past four years.

There are four categories in the certified organic food system (Table 2.) Organic food is food produced only by organic manure. By regulation, farms producing labeled organic food were reclassified as certified organic food producers.

Table 2. Number of Farm Households Engaged in Organic Farming and Certified Organic Farm Households, 31 December 2002

	No. of Farm Households Engaging Organic Farming	Certified Organic Farm Households	Total
Organic food	225	810	1,035
Organic food in conversion process	31	619	650
No-chemical organic food	2,353	4,172	6,525
Low-chemical organic food	16,805	6,327	23,132
Total	19,414 (61.9)	11,928 (38.1)	31,342 (100.0)

Note: Figures in parentheses are percent.

There are various farming practices carried out under the name of environment-friendly agriculture in Korea. The figures on the most common four practices are shown in Table 3 with specific features of each agricultural practice following.

Table 3. Number of Households Engaged in Various Environment-Friendly Rice Farming Practices, 31 July 2002

	Rice-Duck	Rice-Snail	Rice-Chitosan	Rice-Rice Bran	Others	Total
No. of household engaged	4,149	2,894	4,035	893	3,450	15,421
Land area (ha)	2,948	1,937	2,917	561	2,714	11,077
(percent)	(26.6)	(17.5)	(26.3)	(5.1)	(24.5)	(100.0)

1. *Rice-Duck Farming*

“Aigamo” ducklings, 1-2 weeks old, are introduced into transplanted rice paddy in expectation of multiple roles: weeding, manure addition, plowing, snail control, and creating habitat for water fauna and flora. Major problems of this system are the labor- and capital-intensive needs for erecting fences and feeding ducks with extra off-farm feeds. Also, environment-sustainability is not yet proven.

2. *Rice-Snail Farming*

Golden apple snail (*Ponacea* spp.) is introduced into transplanted rice paddy as a weed predator. However, there is a concern about rice seedling damage by the overwintering snail. The golden apple snail has been documented to devour direct-seeded young rice seedlings in the southern part of Korea. In actual, snails are serious pests in rice in tropical zones and are considered illegal to introduce in most areas.

3. *Rice-Chitosan Farming*

Chitin and Chitosan have an inherent property of being environment-friendly and easily degradable. Chitin and Chitosan are used in the industrial, agricultural, medical, and pharmaceutical sector. In the agriculture sector, they are used as a growth enhancer for plants and meat-yielding livestock.

4. *Rice-Rice Bran Farming*

Rice bran is rich in antioxidants, minerals, essential fatty acids, amino acids, phyto-nutrients, and antioxidant lipoic acid. Lipoic acid is known as an active metabolic antioxidant. The effect of rice bran on environmental sustainability is that less chemicals are applied to the soil. In turn, this reduces chemical runoff into natural waterways consequently reducing pollution and environmental damage. When effective microorganisms (EM) are introduced into an environment and given the right conditions, they can continue to proliferate. The runoff has been reported to improve the flora and fauna of environments downstream from rice bran treated area.

5. Others

There are several other environment-friendly agricultural practices used for crop production in Korea. The materials for the practices are shown in Table 4.

Table 4. Materials Used for Environment-Friendly Farming Practices

Functional for	Purchased	Farmhouse-Self-supplied
Pesticide	Brown rice vinegar, oak vinegar, cytosine	Plant extracts Medicinal plant extracts Tobacco extracts
Fertilizer	Mineral A Mineral C Milk	Biodegradable municipal waste Green grass juice Micro-organic products Enzymes, amino acid
Others	Water-soluble phosphoric acid Wood charcoal powder Peat moss Alcoholic vinegar	Lactic bacteria Crab extract Seawater

FEATURES OF PREVAILING AGRICULTURAL PRACTICES

The common prevailing features of modern Korean agricultural practices are: (1) intensive tillage; (2) monoculture; (3) manipulation of plant genomes; (4) reduced dependence on chemical pest and weed control but enhanced dependence on off-farm resources; (5) lessened concern on water use efficiency; (6) increased labor and capital requirement; and (7) misuse of terms (e.g., control versus management.) Once these features are widely recognized and accepted, we can then begin to follow general principles for the conversion process to environment-friendly agricultural practices. In the conversion, every effort should be given to the recycling of nutrients, use of renewable resources, elimination of environment toxins, use of natural inputs, biological management of pests, as well as biological management of the environment and biota in order to conserve resources and improve health.

POLICIES AND MEASURES FOR OVERCOMING PROBLEMS AND OBSTACLES TO ENVIRONMENT-FRIENDLY AGRICULTURE

In the beginning of converting from current practices to more environment-friendly ones, policy should start at increasing input efficiency and reducing the use of costly external resources or environmentally damaging inputs. The next step would be to substitute conventional inputs and practices with alternative practices and redesign agro-ecosystems to function on the basis of a new set of ecological principles. At the end of conversion, the evaluation, criteria for sustainability and environment-friendly would be based on the principles of sound agro-ecology.

The principles suggested by Stephen R. Gliessman are a useful tool in evaluation of sustainable farming practices (<http://www.principles@agroecology.org>). The common keywords to be included in sustainable farming practices, according to Gliessman, are: biological nitrogen fixation; renewable sources of energy; naturally occurring materials; on-farm resources; recycling of on-farm nutrients; organic matter stocks; no-till or reduced tillage methods; mulching; dry farm management; energy efficient technology; reduced expenditures; pest management; disease management; weed management; beneficial biota; mycorrhizae; *Rhizobia*; free living nitrogen fixers; and diversity.

FUTURE APPROACHES TOWARDS MORE SUSTAINABLE AGRICULTURAL PRACTICES

Soil is a complex living ecosystem comprising innumerable microorganisms that enable plants to take up nutrients essential for their growth and help defend them against diseases and insects. These beneficial microorganisms include *Rhizobium* bacteria that convert atmospheric nitrogen into ammonium for use by plants, mycorrhizal fungi that help plants take up phosphorus and other nutrients, and many microbial pathogens that attack insect pests. Soil ecologists are just beginning to understand

some of the complex interactions between soil microorganisms that enable nutrients to be retained and recycled. These processes are essential to above ground ecosystems.

In Korea for the last two decades, we have investigated the nature of soil, particularly in paddy rice-based farming systems. Based on past experiences, we suggest the following three rice-based farming systems as promising more sustainable agriculture in the future. The basic knowledge behind the systems is briefly described here.

No-till, Direct-seeded Rice-Vetch Cropping System

The socioeconomic situation in rural areas is serious labor shortages and declining income of the farm household. As described previously, the major direct expenses for rice farming are labor and farm machinery. This is one reason to suggest no-till, direct-seeded rice cropping systems as an innovative farming practice. In the system, the soil biota in undisturbed paddy soil can be fully exploited.

Legumes are included in this system to make use of the abundant atmospheric nitrogen. Fixation of atmospheric nitrogen by microbial activity in the rooting zone of the legume yields a form of nitrogen available to the higher plants and overall farming system.

Among the legumes used for this system, Chinese milk vetch (*Astragalus sinicus*) lasts longer than others in paddy conditions. Once it is established, the vegetation can be maintained permanently unless the legume vegetation is removed before seed formation. The need of seed maturity in the legume crop necessitates a slight delay in rice planting under this system.

No-till, Direct-seeded Rice-Green Manure Cropping System

Grass cover crops are higher in carbon-to-nitrogen ratios (C:N) than legume cover crops. The high carbon content of grasses means that they will break down more slowly than legumes resulting in longer-lasting residue. As grasses mature, C:N increases. This brings up two considerations. First, the residue higher in carbon is harder for soil microbes to break down, thus making the decomposing process longer. Secondly, the nutrients contained in the cover crop residue usually are less available to the subsequent crop due to rapid decomposition.

Grass cover crops can produce a large amount of residue/biomass, which contributes to their ability to prevent erosion and suppress weeds while they are growing or when left on the soil surface as mulch. Grasses contain some nitrogen in their plant tissue, but grass cover crops generally are not considered significant sources of N for the cropping systems. They do, however, help keep excess soil N from leaching and prevent the loss of soil organic matter through erosion.

Management of grasses in the cropping system may involve balancing the amount of residue produced with the possibility of tying up N for more than one season. Mixtures of grass and legume cover crops can alleviate the N-immobilization affect, produce as much or more dry matter as a pure grass stand, and may provide better erosion control due to the differences in growth habit.

A No-till Direct-seeded Rice-Wheat/Barley Cropping System

In Korea, food self-sufficiency is less than 30 percent and has become a priority policy. High rice yield in the past was made possible due to plant breeding and heavy application of nitrogen fertilizers. The heavy nitrogen applied, however, is not efficiently utilized and a large part of the nitrogen fertilizer is lost and/or penetrates deeply into soil. Consequently this can cause water pollution (Mengel, *et al.*, 1980.)

Wheat is becoming more important in Korea but the major amount of wheat for consumption is still imported. Therefore, a strategy to increase wheat production is necessary. Domestic wheat production has almost come to an end because of the severe shortage of labor in rural areas, high production cost, and low grain quality. Fortunately, a new planting device has been invented and can be easily mounted on a rice combine. Thus the jobs of rice harvesting and wheat sowing can be done simultaneously. This enables farmers to produce rice and wheat with no additional energy consumption.

The main constraint for direct-seeded rice-wheat/barley cropping systems is poor seedling establishment primarily due to the lack of tolerance to low O₂ stress in flooded soil by the wheat/barley seedlings. Dryland farming works in this situation. For more information regarding dryland farming in the no-till, direct-seeded rice-wheat cropping system under paddy conditions, see <http://www.taepyeong.co.kr>. The details on this system are also well documented at <http://www.kasa.re.kr>.

CONCLUSION

In Korea, the Green Revolution was a partial solution to increase food supply but failed to maintain environmental sustainability. Now we need another “Greening” revolution.

In conclusion, it should be noted that the prevailing agricultural practices in Korea are: (1) not fully based on the principles of agro-ecology; (2) more dependent of external and off-farm resources; (3) more labor- and capital-intensive; (4) lacking in concern to long-term benefits; and (5) lacking in concerns of whole system management.

Let us be challenged from the Bible, the word of God, to obtain a new concept in building up more sustainable agricultural practices. First Timothy 4:4 says, “Since everything God created is good, we should not reject any of it. We may receive it gladly, with thankful hearts”.

“Weeds are only plants, of which we do not know their virtue. Roots of the weed sucked first life from the genesis of the earth and hold the essence of it still. Always the weed returns; but the cultured plant retreats before it.” (Beryl Markham, *West with the Night*, 1942.)

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3. LAO PDR

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INTRODUCTION

The People's Democratic Republic of Laos (Lao PDR) is located in Indochina, South-East Asia, and has an abundance of natural resources. The land area of Lao PDR is 236,800 km² with 80 percent of the country covered in mountains and hills. Rice is the primary staple crop of the Lao people and the country is self-sufficient in rice production.

Lao PDR is still rich in natural forest cover. In the 1940s, 70 percent of the land was covered with forest. Today, the forest cover has been reduced to 47 percent of the total area of the country. The main causes are shifting cultivation, uncontrolled burning, and inappropriate forest management. The current population of Lao PDR is 5.5 million and there are three main ethnic clusters: Lao Loum, Lao Theung and Lao Soung.

Eighty percent of Lao PDR's population rely on nature and natural farming systems for their livelihood. They are generally grouped according to the different ecosystems of the country. The Lao Loum live in the lowland plateau along river ways and their main occupation is the production of paddy field rice. The Lao Theung live in the hot temperature, midland remote areas, mostly located in sloping lands. Their main occupation is practicing shifting cultivation. The Lao Soung are located in the highlands (mountainous areas) which are very remote and their main occupation is also the practice of shifting cultivation.

DEFINITION OF SHIFTING CULTIVATION

Shifting cultivation, as seen by the Lao PDR Government, is a traditional farming system practiced for centuries by Lao farmers. It is generally viewed as a somewhat backward, ancient system that fails to use modern science and technologies for production. Slash-and-burn farmers basically rely on natural fertility by encroaching on forested lands, slashing and burning the forest biomass, for the main purpose of rice and other food crop cultivation. The slash-and-burn step is usually followed by 2-3 croppings and then the farmers rotate to other unused areas and begin the cycle again. They leave the abandoned fields to grow up back into forest cover and will possibly one day rotate back to that same area for food production.

The Reasons for Practicing Shifting Cultivation

- The Lao people have practiced shifting cultivation for centuries. It is a traditionally accepted method of production. Previously, there was no government policy and no direction to encourage the people not to slash-and-burn. Even though this has changed, the deep-set ways of the Lao people make it hard for them to change.
- Most of Lao PDR is mountainous and this is little "arable" land for cultivation and animal husbandry. Water is also a scarce commodity especially during dry season. These factors encourage the people into a semi-nomadic type of lifestyle favoring the slash-and-burn farming system.
- Many of the Lao people involved in shifting/slash-and-burn cultivation, do not have access to technical assistance from extension workers, access to improved agricultural inputs, etc. Thus the production systems of most Lao farmers are going to be dependent on natural methods.

THE EFFECTS OF SHIFTING CULTIVATION

Shifting cultivation is one of the main causes of natural resource deterioration in Lao PDR, especially in relation to total forest area destroyed. Evidences of this include:

1. as forests have been destroyed and disappear, the forest cover decreases step by step and this leads to a decrease in food, wildlife and environment.
2. in the mountain areas, where the people are engaged in shifting cultivation, the land becomes grass wasteland with little or no value.
3. in most areas of shifting cultivation, the land becomes very poor, losing soil fertility. Consequently, rice harvest is very low and there is a low profit of agricultural crops. Moreover, in the rainy season, the poor, exposed soils become havens for soil erosion.
4. the effect to the natural environment, mainly the forest status, has been changed leading to hotter weather and unusual rainy/dry season happenings.
5. the farmers, especially when they are very poor and produce insufficient food and rice, take much time to find food, water, and wood for construction and energy. This is because they move to a new place quite often that lacks suitable habitats as well as permanent employment.

GOVERNMENT POLICIES FOR ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES IN THE UPLANDS

Lao PDR Government has recently enacted new policies to protect natural resources and take care of the ethnic people living in the uplands. The Lao Revolutionary Party Congress number VII, regarding stabilization of slash-and-burn practices, states “achieving *partial stabilization* of *Slash-and-Burn* by 2005 and *total stabilization* by 2010.” An expectation is that by the year 2020, poverty will be minimized in the whole country with shifting cultivation completely stopped. Shifting cultivators by that time will have alternative forms of livelihood leading to a protected environment and more economically stable people.

Strategies for reducing shifting cultivation and the stabilization of people in the uplands include integrated crop planting, rotation crop planting for soil improving, tree planting and small animal husbandry.

If the stabilization of slash-and-burn production methods are to be reached, the solution must be systematic and have continuity. Improved livelihood of the villagers by transforming current shifting methods into a more permanent form of production such as food crops (vegetable and others) should include commercial crops such as legumes, tree plantations, animal farming, and the harvesting of non-timber products in a sustainable way. There should be the introduction of handicrafts as well as other household industries. An emphasis should also be placed on self-sufficiency on food, rice in particular. Along with these issues for sustainable development, there should be a consideration of gender equality in the society.

Gender issues involve the relationship between men and women in a society and culture. So far, gender issues are widely understood in the field of community development at the village level. However, many people still do not understand and think that only women are promoted to participate in the community development activities. The interrelation between men and women at the village level is crucial to sustainable development. The whole village working together, men and women, is a key to solving the problems faced.

In closing, as far as the environment is concerned, the Lao PDR Government has issued a series of rules and regulations to protect and manage our forest areas. They have carried out surveys to allocate forest reserves, catchments to protect forests and commercial forests, and the establishment of sub-programs in each local area aiming to make full use of forest, water and soil resources with effectiveness. One long-run goal is to reforest open lands and degraded forest areas through tree planting programs. Moreover, the government has a plan to stabilize *swidden* farmers by introducing and encouraging sedentary occupation, especially in areas where forest destruction is critical. For instance, shifting to the practice of paddy growing, animal husbandry, planting of fast growing trees and handicraft production has proven to be attractive alternatives to upland shifting cultivators. Lao PDR's Rural Development Program and Human Resource Development Program have been initiated and have achieved considerable success in some areas.

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4. PAKISTAN

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INTRODUCTION

Agriculture accounts for 24 percent of the GDP and employs 48.4 percent of the total work force in Pakistan (Economic Advisory Wing [EAW], 2003.) It contributes to growth as a supplier of industrial raw materials and supports about 52 percent of the country's exports (Ministry of Environment, Local Government and Rural Development [MELGRD], 2001.) Sixty-seven percent of the country's population lives in rural areas and is directly or indirectly linked with agriculture (EAW, 2003.) Pakistan's economic development, environmental sustainability, and population welfare are therefore, strongly connected with agriculture.

The agriculture sector has undergone several changes over the years to meet ever-increasing food, fiber, fodder, and forest products demands of the nation. Major changes occurred during the "Green Revolution" in the mid-1960s with the introduction of high-yielding varieties (HYV) and intensification of farm inputs. As a result, the farm outputs increased enormously. Simultaneously, a number of environmental problems also emerged due to overexploitation of the natural resources and indiscriminate use of artificial inputs. Per hectare crop yield has been stagnant for the last few years, which is a matter of great concern for the nation.

AGRICULTURAL PRODUCTION SYSTEMS

Agricultural production systems in Pakistan consist of a mix of crop, livestock, fisheries, forest, and forage production. Out of Pakistan's total of 79.61 million ha, crops occupy around 22.0 million ha (Bureau of Statistics, 2002.) There are four major cropping patterns, namely; rice-wheat, cotton-wheat, sugarcane-wheat and maize-wheat. Wheat accounts for more than 70 percent of the cropped area (Pakistan Council of Science and Technology [PCST], 2003.) Cotton and rice, the two major foreign exchange earning crops, are cultivated on 3.1 and 2.1 million ha, respectively (EAW, 2003.) Sugarcane, an important cash crop, is grown on 1.0 million ha. Maize, pulses, oilseeds, tobacco, fruits, and vegetables are also grown over large areas. Major constraints include the limited availability of irrigation water, inadequate availability of important inputs like certified seed, fertilizers, pesticides, and credit.

Livestock accounts for nearly 37.5 percent of value-added in agriculture and about 94 percent of the GDP. The livestock population of 130 million head mainly consists of 50.9 million goats, 24.4 million sheep, 24.0 million buffaloes, 22.8 million cattle and 3.9 million asses (EAW, 2003.) About two-thirds of the entire population of sheep and goats and over half of the cattle population depend on rangelands (MELGRD, 2001.) Pakistan has also been blessed with a vast and extensive expanse of both marine and inland fisheries resources. During 1999-2000, the total fish production in the country was estimated at 627,000 mt (EAW, 2003.)

Forested area in Pakistan covers about 3.97 million ha which is 4.99 percent of the total area. Less than 30 percent of this area is utilized economically. The rest is under protective cover. The share of forestry in agriculture is slightly more than 1 percent and the share in GDP is around 0.25 percent. The rangelands spread over an area of about 26 million ha (Ministry of Food, Agriculture and Cooperatives, 1993.) However, they suffer from acute degradation problems as their productivity is estimated to range

from 15 to 40 percent of their potential (Environment and Urban Affairs Division [EUAD]/International Union for Conservation of Nature and Natural Resources [IUCN], 1993.)

ENVIRONMENTAL IMPACT OF AGRICULTURAL PRACTICES

The major agricultural practices consist of tillage and application of farm inputs like water, seed, fertilizer, and pesticides. In a bid to enhance farm output, a number of agricultural interventions were introduced in the 20th century. Some of those have caused severe damages to the environment and are discussed below.

Fertilizer Use

Use of chemical fertilizer in Pakistan has steadily increased through the years. However, average use is generally lower than recommended rates mainly due to farmers' poverty. The present average consumption of fertilizers is about 133 kg/ha (PCST, 2003.) The heaviest used fertilizers are N-based ones.

1. Fertilizer Induced Environmental Pollution

Fertilizer-related environmental problems have not been extensively studied in Pakistan. However, nitrate pollution in the upper 2-ft of soil layer and heavy metal concentration (Co, Cu, Zn and Mg) in the upper one-foot layer has been reported (Jabber and Malik, 1994.) Nitrate residues have been detected in food plants/grains. NO₂ emissions from agricultural soils were estimated to be 29.91 Gg during 1993-94. This is not considered very high (MELGRD, 2001.)

Pesticide Use

Privatization of pesticides in 1980 steadily led to increased pesticide consumption from 665 mt in 1980 to 14,773 mt in 1990 and 61,229 mt in 2000 (Ahmad, 2002.) About 76 percent of the pesticides used are used on cotton, 4 percent on rice, 3 percent on sugarcane and 17 percent on other crops (Khan and Amjad, 1998.) Injudicious application of pesticides on major field crops, particularly cotton and vegetables, is a common practice (Rafi, 2002.)

1. Environmental Hazards of Pesticide Use

Soil studies in some parts of the country where DDT was in use revealed that DDT was present up to 5.77 ppm in cotton growing areas, 0.6 ppm in rice fields and 0.2-0.5 ppm in sugarcane and tobacco fields and fruit orchards (Baig, 1985.) These levels of DDT are a potential danger to soil micro-fauna (Hassan and Khan, 2002). Shallow waters from Samundri in Faisalabad district of Pakistan drawn from a depth of 30-40 ft were found contaminated with monocrotophos (0.04-0.06 ppm,) cyhalothrin (traces to 0.0002 ppm,) and endrin (0.0001-0.0002 ppm.) These amounts are within the WHO safety limits but their accumulation in groundwater over time is a serious danger (Jabbar and Malik, 1994.) Shallow groundwater in Multan contained pesticides residues exceeding maximum residue limits (MRL.) When studied along with some vegetables and fruits (Ahad, *et al.*, 2001,) about 20 percent of fruit and vegetable samples were found contaminated with DDT, BHC, eldrin and heptachlor with content values higher than MRL (Zia, 1998.)

2. Loss of Biodiversity/Beneficial Organisms

Excessive and indiscriminate pesticide use has disturbed and killed non-target and environment-friendly organisms. Pesticides have killed birds like hawks and sparrows, rabbits and useful insects such as bumblebees and honeybees. In cotton growing areas where there is massive use of pesticides, honeybees have all but vanished (Hassan and Khan, 2002.) Studies also show that the population of natural enemies in cotton growing areas has declined by as much as 90 percent during the last decade (Ahmad, 2002). There are also instances of human deaths occurring due to chronic pesticide poisoning in Pakistan (Matin, 2002.)

Water Management Practices

Aridity in Pakistan has made irrigation water the most critical input in agriculture. Both surface and groundwater sources are tapped to meet the crop water needs as rainfall accounts for only 15 percent of crop water requirements.

1. Irrigation Practices

In Pakistan, a basin irrigation method is generally followed which often leads to over-irrigation (Qureshi, 2002.) In some studies the application efficiencies were found between 23-30 percent in basin irrigation of cotton fields (Kalwji, 1997.) Water use efficiency in rice-wheat system, a major crop rotation in Punjab, is generally low because of poor water management practices followed for rice irrigation which has given rise to water-logging and salinity (Qureshi, 2002.) *Rod Kohi* irrigation system (spate irrigation) is also practiced in some parts of the country using runoff water for irrigation through water spreading techniques. It is a good method of irrigation but suffers badly from management constraints.

2. Water-logging and Salinity Problems

The seepage from massive weir-controlled irrigation systems and the field application losses have resulted in severe problems of water-logging and salinity (Mirbahar and Sipraw, 2000.) Almost 38 percent of Pakistan's cultivated land is water-logged with a water table shallower than 3 m. Of this, 15 percent is severely water-logged with a water table shallower than 1.5 m. More than 6 million ha is saline, sodic, or saline-sodic.

3. Groundwater Depletion

Groundwater use, growing at the rate of 6 percent per annum, accounts for 38 percent of the country's annual water supplies. Three million ha are currently irrigated by tube-wells. About 70 percent are pumping hazardous water that causes salinity/sodicity (PCST, 2003.) Excessive mining of groundwater, due to prolonged drought spells during the recent past, has resulted in severe depletion of groundwater causing huge damages to orchards in Baluchistan province. Even water for drinking is not available in some places.

4. Methane Emissions from Rice Cultivation

Anaerobic decomposition of organic material in flooded rice fields produces methane, which escapes to the atmosphere by diffusive transport through the rice plants during the growing season. Rice cultivation in Pakistan is primarily carried out under flooded conditions producing around 1,637 Gg CH₄ annually (MELGRD, 2001.)

Tillage Practices

Several tillage practices based on soil type, ecological conditions, and particular crops are applied in Pakistan. In most cases, the farmers conduct continuous shallow plowing for moisture conservation and weed control resulting in development of a hard pan below the plowed layer. This not only hinders the percolation of rainwater but also affects the root growth and emergence of rainfed crops (Qureshi, 2002.) Improper cultivation practices have led to accelerated soil erosion rates causing sedimentation of irrigation structures.

1. Mechanized Cultivation

In Pakistan, land preparation, weeding, pesticides application, and wheat threshing have been mechanized to the level of 80, 70, 65 and 95 percent, respectively (Khan and Amjad, 1998.) Overall effects of mechanization are positive but excessive use and inappropriate tillage practices have resulted in accelerated soil erosion, enhanced soil compaction, and other associated problems (reduced soil aeration, water infiltration, microbial activity, etc.)

2. Depletion of Organic Matter

Ninety-six percent of arable land in Pakistan does not contain the optimum levels of organic matter needed for productivity (MELGRD, 2001.) One analysis showed that about 77 percent of soils have an organic matter content <0.80 percent and only 4 percent of the soils have organic matter content of >1.2 percent. This low organic matter is a consequence of climate (arid to semiarid) and prevalent agricultural practices (Qureshi, 2002.) Crop residues and animal wastes are mostly used as fuel and fodder and not returned to the soil.

Forest and Rangeland Degradation

According to estimates, the national rate of deforestation is around 7,000-9,000 ha per annum, which equals to a 0.2-percent annual decline in the forest cover. Both rangeland and forests are subject to uncontrolled livestock grazing. Rangeland productivity has been reduced to 15-40 percent of its potential. This has resulted in acceleration of soil erosion and loss of biodiversity.

Cultivation on Sloping Lands

Ninety percent of Pakistan's freshwater comes from the northern upland watersheds. Being subsistence farmers, most northern uplanders cultivate steep slopes and cut trees for fuel wood and timber. Cultivation of steep slopes (over 30 percent) is a major source of erosion. Soil erosion affects irrigation systems in the plains and reduces the functional life of reservoirs. Loss of topsoil results in loss of nutrients thus affecting productivity (Pakistan Agricultural Research Council [PARC], 2001.) In Pakistan, the highest erosion rates of 150-165 mt/ha/yr are seen in the Indus catchment basin (Ministry of Food, Agriculture and Cooperatives, 1992.)

Methane Emissions from Livestock Raising

The livestock sector is a significant source of methane emissions. Methane is produced by enteric fermentation from the normal digestive process of ruminant animals and decomposition of manure under anaerobic conditions. Annual methane emissions from livestock were about 2,147 Gg in 1993-94 (MELGRD, 2001.)

ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES

Several agricultural practices, technologies, and approaches have been developed for agro-environmental sustainability focusing both on crop productivity and natural resource conservation. Some indigenous technologies supporting healthy environment have also been identified and reintroduced. A brief account of the major environment-friendly farming practices and technologies is given as follows:

Organic Farming

Organic farming is traditionally practiced in some parts of Pakistan. Most of the fruits and nuts in the mountainous region are grown in an organic environment where synthetic fertilizers and pesticides are seldom used. Some other fruits like "falsa" (*Greivica asiatica*) and "dates" (*Phoenix dactylifera*) are grown totally organically.

Organic farming replaces agro-chemicals with organic materials that are considered environment-friendly. A fertigation system using effective microorganism (EM)-based innovative approach has been developed for building and maintaining organic systems on a long-term basis. Integrated systems for organic farming and waste management are also being developed. The essential elements are bio-gas production, fermentation slurry for liquid fertilizer using EM, organic compost formation using EM, and green manuring of legumes to build soil fertility.

1. Bio-fertilizer

Bio-fertilizers are formulations of useful organisms that either synthesize usable plant nutrients or increase the availability and root accessibility of nutrients already present in the soil. Quite a few bio-fertilizers have been developed by different organizations in Pakistan. Bio-zote is one manufactured from the use of *Rhizobium*. It is used for fertilization of leguminous food crops including chickpea, soybean, peanut, etc. Bio-zote is applied as fertilizer to chickpea on a sizeable area in Punjab province. It is environmentally safe and increases the yield of leguminous crops up to 40 percent. The cost of Bio-zote is about Rs.20/acre and precludes about a half bag of urea per acre.

2. Compost and Composting

Compost is an important organic fertilizer produced through the decomposition of plant and animal waste materials. An innovation made in traditional compost pits for quicker decomposition of the wastes is presented here.

A 3 x 3 x 1 m pit is dug into the soil and covered with a plastic sheet from the bottom to the ground surface. The pit is filled with all kinds of organic wastes including home wastes, animal dung, ash, leaves, weeds, etc., up to 30 cm deep. The dumped material is saturated with a solution of 5 percent rock phosphate and 2 percent urea. Two more layers of organic waste is added in a similar fashion. Five perforated PVC pipes of 2-inch diameter are erected from bottom to top for aeration purposes. The pit is then covered with a 10-cm thick soil layer. After one month, the dumped material is turned upside down. Compost is ready for use after three months. In other methods the process is completed in 6-12 months.

Integrated Pest Management

In Pakistan, integrated pest management (IPM) technologies and strategies have been developed for a range of crops including sugarcane, cotton, vegetables, apples, and mangoes, but few have been successfully implemented.

1. IPM Methods for Mangoes

Female mealy bugs (*Brosicha stebbingi*) lay eggs in the soil around trees and the young larvae move to the leaves in spring. Hoeing around the base of the trees in winter is found to be effective in exposing and killing of eggs. Banding of tree trunks with slippery or sticky materials prevents the larvae from climbing the trees.

Ladybird beetles are an important predator on mango pests. They need to overwinter in shelters such as rough tree bark. Mangoes do not provide such shelter due to their smooth trunk resulting in immigration. Putting rough sacking around mango tree trunks provides a good shelter to the ladybird beetles during winter. Moreover, with this application, they become active earlier in the season and give better control of mealy bugs.

Fruit flies (*Bactrocera dorsales*) lay eggs in the mango fruit, which greatly reduce the market value of the crop. Attractant traps made from cheap local material and baited with methyl eugenol are used for insect control instead of pesticides.

The scale insects (primarily *Aspidiotus destructor*) problem has greatly decreased due to biological control of fruit flies and mango hoppers. As a secondary pest, it had increased due to heavy pesticide applications applied, which removed its natural enemies.

Mango hoppers (*Amritodus* and *Idiosepus* spp.) are not effectively controlled with biological methods. However, use of insecticides on the lower part of the tree (less than 5 m) effectively controls the pest. The amount of chemicals applied is thus substantially reduced.

2. Biological Control of Sugarcane Borers

Lepidoptera stem borers are serious pests of sugarcane in Pakistan. These include early stem (shoot) borer, *Chilo infus catellus* (Sn.) top borers, *Scirpophaga* (*Trypoyza*) *nivella* (F.) and *S. excerptalis* (*Trypoyza nivella intacta*.) The first two are the most serious.

Biological control measures for sugarcane stem borers were initiated in 1983 by introducing the endo-larval parasitoid, *Costesia* (*Apanteles*) *flavipes*. It is now widely distributed and is reported to give high levels of parasitism on most sugarcane borers with the exemption of top borers. Releases of the egg parasite *Trichogramma chilonis* have also been found very effective against cane borers. Bio-labs have been established in the sugar mills and at the farmer's field for production of trichocords on a larger scale. Combining releases of this parasite along with *Telonomus dignus* is effective.

Saline Agriculture

The saline agricultural program aims to obtain better use of saline land and saline irrigation water on a sustained basis through the profitable and integrated use of genetic resources (plants, animals, fish, and insects,) and improved agricultural practices (Qureshi and Lennard, 1998.) Advantages of this approach include improved productivity and increased reclamation of salt-affected land with additional benefits of environmental improvement through enhanced biological activity. A number of salt-tolerant crop varieties and grass, shrub, and tree species have been identified for planting on salt affected land (Table 1.) Cultivation and cultural practices for growing different crops and species on salt-affected lands have also been established.

1. Biological Reclamation of Saline Water-logged Areas with 'Kallar' Grass

Leptochloa fusca locally known as "Kallar grass" is a perennial grass cultivated in many parts of Pakistan. It can be easily propagated through seeds, stem cuttings, or root stumps and exhibits excellent growth under saline, sodic, and flooded soil conditions. Kallar grass known for salt-tolerance is well adapted to water-logged conditions and has well-developed aerenchyma in the roots. It has the ability of lowering saline groundwater thus providing a better soil environment to crops (International Centre for Integrated Mountain Development [ICIMOD], 1997.)

Soils on which Kallar grass is grown may improve sufficiently to support other filed crops. A number of farmers in the Punjab province have reclaimed their salt-affected wastelands by growing Kallar grass for 3-5 years continuously. This grass in Central Punjab has reclaimed large salt-affected

areas. Farmers are also making a good living by raising livestock on Kallar forage. Around 30-35 mt/ha of green fodder of Kallar grass can be harvested annually.

Table 1. Promising Salt-tolerant Plants for Saline Agriculture in Pakistan

S.No.	Name of Crop/Plant	Name/Variety/Species
1.	Rice	KS-282, NIAB-6
2.	Wheat	SARC-1, Blue Silver, LV-265, Kharchia-65
3.	Cotton	NIAB-78, MNH-93
4.	Grasses	<i>Chloris gayana</i> , <i>Elytrigia elongata</i> , <i>Leptochloa fusca</i>
5.	Forest trees	<i>Acacia nilotica</i> , <i>Albizia lebbek</i> , <i>Eucalyptus camadulensis</i> , <i>Leucaena leucocephala</i> , <i>Prosopis cinararia</i> , <i>P. juliflora</i> , <i>Sesbania bispinosa</i> , <i>S. sesban</i> , <i>Tamarix aphylla</i>
6.	Fruit trees	<i>Grewia asiatica</i> , <i>Manikera zakota</i> , <i>Phoenix dactylifera</i> , <i>Psidium guava</i> , <i>Syzygium cumnii</i> , <i>Zizyphus mauritiana</i>
7.	Bushes	<i>Atriplex amnicola</i> , <i>A. lentiformis</i> , <i>A. undulata</i> , <i>Maiseana brenifolia</i> , <i>M. aphylla</i>

2. An Innovative Approach to Reclaim Sodic Soils with Gypsum Application

An innovative approach has been developed to reclaim sodic soils in Pakistan using gypsum powder as an amendment. Soil samples are collected from 0 to 15 and 15 to 30 cm depth from different locations on the affected area. The soil is analyzed for electrical conductivity, pH and ESP to assess the degree of degradation and gypsum requirement. Gypsum powder is applied accordingly and mixed with the sodic soil. Heavy irrigation with good quality irrigation water is applied and thoroughly mixed with the help of a wooden plank pulled by a tractor. After 3-4 hours, the stagnant water is flushed and removed to a nearby pond or surface drain. Afterwards, the soil environment is favorable for most of the moderately salt-tolerant crops such as wheat and rice. Combination of gypsum and farm yard manure accelerate the reclamation process and consequently the crop yields are increased. Paddy yield was increased by 66 percent and wheat 102 percent as compared to control plots where gypsum was applied along with 50 mt/ha of farm yard manure (Ahmed and Saleem, 2001.)

3. Skimming Wells for Safe Use of Groundwater

The indeterminate, uncontrolled and unregulated abstraction of fresh groundwater in Pakistan is leading towards a serious environmental risk in the shape of aquifer contamination and secondary salinization. The Indus Plain aquifer is of marine origin. Seepage from irrigation networks and deep percolation from field irrigation has formed freshwater layers of varying thickness perched over the native saline groundwater. The aquifers with shallow fresh groundwater thickness exist mainly in the center and lower parts of the “Doabs” and cover about 30 percent of the irrigated area of Pakistan. Sustainable groundwater development in such areas requires careful thinking in the selection, design, and operation of irrigation wells. Low discharge, shallow-skimming wells are an attractive means of simple, cost-effective, and traditionally familiar option for sustainable freshwater abstraction.

Watershed Management for Soil Erosion Control

The Watershed Management Program was started in the 1970s with primary focus on afforestation and soil conservation on private lands in the northern mountains. The program was later on extended to State and community lands. An integrated approach of biological and engineering measures was adopted. The biological methods included planting of fruit and forest trees on farm and wastelands whereas the engineering measures mainly comprised of terracing of cultivated fields and construction of check dams in the gullies and streams. As a result of afforestation programs launched in last 30 years, a culture of tree planting on private lands has been induced.

Sloping Agricultural Land Technologies for Degraded Lands

Mountainous areas of Pakistan, constituting 60 percent of the total land mass, has several resource degradation problems mainly due to deforestation, steep slope cultivation, and overgrazing. The agricultural productivity in these areas is quite low for lack of inputs and severe soil erosion coupled with declining fertility. Mountain farmers in Pakistan have been practicing terraced agriculture but have not been able to check erosion effectively. Sloping Agricultural Land Technology (SALT) has recently

been introduced as a reliable solution for sustained resource development in mountain environments. The double hedgerows of Ipil-ipil (*Leucaena leucocephala*) and mung beans (*Vigna radiata*) in the alleys were successfully established in sub-mountainous areas receiving 1,000-1,200 mm rainfall per year. SALT, besides increasing land productivity, has also been helpful in improving the soil fertility and conservation of environment.

Silt Collection by “Donga” for Resource Conservation

Donga is a traditional technology from Baluchistan province of silt collection from water and using it for raising agricultural crops. About 73 percent of Baluchistan is made up of high and low mountains, and gravelly fans and terraces. Much of the surface of the mountain and hill slopes comprises bare rock (about 70 percent) without soil cover. Small patches contain shallow, strongly calcareous, gravelly and stony loams. Lack of good deep soil is the inherited and the major physiographic constraint of crop and orchard production.

“Donga” is in fact a dug pond measuring roughly 20 ft x 50 ft along a side of a tributary stream. The pond is filled with flood-water through a small inlet in the dike, which allows only muddy water in and precluding rocky material. This water is stored there for 2-3 months. Once the water dries up, it leaves behind silt in the bottom of the “Donga” which is collected and taken to the field to establish orchards. Over time, a “Donga” may itself become a field and a new “Donga” take place next to it. Slowly and gradually the wide bed of a stream is converted into fertile agricultural fields. Apple orchards have been established by local farmers on a large scale in the Quetta valley of Pakistan using “Donga” technology over the past few decades.

Agro-forestry

For centuries, farmers in Pakistan have been raising and maintaining trees on their farmland for various purposes. However, their approach has largely not been according to scientific recommendations. Agro-forestry as a need and concept was recognized about three decades back. Several agro-forestry models are in practice in the country. However, farmers still mostly prefer to plant trees in linear form around the fields. Agro-forestry models adopted on large scale by the farmers are discussed as follows:

1. Shelter-belts in Thal Desert

Tree planting in the Thal desert of Pakistan is a good example as to how trees can be used in conjunction with agriculture to the advantage of both. Shelter-belts of trees, mostly comprised of *Tamarix aphylla*, are raised alongside water channels and roadsides. The shelter-belts raised at a right angle to the wind direction are necessary to protect the roads, water channels, agricultural fields, and fruit orchards from shifting sand dunes and scorching sand storms. The technology was highly successful in protecting large areas from moving sand dunes. It also helped ameliorate the environment by keeping the temperature down. The technology was awarded a United Nations Environment Program (UNEP) award in 1995 (PARC, 1999.)

2. Poplars on Farmlands in Peshawar Valley

The farmers of Peshawar valley have been raising poplars on farmlands as a cash crop since the early 1970s. Plantings are carried out around agricultural fields, along watercourses, in block plantations and in inter-culture with agricultural crops and fruit plants. Block plantations are raised at 5 x 5 m spacings to allow a tractor to move freely. Around 330 trees are planted per hectare. About 300 trees are matured for harvesting at the rotation age of 10 years. The farmers receive US\$6,500/ha for the trees. The land can also be used for crop production during the first three years until the crowns meet giving too much shading for under story crops.

Zero Tillage

Zero tillage technology has been used to address issues like soil erosion, sustained crop yields, energy conservation, and management of sowing time. In Pakistan, zero tillage technology was introduced to avoid late sowing of wheat in rice-based cropping system (Aslam, *et al.*, 1989.) In this technology, wheat is directly drilled in the standing rice stubble with an appropriate drill and no land preparation is required for wheat planting (Aslam, *et al.*, 1991.) Zero tillage technology adds to environmental sustainability in two ways: a) the tractor use is minimum hence less fuel burning; and b) reduced dust pollution due to a lesser number of plowings.

Water Management in Rice Paddies

Rice is cultivated under completely flooded conditions leading to anaerobic decomposition of organic matter responsible for methane emissions. Methane emissions can be reduced substantially with the help of mid-season drainage allowing for aeration of the soil for 2-3 days and does not have a negative impact on the crop. The rice-growing season may be divided into two stages: a) transplanting to full effective cover; and b) full effective cover to maturity. For the first stage, flooding is required to maintain a weed-free growth of rice. After full effective cover, the fields can be maintained at soil saturation level only. This helps mitigate methane emissions and conserve water (MELGRD, 2001.)

Improved Feed for Livestock to Reduce CH₄ Emissions

To reduce methane emissions from livestock, a viable mitigation option is the usage of improved feeds. By introducing multi-nutrient feed blocks (MNB) into livestock feed, the diets can be made more digestible. This reduces methane emissions by an average of 23 percent per animal (MELGRD, 2001.)

MAJOR OBSTACLES IN EXPANSION OF ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES

Various technical, social, economic, institutional, structural, and political barriers constraining environmentally sound sustainable agricultural development in Pakistan have been identified. Similarly, the expansion of environment-friendly agricultural practices is also constrained by many problems. Major issues and constraints are briefly discussed as follows:

- Some of the early technologies were transferred without studying the subsequent environmental consequences and are now hindering the expansion of new technologies. Introduction of exotic plant species like eucalyptus, mesquite, paper mulberry, etc., has resulted in creating their own environmental problems.
- Environment-friendly agricultural technologies sometimes do not provide immediate financial benefits making large-scale dissemination difficult. In particular, this can be seen in inadequate experimentation at the farmers' field level.
- The farmer lacks the resources and facilities required for adoption of new technologies.
- The farmers do not have access to the requisite information, skills and credit necessary for adoption of environment-friendly practices.
- Sophistication involved in the new technologies has hindered their large-scale implementation.
- The love of traditional practices by the common farmer makes the diffusion process difficult.
- The common farmer in Pakistan is financially weak and is interested in immediate returns and not in a position to afford the risk of experimentation.
- Institutionally there is lack of clarity regarding functions and responsibilities of national, provincial and local government and institutions concerned with environmental planning and implementation.
- Institutional capacities are not adequate in the execution and extension of environmentally sound technologies.
- There is lack of coordination between various sectors of the government responsible for dealing with matters related to the environment.
- There is a lack of political commitment for environmentally sound sustainable agriculture. This has resulted in poor implementation of highly useful and important natural conservation strategies approved since 1993.
- Frequent changes in government have resulted in discontinuity of policies and negatively affected the implementation of development programs.

POLICIES AND REGULATIONS FOR MITIGATION OF NEGATIVE IMPACT OF AGRICULTURAL PRACTICES

In general the government policies in Pakistan have remained focused on economic development grossly ignoring the importance of resource conservation and environmental sustainability. Yet ample

consideration has been paid to environmental aspects in the agriculture, energy, and water industry as well as social sector programs. A brief account of policies that have helped mitigate the impact of agricultural practices is as follows:

- Policy measures in the agriculture sector have curtailed water-logging and salinity.
- Forest policies and regulations have kept public forest estates intact and increased forest resources (Ministry of Food, Agriculture and Cooperatives, 1992.)
- The forest policy of 2001 has placed great emphasis on protection of fragile ecosystems and desertification control.
- Promulgation of the Pakistan Environmental Protection Act (1997) and the Wildlife Act are proving useful protection of natural resources including biodiversity.
- The use of prohibited toxic pesticides and marketing of adulterated and fake fertilizers have been effectively controlled through regulatory measures.

Pakistan's 10-Year Perspective Plan (2001-11) contains several strategies and programs for environmental sustainability that will check environmental degradation processes caused by agricultural practices.

1. Constraints in Implementation of Policies and Regulations

The major constraints affecting implementation of policies and regulations include:

- Proper mechanisms do not exist for implementing policy directives.
- Agriculture, forestry, livestock, and fisheries are provincial responsibilities in Pakistan.
- Provinces sometimes do not comply with national policies.
- Policies, guidelines, and goals formulated without proper background studies are affecting the implementation process.
- Finance for implementation of the proposed strategies is usually not available.
- Top-to-bottom approaches have generally been adopted in development of policies and do not correspond effectively to real life situations.

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5. PHILIPPINES

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INTRODUCTION

Status of Agricultural Resources

The Philippines, consisting of 7,107 islands, is predominantly an agricultural country. Measuring about 30 million ha, the country uses two-thirds of its land area to raise various crops and livestock. Because of the archipelagic nature of the country, it hosts an interesting mix of life forms and boasts of high diversity that is unique from island to island.

About 75 percent of the soils in the country or 22.9 million ha are “slightly to severely eroded”. Severe low fertility is reported in 40.8 percent or 12 million ha of the total land area (Rondal, 1999.) Other important soil problems include soil acidity and soil salinity. The most common deficient nutrients are phosphorus, potassium, sulfur, and zinc (Bureau of Soils and Water Management [BSWM], as cited by Department of Environment and Natural Resources [DENR], 1996.)

From 1988 to 1994, the country’s available groundwater decreased by 1.4 percent per year, while the available surface water decreased by 3.7 percent (Integrated Environmental Management for Sustainable Development Program [IEMSDP]-Environment and Natural Resource Accounting [ENRA], as cited by National Statistics Coordination Board [NSCB], undated; NSCB, DENR, United Nations Development Programme [UNDP], National Economic and Development Authority [NEDA], 1998.) This can be traced to the recharge rates that are lower than the abstraction rates for both types of water resources. From 1996, the demand of the agriculture sector constituted a large chunk (85 percent) of water usage, while industrial and domestic consumption was smaller (7.8 and 7.2 percent, respectively) (Villenas, 2001.)

The country’s alienable and disposable (A&D) lands increased by 19 percent (i.e., from 11,883,353 ha [39.6 percent of the country’s total land area] in 1960 to 14,145,078 ha [47.15 percent] in 2000.) Almost 90 percent of this is devoted to agricultural production. The increase in A&D lands was simultaneously accompanied with an increase in the conversion of agricultural lands to residential and industrial lands.

Recognizing the importance of arresting the deteriorating environment, the country formulated the Philippine Agenda 21 (PA21) as the overriding framework for sustainable development throughout the national, regional, and local governance. To put PA21 on the ground, the government issued several instructions, which called for the massive participation of all sectors since 1996.

Further strengthening the environmental health, the Philippines set in place the Agricultural and Fisheries Modernization Act (AFMA) in 1997, another significant policy framework. AFMA aims to promote a kind of development that is attuned to the preservation of the life-support systems of the natural resources. This framework adopts indicators and targets that enhance global competitiveness and sustainability of the agriculture and fisheries sectors.

AGRICULTURAL PRACTICES AND FARMING SYSTEMS IN THE PHILIPPINES

Major Trends

1. Green Revolution

The Green Revolution gained prominence from the 1960s to the 1980s. Under this endeavor, the Philippine Government implemented several food production programs such as the *Masagana 99*, *Masaganang Maisan* Program, *Gulayan at Kalusugan*, and Livestock and Poultry Production Program. As expected, the country significantly increased its crop production to 143.5 percent from 12,243,000 mt in 1965 to 29,809,000 mt in 1980. However, rice self-sufficiency and surplus production were short-lived, since the average rice yield attained in 1986 was only 2.67 mt/ha. To date, national average for rice production is around 3.3 mt/ha.

The Green Revolution also encouraged the expansion of agricultural areas even to marginal lands. This is reflected by the decrease in the unclassified forestlands by 92.5 percent from 1960 to 1996 (from 39 percent of the total land area to 2.91 percent.) On the other hand, production area increased by 60 percent in 1980. From 1980 to 2000, there was also an increase of 6 percent in the production area from 12,155,400 ha to 12,891,600 ha (NSCB, 2000.)

As farming has become more intensive through increased cropping intensity per unit area of land, the use of supplementary production inputs such as government-subsidized chemical fertilizers (particularly urea,) pesticides and irrigation; high-yielding varieties (HYVs); and machinery to improve production efficiency has become more prominent also. The use of HYVs has also paved the way for constructing irrigation facilities; thus, giving significant increases in yields ranging from 20 percent to as high as over 100 percent compared with those from the non-irrigated HYVs (National Irrigation Administration [NIA], 1990.) Without irrigation, the HYVs gave yields almost equal to or sometimes lower than those from the traditional varieties.

2. Water Pollution

Continuous application of fertilizers has polluted the surface and groundwater resources. As a consequence, algal blooms and red tide outbreaks have occurred (Bureau of Fisheries and Aquatic Resources [BFAR], as cited by NSCB, undated.) Residues of organochlorine pesticides, such as endosulfan (commonly used as pesticide during the Green Revolution era until the early 1990s, and now a banned pesticide) were found in most bodies of water near farm areas and fish samples from Malasipit in San Miguel, Bulacan. Fish samples from small farm reservoirs and rice-fish culture systems in Muñoz, Nueva Ecija, also showed endosulfan residues.

Likewise, in Calamba and Calauan, Laguna, artesian wells adjacent or within rice paddies contained residues of endosulfan and two organophosphorus pesticides, monocrotophos and chlorpyrifos (Medina, *et al.*, 1991.) Varca's study (2002) on monitoring artesian wells used by rice farmers showed that in the wet season the water from the wells, situated about 1-15 m near rice fields, contained endosulfan, monocrotophos, and chlorpyrifos.

Pollution in lakes, such as Laguna de Bay, comes from agriculture, domestic, and industrial wastes. Today's Laguna de Bay is only 3-5 m deep. In times past, it was 12-15 m deep. This has been caused by heavy sedimentation and siltation – an offshoot of soil erosion and other activities. Earlier studies made by Reyes (1986) confirmed the presence of mercury (Hg), lead (Pb), and cadmium (Cd) in Laguna Lake. When pesticides are applied to protect crops from pests and diseases, only about 15 percent of the preparation hits the target with 85 percent mostly deposited in the soil, water or air (Varca, 2002.)

3. Agro-ecosystem Approach

The birth of the agro-ecosystem concept in the 1980s came in response to the negative impacts of the "Green Revolution." The deterioration of the natural resource base due to soil erosion, nutrient depletion, loss in biodiversity, deterioration of water quality, and offsite impacts were some of these negative impacts leading to inequity and low sustainability. Thus, there is now an urgent need to focus on innovative conservation and production practices that will provide farmers with economically viable and environmentally sound alternatives in their agricultural production systems.

Integrated pest management (IPM) is one of the agro-ecosystem approaches that has been developed for some crops such as rice, corn, and vegetables. Some farmers in the Philippines are currently practicing IPM.

Other agro-ecosystem cropping patterns use complementation of crops to increase the productivity such as multistory cropping under coconut. In Silang, Cavite, farmers grow coffee, pineapple, and a mixture of fruit trees like soursop, jackfruit, and lanzones under coconut. Whenever possible, they also grow root crops such as *ubi*, *gabi*, and cassava. In Jaro, Leyte and Pigkawayan, Cotabato, farmers raise perennial crops such as banana, coffee, and black pepper under coconut. In Lucban, Quezon and Bansalan, Davao del Sur, annual crops such as Baguio beans, eggplant, ampalaya, tomato, cucumber, stringbeans, and corn are cultivated under coconut. Farmers also raise other crops such as pineapple and passion fruit under coconut.

In rice-based areas, ducks are used to biologically control rice black bug, while frogs prey on rice whorl maggots. Other beneficial insects such as spiders and damselflies prey on green leafhopper, brown plant hopper, whorl maggot, case-worm, white and yellow stem borer, and leaf folder in rice.

4. Biological Fertilizers

Also referred to as bio-fertilizers, they generally originate from microbes. These microbes are classified either as biological nitrogen fixers (BNFs) or as mycorrhiza. BNFs are organisms that directly obtain nitrogen (N) from the atmosphere and convert this atmospheric N into organic forms readily available to the plants. There are four groups of BNFs, namely; rhizobium, azospirillum, azolla, and blue-green algae.

INNOVATIVE ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES

Sustainable agriculture is the management of resources for agriculture to satisfy the changing human needs, while maintaining or enhancing the quality of the environment and conserving natural resources. Sustainable agriculture is also an agricultural system that promotes the following goals: increased productivity and income of human communities; increased equity and enhanced stability; and sustainability of the system through soil, water, and nutrient conservation.

Diversified Cropping/Integrated Farming System

To promote agricultural biodiversity, researchers have studied these approaches. For instance, corn and peanut intercropping helps control corn stem borer. In this cropping system, the young spiders feed on springtails found under the leaf litter of the peanut plant, while adult spiders feed on corn stem borer caterpillars. The shading effect of corn, when it is grown with mung bean or sweet potato, reduces weed growth. The combined effect of corn and cowpea, when planted together, prevents the spread of pathogen inocula (Altieri, 1995 as cited PCARRD National Agricultural Ecosystem R&D Team, 2003.) Other crop combinations such as cabbage-tomato produce aromatic odors that repel the cabbage diamondback moth.

In the case of multiple species cropping, the identified limitations include competition for water, nutrients, and sunlight resulting in significant reductions in soil moisture and nutrients. This sometimes is observed in combinations of annual and perennial crops. To overcome these negative effects, the farmer can combine deep-rooted species with shallow-rooted crops. Also, organic materials available in the farm can be used to enhance soil fertility and supply the nutrients needed by all crops. The farmer can plant crops that differ in their light requirements, crown patterns, and height. For example, trees with narrow crowns compete less for sunlight and allow more light to penetrate to under storey crops.

There are a number of practices used for soil conservation. They include: (1) surface cover; (2) cultivation; (3) multiple species cropping; (4) erosion control measures; and (5) fertility maintenance. Two of the major technologies are discussed here in detail.

Alley Cropping

This involves the planting of hedgerows across sloping lands or along contours and the use of alleyways between hedgerows for annual food crops. Fast-growing N-fixing trees, fruit trees, shrub legumes, cash perennials or grasses are commonly used as hedgerows. These include: *Leucaena leucocephala*, *Tephrosia candida*, *Gliricidia sepium*, and *Flemingia macrophylla*. Improving the functionality of hedgerows is based on species adaptability, cultural practices like spacing between and

within hedgerows, frequency of trimming, and crop combinations. Hedgerows serve as windbreaks to alley crops during inclement weather and shade as well. Alley cropping reduces soil loss to a tolerable level of less than 10 mt/ha/year. Alley cropping is a very effective management practice anchored on increasing agricultural productivity in sloping areas, while conserving and maintaining ecological integrity. Other benefits from the technology are terrace formation, sustained soil fertility, improved crop yields, and economic benefits supportive of the twin goals of soil conservation and increased production.

Alley cropping helps maintain the productivity of relatively fertile soils. It helps rehabilitate degraded hilly lands. Perennial crops combined with hedgerows provide additional income. It provides significantly higher yields than the farmers' common practice of plowing up-and-down the slope.

The alley cropping technology, along with other very promising soil conservation techniques, is the focus of the current program on "Management of Sloping Lands for Sustainable Agriculture in the Philippines." Including a network of seven Asian countries (China, Lao PDR, Philippines, Malaysia, Indonesia, Vietnam, Thailand,) this program aims at conserving soil resources in the region through participatory research and application of appropriate land management technologies. The network is under the auspices of the International Water Management Institute (IWMI) – South-East Asia Regional Office.

The alley cropping technology went through various phases of validation, re-validation on a wider scale, on-farm research, and wide promotion via the Conservation Farming Village (CFV) modality of technology promotion. In the on-farm research, socioeconomic information was emphasized over the biophysical factors, such as farmers' attitude, perception, and feedback (Armada and Correa, 2002.) A number of activities are now lined up for the dissemination of the technology under the program such as strengthening existing research-extension cooperation to include NGOs and enhancing the capacities of trainers rather than direct training of extension workers and the farmers.

The alley cropping technology is also promoted through PCARRD's various mechanisms that cater to the needs of the upland farmers. Other government institutions and state colleges and universities (SCUs) in the country also promote the technology. PCARRD promotes alley cropping under the ASIALAND Network project in collaboration with IWMI. At present, the alley cropping technology is promoted for adoption through CFV communities (PCARRD, 2001.) CFV involves the following aspects:

1. A model village where many farmers practice and promote conservation farming technologies like hedgerow farming, contour farming, alley cropping, bench terracing, minimum tillage, natural vegetative strips, Sloping Agricultural Land Technology (SALT), and others
2. Adoption of a community-based participatory approach to technology development, promotion, and utilization, wherein researchers, extension workers, and farmers work and learn together
3. Documentation and utilization of successful farmers' experiences to encourage other farmers to duplicate their practices. Farmers' training and cross-farm visits, among others, are held to allow farmers to observe and experience scientific farming practices. Visits to model farming villages give farmers the opportunity to share and learn farming skills
4. Encouraging other farmers in the area to adopt conservation farming technologies, through the collaboration of many government agencies
5. By establishing a CFV, efforts towards technology dissemination becomes a community initiative. Soil and water conservation technologies are disseminated through the establishment of a Conservation Farming Information Service (CFIS) located at the training shelter
6. Training participating agencies in the preparation of printed (IEC) information, education, and communication) materials
7. Development and validation of SLM databases for expedient use of information pave the way for farmers and other development actors to make informed decisions
8. Involvement of educational institutions in the promotion of soil and water conservation awareness programs
9. Strengthened linkages with the policymakers at a higher-level decision-making strata.

Organic Farming

The oil crisis that led to the increase in the cost of imported inorganic fertilizers in the mid-1970s triggered the commercialization of organic fertilizers (Olegario, 1996; and Maglinao and Librero, 1997.) In support of organic farming, the University of the Philippines Los Baños-Institute of Biological Sciences (UPLB-IBS) developed the Rapid Composting Technology (RCT) by using *Trichoderma harzianum*, a fungal decomposer of organic cellulosic materials. *Trichoderma* reduces decomposition time of agricultural wastes from the normal 5-6 months to 3-5 weeks. Field trials showed that application of RCT resulted in increased rice grain yields by an average of 10.65 percent. This yield increase gave a corresponding increase in farmers' income by an average of 17.48 percent over that of the farmers using traditional practice.

T. harzianum has shown no harmful effects on man or plants. The compost generated from the process contains about 3.99 percent N, 1.65 percent P, and 4.48 percent K. It is a rich source of iron, calcium, magnesium, aluminum, manganese, and zinc. *T. harzianum* also buffers the changes in soil pH. It improves soil tilth, aeration, and water-holding capacity. It provides humus or organic matter, which cannot be provided by chemical fertilizers. It likewise serves as soil conditioner.

Underscoring the importance of composting technology, the government launched the National Program on Rapid Composting and Use of Compost as Fertilizer in 1989. This was expanded in 1992 with support from various government institutions (Maglinao, 1997a.) The program encouraged the farmers to adopt the technology by producing and utilizing their own agricultural/farm wastes for their own compost preparation.

The program accomplished the following:

1. Thirty-nine mass production centers (MPCs) were established to produce compost fungus activator (CFA);
2. Twenty-one compost production units (CPUs) were operational;
3. Seventy-thousand and three farmer-cooperators on the use of RCT and 4,366 technicians were trained on CFA production;
4. NGOs and cooperatives and linkages with other agencies were established; and
5. 131,480 ha were covered (compost was applied) and 83,907 farmers were benefited.

Comparative yield assessment between users and non-users of RCT showed an average of 791 kg/ha yield more for users (Librero and Tidon, 1997.) The survey also showed that compost users attained a higher gross return per hectare than non-users due to the higher yields. This was in spite of higher expenses for compost fertilizers and higher cost of labor. Hired labor is used for land preparation, planting, fertilizer application, spraying and other crop care.

On the other hand, the Balanced Fertilization Program under the “*Gintong Ani*” (Golden Harvest) aims for stable production of affordable staples. As a central strategy for sustainable agricultural development, the program advocates distribution of appropriate fertilizers. Concepcion (1997) indicated that the emphasis on the use of urea in the 1980s and 1990s resulted in serious nutrient imbalance where proper ratio of 2-3 parts N for every 1-part P, was exceeded. Shares of urea to total annual fertilizer usage were 67 percent (1971-80); 71 percent (1981-90); and 41 percent (1991-96.)

Concepcion (1997) indicated that intensification of irrigated rice lands were anchored on the introduction of HYVs and the massive build-up of irrigation systems. This balanced fertilization program necessitated Fertilizer and Pesticide Authority (FPA) cooperating with local fertilizer industries in the supply and delivery of affordable, accessible, and location-specific fertilizers. Under this program, the Bureau of Agricultural Research (BAR) and PHILRICE launched a nationwide techno-demo for rice and corn production. The intervention called for location-specific fertilizer recommendation using a combination of organic and inorganic fertilizers. This reduced the effects of variations in soil and climatic conditions. The target yield is 5 mt/ha. This is a conservative target considering studies show rice yield potentials as much as 8 mt/ha.

Organic materials, particularly those for paddy rice, include crop residues, animal manures, green manures, industrial and urban wastes, commercial organic fertilizers, and compost. About 25 percent of N, phosphorus (P,) and sulfur (S,) 80 percent of potassium (K,) calcium (Ca,) and silicon (Si) and 50 percent of magnesium (Mg) absorbed by the rice plant from the soil is retained in the straw. About 75 percent of N, 74 percent of P, and 86 percent of K in feeds given to animals can be recovered in excreta.

Green manure comes mostly from leguminous plants. These contain high N content and decompose rapidly (Cosico, 1996.)

Cosico (1996) highlighted some findings on the use of organic materials on paddy rice:

1. Numerous studies have shown that the combined use of organic and inorganic fertilizers, usually at a 50:50 ratio is best.
2. Long-term application of compost to soils increases fertility, cation exchange capacity (CEC,) water-stable aggregates and biological N-fixing capacity.
3. Straw incorporation increases the soil N supply by 48 kg/ha per season. Up to 80 percent of N absorbed by rice crops, even in fertilized fields, comes from mineralization of organic matter N.
4. In burning rice straw, the temperature reaches 700°C. With this temperature, all carbon (C) and N, 25 percent of P and 21 percent of K are lost.
5. Straw incorporation stimulates growth of soil organisms since 40 percent by weight of straw is biodegradable C. It also increases biochemical activity, immobilizes N, produces organic acids and releases carbon dioxide (CO₂), methane (CH₄), ethylene (C₂H₄) and hydrogen sulfide (H₂S.)
6. Composted rice straw produces higher grain yield than that of fresh straw.
7. Rice receiving hog manure sludge combined with inorganic fertilizer at a 50:50 ratio yields similar amounts as those from rice receiving inorganic fertilizer at full dose. Best yield result is obtained when the combination is applied at 2-4 weeks before transplanting.
8. Green manure can replace 50-100 kg N from inorganic fertilizer. Green manure also increases the effectivity of N-fertilizer. Most of the known green manures release N within four weeks after soil incorporation.
9. Use of azolla in paddy is as effective as the use of N-fertilizer. However, the former is uneconomical due to high labor cost in propagation, maintenance, and opportunity cost of the land.
10. There are now several green manure crops suitable for paddy rice. *Sesbania* is the foremost and is noted for having a high N-fixing.
11. New research trends are directed towards determining the best system by which specific green manures can fit into the various rice-based cropping system for maximum cost-effectiveness and high acceptance.

Organic farming provides a number of benefits including increased water-holding capacity (due to the increased organic matter content of the soil,) loosened soil for better aeration, higher levels of production, and better quality crops. Inciong (1996) indicated that farmers from Baguio, Benguet, and the rest from the Mountain Province, usually use chicken manure as fertilizer for their vegetables, fruits, ornamentals, and root crops. Organic matter supplies some of the nutrient requirements of plants and promotes granulation and good tilth for aeration, easy root penetration, improved water-holding capacity, and favorable environment for beneficial soil organisms.

Organic fertilizers come either from animal or vegetative materials. These include swine solid and liquid waste, methane digest residue, plant compost, dried blood, and bone. Chung-chu Liu and Lin-Zen-Quan (1982) as cited by Inciong (1996) concluded that the combination of organic and inorganic fertilizers provides steadier and longer lasting overall nutrients. This combination also results in maintaining the equilibrium of organic matter in the soil, supplying energy sources for soil microbes, and improving soil structure. In addition, the combination of organic and inorganic fertilizers increases the efficiency of fertilizer use. Correspondingly, crop productivity is increased.

MAJOR OBSTACLES TO THE EXPANSION OF SELECTED AGRICULTURAL PRACTICES

High Labor Requirements

There are a number of constraints to technology and information adoption. In alley cropping, for example, one problem encountered is the labor requirement. For instance, to establish a hectare of tree-based hedgerows, labor requirement is roughly 58 man-days (Fujisaka, *et al.*, 1995; and International Center for Research in Agroforestry [ICRAF], 1996 as cited by Huelgas, 1997.) Hedgerow pruning alone requires 124 man-days/ha/year when spaced at 6 m apart (ICRAF, 1996 as cited by

Huelgas, 1997.) High labor requirement prevents some farmers from adopting the technology. Related studies by Librero and Tidon (1997) indicated that the production of compost with RCT is also laborious and time-consuming.

Growing more crops requires higher labor and management inputs. However, this may be true only during the first years of establishment. In the long term, multiple species cropping distributes labor more evenly across the year. For instance, during lean months, when the farmer and his family are not busy with annual crops, they can harvest fruit or wood from perennials. This eliminates peak and lean months of employment and ensures the farming household a continuous supply of food and/or income. Likewise, management inputs like weeding, cultivation, and fertilization benefit more than one crop. This is the case with coconut, which usually produces higher yields when intercropped than when grown alone.

Lack of Available Resources

Survey respondents also identified water and lack of CFA as constraints. Others even observed the increase in pest occurrence when RCT-based compost was applied. In terms of technical assistance, it was noted that information materials were too technical. Improvements in program implementation reversed the situation through a number of strategies, including involvement of the Municipal Agricultural Officer (MAO) as supplier of CFA under the municipality's program as well as the mechanization of compost production, and the greater involvement of NGOs.

Limited Understanding

Generally, farmers' limited understanding of technologies is one reason behind the rather slow diffusion of information. Based on awareness, knowledge, attitude, and practice (AKAP) studies, the very complex processes involved in the technology adoption and the existence of multiple institutions involved add to farmers' confusion. Maglinao (1997b) reported that there are factors that need to be considered in farmers' decision to adopt the technology of contour hedgerows. These are:

1. sufficient soil tillage and rainfall to cause both soil erosion as problem and enable natural terracing to take place as a solution
2. lack of off- and non-farm labor opportunities
3. closed land frontier and unprofitable shift to other parcels
4. survival of hedgerows even during the dry season
5. cooperation of the community members.

There is a need to educate the farmers in using organic farming. They have been used to applying inorganic fertilizers, their immediate effects on crops, and their availability in agricultural supply stores. In contrast, organic fertilizer requires more labor and yield benefits take a longer time to be seen. Thus, educating farmers on the benefits of organic farming would be part of a good marketing strategy for organic farming businesses (Posa, 1996.)

Villamena (1996) identified a number of problems in marketing bio-organic fertilizers such as low availability, low awareness level, low trial rate, and low repeat purchase. These can be addressed through market solutions in the form of proper placement, advertising, pricing/promotion, and product improvement/service quality, respectively.

One primary reason why these microbial inoculants are not widely used is that they are not readily and widely available (Cosico, 1996.) Despite effort to promote organic farming, still there is a rather slow sale of organic fertilizer, as opined by the President of Organic Fertilizer Manufacturing Association (OFERMANA) (Tan, 1996.) This is mainly because of lack of regular market for farmers' organic produce. To strengthen this area, there is a need to bring together farmers, producers, traders, and consumers to establish a common understanding of promoting sustainable organic agriculture.

Along this line, NGOs and People Voluntary Organizations (PVOs) in 1996 created a general awareness on organic farming and set up marketing arrangements and network of all organically grown produce. OFERMANA has linked with the International Federation of Organic Agriculture Movement (IFOAM) and formed the Organic Crop Improvement Association of the Philippines (OCIA.) The main purpose was to provide organic farmers and processors with technical assistance, education, information, publication, and research and development (R&D) results.

Constraints to Adoption

Maglinao (1997a) pointed some factors that need to be addressed to facilitate the adoption of organic farming by farmers. These include the following:

1. Procedures/requirements for product registration should be reviewed and simplified.
2. Product improvement and quality monitoring should be implemented.
3. Technology promotion and commercialization-coordination with local government units (LGUs) and NGOs for RCT need strengthening.

Research-extension linkages in the past have underscored the need for farmers to make their own modification in the technology. They tend to modify the methodology by using different, cheap, or locally available materials along with different combinations and techniques to suit their own conditions and needs. Thus, the merit of on-farm research/trials becomes evident as a way to encourage farmers to be more receptive to technologies. Also, the farmer-scientist/researcher and development agents working as a team in any technology development and management is gradually gaining ground. Participatory technology development of this nature is now given due attention by the government.

POLICY INITIATIVES AND STRATEGIES TO MITIGATE NEGATIVE IMPACTS OF AGRICULTURAL PRACTICES

In understanding the adoption of soil conservation technologies for upland farming and any other technological innovation for environmental sustainability, policies and strategies adopted by the country should be carefully analyzed.

Training and Capacity Building

These should always be a major component of any technology promotion program and should be on a continuing basis. Target participants are technicians, farmer-cooperators, students, and staff of LGUs, NGOs, and civil societies. They ensure the spread and widen the reach of the information campaign. Critical to this strategy is the identification of key individuals or groups that can ensure the multiplier effect of communication flow at a given period of time. In the Philippines, training programs are on co-sharing arrangement and at times, funded through external sources (foreign/local). Roving venues are also very effective to tap local capabilities and expertise to enhance knowledge of important development actors.

Collaboration and Linkages

Experiences in the country highlight the role of LGUs in promoting technologies with strong technical support from other institutions. Initial links with other government programs such as the Municipal Solid Waste Management Program, Small Farm Reservoir, Balanced Fertilization Program, etc. are also in the offing. Intensive promotion is made through links with Philippine Information Agency (PIA,) TV stations, and agriculture magazines. The Technology Livelihood Resource Center (TLRC) should also be tapped. For financial loan packages, the Land Bank of the Philippines (LBP) serves as a major conduit of credit to rural areas.

Institutionalization

It is critical to build linkages among appropriate government agencies, like the Department of Agriculture (DA,) the DENR, and the LGUs that have the mandate to ensure agricultural productivity and environmental sustainability. This allows for allocation of resources to promote the technologies and ensure human resources working on areas for their widespread adoption. Time and again, lack of trained human resources is identified as one of major constraints in applying environment-friendly technologies in farmers' fields.

Socioeconomic Variables

These factors play a significant role in the widespread adoption of technologies, especially soil conservation technologies in the uplands. Access to markets, prices of products, credit, and other farm inputs have significant influences on technology and information utilization. More often than not,

farmers opt for short-term benefits rather than for long-term ones in soil conservation because of the time value of money. This is one reason why multi-crop and crop-livestock integration have relatively faster rates of adoption than those innovations that give limited benefits.

Concomitantly, there is a need for aggressive information dissemination on the long-term beneficial effects of soil and water conservation. Maglinao (1997b) opined that the extent to which relevant information is made available at the right time, packaged, and translated into usable forms determines the success or failure of a technology transfer effort. In addition, the technology that fit to farmers' poverty situation should be a major consideration in the technology adoption process.

Provision of Subsidies and Incentives

Incentives are crucial in order to start up activities under a program for sustainable development. However, studies have shown that the use of subsidies should be avoided as far as practicable. Maglinao and Phommasack (1997) indicated that subsidies should be used only for specific sites, in exceptional cases, and to initiate programs only. They should be phased out at the earliest possible time and be in the form of non-cash inputs such as seeds, fertilizer, and farm implements.

The ASIALAND network project in the country makes use of incentives for farmers that will adopt soil conservation practices. Currently, the project provides assistance in the form of farm inputs (in kind) under the Conservation and Productivity Enhancement Program (CPEP). The assistance is on a rollover system to ensure availability of start-up funds for a greater number of beneficiaries. Without interest, the only requirement is for farmers to bring a friend and share the knowledge gained from the project; thus, facilitating the "multiplier effect" in technology and information process. Other programs of the government like the "*Gintong Ani*" Program – Balanced Fertilization, and the Integrated Social Forestry Program, have in one way or another adopted the scheme of providing incentives and subsidies. All of these have shown remarkable positive impacts on target beneficiaries.

Policies and Regulations Mitigating Negative Effects

There is a pending bill in the Congress, House Bill No. 9820, to enact the establishment of the sloping agricultural land technology and conservation farming programs. This bill recognizes the importance of devising conservation farming systems for the hillsides that will secure food supply for families in the countryside. Heavy exploitation of the uplands and the concomitant soil erosion are considered the worst environmental problems in the country according to World Bank report in 1989 and Food and Agriculture Organization (FAO) in 1992. These problems affect 63-76.1 percent of the total area. This proposed legislation supports the Agenda 21 (Earth Summit, Rio de Janeiro, 1992) that addressed land degradation by launching conservation and rehabilitation programs in critical and vulnerable areas.

The Committee on Agriculture and Food together with Committee on Finance proposed Senate Bill 479, an act promoting bio-organic farming in the country. The bill seeks to stop the use of chemical or inorganic farm inputs, pesticide, herbicides, and feed additives, and instead rely on biological means of conditioning and enriching the soil and controlling pests. The aim is to reduce heavy importation of chemicals thus making the country save dollar reserves.

As a government policy, organic fertilizer should be duly registered with the FPA. To encourage production and use of organic fertilizers, cooperatives producing their own organic fertilizer and selling within their members need not secure a license and register their product with FPA. A draft National Standard for Organic Fertilizer is now underway to ensure safety and quality of organic fertilizer. There is growing need for continuous assistance in promoting the technology in terms of the following (Olegario, 1996):

1. Dissemination of information on the benefits of using the technology
2. Continuous government support in terms of access to national food productivity program through fertilizer subsidies/credit to organic fertilizer uses
3. Logistical support for promotion and marketing particularly in crafting the final standards for bio-organic fertilizers.

In September 2002, recognizing the importance of environmental sustainability, the government issued Memorandum Circular No. 35 to promote better farm practices and environmental conservation

to mitigate the effect of drought during El Niño years. All concerned, particularly the Department of Public Works and Highways, are directed to prescribe the use of coconut peat and other coconut husk materials in farming and horticulture as an effective soil conditioner, geo-textiles and bio-logs or fascines made from coir or coconut fiber for erosion control.

Despite efforts of science and technology (S&T) entities to craft policies that will solve agro-related environmental problems, legislative agendas prove difficult to get approved. The following are some impediments:

1. Every proposed policy includes creation of a new organic body tasked to oversee policy and program provided for in the policy agenda. More often than not, this proposed body overlaps with existing government entities, thus only adding to the already bloated bureaucracy. For instance, the proposed bill on establishing the Agricultural Land Technology Farming Program calls for the creation of the Undersecretary for Modern Upland Farming under the DA, when this function can already be absorbed or covered by the existing Undersecretary for Operations.
2. An appropriation called for in every bill is not always forthcoming. While noble ideas spring from clear identification of problem addressed in the policy, lack of funds always provide a major impediment.
3. Differences in definitions require, at times, a paradigm shift on the part of the legislators and the general public. This also results in a long gestation periods for proposed bills before they can become law.
4. Lack of provision for institutionalization of some services. Support service should be provided through involvement of relevant government institutions. Providing the link to other existing programs should also be stipulated in order to make a holistic and sound provision of needed services and support systems. For instance, soil conservation-related policies call for a link to infrastructure and services provided for under the existing AFMA. Likewise, support services should not only cover water management through irrigation facilities and other infrastructure but also credit, availability of farm inputs like seeds, as well as training and capacity building.

What makes the new legal issuances attractive can be articulated in the following strategies:

1. Collaboration with various government agencies and NGOs allowing for sharing of resources, tapping into existing strengths and capabilities, and avoiding duplication.
2. Full participation of people's organizations, NGOs and the general public through wide dissemination, public hearings, joint projects and participatory decision-making in planning, monitoring, and evaluation.
3. Multi-level, multidisciplinary involvement of various stakeholders. This allows for attention given the multifaceted nature of agricultural development on a sustainable basis.

CONCLUSION

Environmental sustainability, anchored on best practices in agriculture, supports the twin concerns of increasing productivity and sustaining fragile environments. A number of technologies are already in place but what is needed are massive and comprehensive technology delivery efforts both by private and public entities. The expedient application of environment-friendly technological innovations relies on a holistic approach based on interplay of social, economic, technological, and strong political will of those in the decision-making process. Technical feasibility is not the only factor for adoption. Socioeconomic factors are crucial as well.

The increasing population and the growing concern for protection and conservation of natural endowments call for strategies that are responsive and cost-effective. Participatory decision-making in technology development and management will ensure greater acceptance of technological innovations. Policy advocacy efforts provide a major link of development actors to decision-makers at the highest levels. Effective feedback mechanisms and reliable communication flows should be the main agenda behind IEC strategies as well as information and communications technologies (ICTs.) Innovative modalities for technology promotion and commercialization must also be along the interaction of physical, biological, socioeconomic, technical, and political underpinnings.

The current scenario, where farmers still heavily depend on the use of chemicals, calls for a unified effort on the part of the government and the private sector towards protection of the environment and ensuring human safety. However, this needs a sustained effort inasmuch as a deeply-rooted practice cannot simply be reversed overnight. The public needs continuous information campaigns highlighting benefits (short- and long-term) of environment-friendly agricultural practices. Policies must also be geared at cost-effectiveness in the use of farm production inputs including labor, capital, land, and time. Environment-friendly technologies and best practices deserve sustained policy commitment and provision of needed financial resources by the government.

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INTRODUCTION

Agriculture in Singapore has changed radically from subsistence farming of the 1960s to modern intensive urban farms of today. In the 1960s, there were some 20,000 farms occupying more than 14,000 ha of land. With rapid industrialization and redevelopment, farmland gave way to industry, housing and urban infrastructure. Larger commercial farms using more intensive production methods replaced the subsistence type farms. Currently, Singapore is home to 238 farms on nearly 800 ha of land in six Agro-technology Parks. Forty-five of the farms are outside the Parks. In addition, there are also commercial floating fish culture farms in the eastern and western parts of the Straits of Johor (as of March, 2002.)

FARMING IN THE CITY

The challenge of agriculture in modern day urban Singapore is to maintain economic and commercial sustainability. Growers have to apply the most appropriate production technology and management techniques to maximize returns on capital in the face of strong competition from produce imported from other countries.

Farm lots are tendered out on 20-year leases or short-term 3-year tenancy to farming companies. Intensive farming can potentially cause pollution problems. In addition to soil and water pollution, air pollution in the form of bad odors can be a problem especially in light of Singapore's high density living. More recently, emphasis has shifted to environmental sustainability in the areas of soil, nutrient and pest management.

For the purpose of this seminar, I shall focus on the activities related to vegetable and food crop production. In Singapore, a total of 67 farms occupying 119 ha were engaged in these activities during the year 2002. Of these, 84 percent were involved primarily in production of leafy and fruit vegetables under soil cultivation.

VEGETABLE FARMING USING SOIL CULTIVATION

Protected Cultivation

Based on research in the early 1990s, the Agri-Food and Veterinary Authority (AVA,) being the national authority on agriculture in Singapore, has actively promoted the use of simple net structures as physical barriers to prevent crop damage due to pest attacks as well as heavy tropical rains. The netting has reduced leaf-rot (*Rhizoctonia solani*) incidence as well as DBM (diamondback moth, *Plutella xylostella*) damage, decreasing the need for pesticide application. From a study reported in 1992 (Yong, *et al.*), protection of crops by using translucent screens could increase yields of four types of leafy vegetables by 20-40 percent compared to open field crops. Although initial capital outlay is high,

savings from the reduced spraying as well as better quality vegetables have made it acceptable. Currently, more than 90 percent of vegetable farms grow their crops under protective netting.

As an improvement to the simple netted structure, plastic roof structures were introduced in 1998 to minimize the impact of heavy rains on leaching of nutrients from the soil. Currently, some 10 farms are using this type of structure for production of their leafy vegetables.

Pest and Disease Management

Pests and diseases are major limiting factors in vegetable production because of the favorable climatic conditions for their proliferation. To address pest problems, the AVA has promoted the change from a predominantly chemical (pesticide) approach in the past to the use of crop specific Integrated Pest Management (IPM,) including methods to trap and monitor pest populations.

Less persistent and low application rates of pesticides have been recommended and adopted for use during vegetable production. The pyrethroids are a good example of this. Farmers are trained in pesticide usage through the Certification of Pesticide Operator Program managed by AVA. Good agricultural practices such as adherence to labeling conditions and requirements and recommended application rates of pesticides is part of the continuing education program. Effort is focused on assisting the farmers to find specific treatment needs for specific pest problems. The aim is to discourage indiscriminate, cure-all and wasteful spraying.

Most farmers practice some form of cultural control against the major pests. Sanitation in removing diseased plants or weeds, which may be alternate hosts or refuge for pests, is a time-tested practice. Crop rotation is also practiced where *Brassicas* are rotated with either bayam, kangkong or lettuce.

Soil and Nutrient Management

The intensive and prolonged use of inorganic fertilizer has caused changes in soil structure such as hardening of soil and depletion of organic matter. As early as the 1970s, studies were conducted to find sources of organic fertilizers in order to maintain the soil organic matter and improve soil texture (Koay, *et al.*, 1976 and 1977; and Koay and Chua, 1979.) Chicken manure was introduced and adopted by most farmers as it produced the most satisfactory effects on crop yields.

By the 1990s, the AVA had developed and promoted the use of compost as a more environment-friendly fertilizer. Compost is stable and has less nutrient loss compared to unprocessed manure. Composting methods (traditional, microbial-aided, vermi-composting, etc.) and the resulting composts are tested and improved so that such composts could be used to supplement inorganic fertilizers (Lam, *et al.*, 2000.) In addition, compost formulations with non-manure materials have been developed by AVA with the intention of replacing manure-based composts that may cause unfavorable odors. Commonly available organically based waste products, such as wood shavings, soybean waste and brewery waste, have been used as feedstock to reduce the cost of farm inputs in addition to promoting recycling.

Crop Diversification

Most of Singapore's farms are specialized and do not grow a diverse range of crops due to the demand of buyers and the market. Research is conducted to help diversify the range of crops grown, both in terms of new variety (e.g., those that are pest/disease resistant) and new types (e.g., those that can attract more income because of novelty.) Fast growing, high-yielding and good tasting commercial varieties of vegetables are field-tested and selected by AVA before being introduced to growers.

Water Utilization and Conservation

Almost all the vegetable farms in Singapore rely on stored rainwater for irrigating their crops. Up to 3 percent of the farmland is set aside for the construction of a water pond as storage. Some farmers channel surface runoff from the farm back into the central water pond. Irrigation in farms is mechanized either with overhead sprinklers or rotating sprinklers placed above the plants. This ensures even watering and less wastage of water.

ORGANIC FARMING IN SINGAPORE

The concept of organic farming has gained prominence in recent years and some Singapore farms have begun to produce leafy vegetables using organic-based methods. By year 2001, five farms using organic-based methods (making up 10 percent of total vegetable farming area) produced an annual volume of 150 mt of leafy vegetables for domestic consumption.

In Singapore where farmland is intensively cultivated for up to eight leafy vegetable crop cycles per year, biological practices such as composting, companion planting, reduced tillage and crop rotation are widely practiced as a means to ensure high sustainable yields and better pest control. The spraying of special foliar fertilizer (e.g., compost teas) and peppering for pest control (i.e., garlic extract, neem extract, etc.) are also practiced. To maintain soil fertility, compost made from wood shavings, chicken manure, brewery waste or seaweed is applied during cultivation. Additional organic liquid fertilizer (fish, seaweed, plant extract, etc.) may also be applied as a nutrient supplement. Some farms have also introduced companion plants such as marigolds and herbs to be grown beside the vegetable cultivation beds as insect traps to reduce pest population on the farms.

A Different Approach to Farming – Bollywood Veggies Pte Ltd.

Bollywood Veggies was set up in year 2001 in the Lim Chu Kang Agrotechnology Park. Occupying an area of 4.4 ha, the farm is focused on the organic production of fruit and root vegetables such as sweet corn, brinjal, okra, pumpkin, sweet potato and tapioca. Vegetables are produced naturally without the use of synthetic chemicals or pesticides, using inputs that are recycled from food and horticultural industries as much as possible.

Recycling is used extensively in the farm. Wood chips are a commonly available waste that has many applications. Wood chips and chicken manure are mixed to produce compost, which is the main fertilizer for the plants. Mulching with wood chips is applied in all the growing beds to control weeds, reduce leaching of nutrients and prevent soil erosion. In addition, horticultural wastes such as tree trunks are recycled in the farm as structural supports (e.g., to shore up the sides of the growing beds,) as stools, and as decorative art pieces.

Ponds are used to collect rainwater and surface runoff so that water could be reused for irrigation. The roofs of farm buildings are designed to direct rainwater into drains that lead into the ponds. Integrated farming is practiced with cultivation of lotus plants in the ponds as well as rearing of fish. Fruit trees such as banana and papaya are mixed into the cropping system with the shorter-term fruit and vegetables for complementary use of the land. Crop rotation is practiced to ensure balanced soil fertility and the minimization of pest and disease build-up. Companion planting using marigolds and lemon grass has been effective to keep pest populations in check.

Other types of ornamental plants and trees are planted in the farm to create a pleasant and aesthetic environment. Typical farms in Singapore are focused on productivity and yield and are thus structured towards optimizing land use. This farm wants to create a vibrant environment that people can enjoy amidst the urban landscape. The farm's approach is to focus on specific and specialized consumer niches. The farm will also provide a place to promote awareness of and for people to learn about the compatibility of farming with the environment.

Each planting plot is designed to tell a story. For instance, "The Garden of Life" is a plot featuring all types of local spices and medicinal plants. The farm has plans to include an Earth Shop selling not only organic and health products but lifestyle products appealing to the young and trendy. The area around the water collection pond is designed as "The Sanctuary" to attract migratory birds. During holidays and weekends, space at the picnic grounds can be turned into a bazaar for vendors to sell food, arts and crafts. This is to provide an avenue for the employment of older citizens who are affected by structural unemployment. At the Visitors Center, activities like wine-tasting and cooking classes will be organized.

CHALLENGES

Singapore is an urban city with high living density. Farming in such an environment requires the farmer to be constantly aware of the impact of his activities on the surroundings and to apply

agricultural technology in the least damaging and most environmentally sustainable way. At the same time, he has to balance it with the economic viability of the farm.

Although farmers are gradually adopting more natural and environment-friendly practices, the short and quick response time of 'synthetic' products such as inorganic fertilizers and pesticides make them attractive for the farmer to use. The main challenge is to educate farmers that the long-term solution to sustainable, higher yields lies in a multi-prong approach either using appropriate and controlled application of chemicals and/or non-chemical approaches to help ensure environmental stability without affecting the commercial viability of the farms.

Research and testing is necessary to come up with a complete package where the farmer is able to produce consistently good yields over the long term and yet incur minimal or no additional cost. In addition, efforts should be continued to infuse and maintain in farmers a mind-set for good agricultural practices and the method for responsible and responsive safe vegetable production.

CONCLUSION

Singapore is known internationally as a modern metropolis with a well-planned urban landscape. It has a small but thriving farming community that faces challenges unique to an urban environment. Active research to find technological solutions to maintain commercial viability and sustainability, together with sensitivity towards environmental sustainability, is a key to the future development of the industry.

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7. SRI LANKA

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INTRODUCTION

Sri Lanka is a tropical island 65,610 km² in size and located in the Indian Ocean. Although small, it has been famous through the centuries for an infinite variety of natural beauty, economically valuable biological resources (such as spices, elephants, and ivory,) a salubrious climate and abundant water resources, fertile soils, valuable minerals, and a friendly people with a rich cultural heritage.

About four-fifths of the island consists of broad lowland plains spreading from the coastline to the south central uplands with elevations of 0-100 m. The uplands make up the other one-fifth of the country and consist of varied terrain with undulating and interspersed mountains and hills ranging in elevation from 500 to 2,500 m. All rivers in the country radiate from this central mountainous region and drain across the lowland plains into the Indian Ocean.

From May to September, the southwestern quarter of the island receives rain from the southwest monsoon. The entire island receives rainfall from the northeast monsoon from December to February. During the first inter-monsoon period, April to May, thunderstorms are quite common. The second inter-monsoon period from October to November is characterized by the passage of low-pressure systems and depressions. The rainfall at this time is widespread, and tropical cyclonic activity may occur. Sri Lanka, however, lies outside the main cyclone belt and cyclones are not a frequent phenomenon in the country. While the terms dry and arid zones may appear to be misnomers because of the annual rainfall received, this classification is based on the fact that these areas are subject to long periods of drought.

Sri Lanka's inland waters yield the only source of water for drinking, irrigated agriculture, and other domestic requirements for her population of over 19 million. The main component of Sri Lanka's inland waters are a network of 103 major rivers that constitute a total collective length of about 4,560 km and cover an area of 59,245 km² (including the basins.) This is about 90 percent of the island's land area. Although Sri Lanka does not have large natural lakes, there are many man-made irrigation tanks, large reservoirs, and irrigation canals.

The natural forest cover in the country is estimated at 24 percent of the total land area. Much of the remaining forest in the country consists of dry zone forest, located mainly towards the northern and eastern regions. In contrast, tropical rain forests occur as small blocks that are often less than 10,000 ha in extent.

AGRICULTURE IN SRI LANKA

Crop cultivation pattern coincides with the rainfall pattern in Sri Lanka. The availability of water for agriculture, either from open water bodies or from ground storage, is totally dependent on the quantity, time, duration, and distribution of the precipitation. However, with the introduction and application of new technologies such as micro-irrigation systems and poly-tunnels, some crops are being grown year round without following the traditional cultivation seasons.

Sri Lanka's traditional farming systems have developed over hundreds of years. The island thus has a wide range of farming systems. Paddy cultivation provides the staple diet of the population and has received the highest attention in the agriculture sector to date. The extent of area under paddy cultivation for all seasons has increased from 479,000 ha in 1959 to 930,000 ha in 1994, while the average annual yield of paddy has more than doubled from 1.5 mt/ha in 1950s to 3.5 mt/ha in 1990. Improvement of paddy productivity has been attributed to more intensive cultivation practices, use of new high-yielding varieties, inorganic fertilizers, and new methods of agronomic practices. Sri Lanka also grows a range of

cereals such as millet, sorghum, and maize, but these have undergone little selection by farmers. The grain legumes grown in the country include cowpeas, green gram, black gram, winged bean and soybean.

Sri Lanka has been famous the world over for her spices. At present there are at least eight indigenous species of cinnamon, 10 wild races of cardamom, seven wild species of pepper, several indigenous varieties of betel, three species of nutmeg, two species of chili and one species of ginger and turmeric. Also, a number of root and tuber crops as well as vegetables are produced.

Plantation crops play an important role in Sri Lanka's economy. Tea, originally introduced to the country in 1839, has undergone selection to give rise to high-yielding clones that are resistant to pest, disease, and drought as well as better rates of fermentation. Original rubber germ plasm was brought to Sri Lanka from South America in 1876 but has since been improved. With regard to coconut, the Coconut Research Institute has developed a number of new varieties and high breeds in Sri Lanka.

Sad to say, much of the genetic diversity has disappeared from Sri Lanka's farming systems. This is due to the shift towards new uniform varieties that depend heavily on chemical fertilizers and pesticides.

STATUS AND ISSUES IN THE AGRICULTURE SECTOR

Sri Lankan farmers, like other Asian farmers, experience three major problems: 1) high cultivation and production cost; 2) low productivity; and 3) low standard of products. The latter does not allow farmers to compete with farm products from other countries. Farmers are well aware of the need to change and have the willingness to change. However, they do not have the capacity to apply required technologies to their farming practices.

The current challenges facing agriculture are balancing market-oriented self-interests with the primary objective of securing social welfare using the best political model. This will result in a demand for quality food items. In turn, WTO conditions with assured phytosanitary standards will impact food security, traditional trade patterns, people's livelihood, and their environment.

Sustainability to Sri Lanka is sustainability of the livelihood of the people. The welfare-oriented policies adopted by government have become investments of a worthy cause to produce a nation of high literacy, high health standards, and skills to apply technology.

ADVERSE IMPACT ON ENVIRONMENT DUE TO AGRICULTURE

The changes made to traditional agricultural systems in the name of Green Revolution agriculture have created many unexpected environmental constraints including:

- from 1900 to 1990, natural forest cover of the island decreased from 70 to 24 percent.
- most of the environmentally sensitive hilly areas were cleared rapidly for agricultural and settlement purposes.
- heavy soil erosion has been observed in hilly areas thus many soils have become infertile and unproductive.
- the frequency of landslides has increased.
- more than 50 percent of the water-holding capacity of the main reservoirs has been filled with silt.
- data on soil erosion for the upper Mahaweli has shown that due to the lack of proper land utilization mechanism, 0.5 million mt of sediment annually flows into the reservoirs.
- the accumulation rate of greenhouse gases is increasing.
- the annual mean air temperature increased over the entire Island, particularly during the period 1961-1990. This increase has been documented to be approximately 0.16°C per decade.
- rainfall trends were found to vary. From 1961 to 1990, decreasing rainfall was evident over most of the Island except in a few isolated areas, where an increasing trend was indicated.
- increasing trends in prolonged and frequent droughts and floods occurred.
- global mean sea level has risen 10-25 cm over the last 100 years.
- increase thunder activity has positively correlated with air temperature.

In view of the importance of the agriculture sector, it is essential that timely measures are taken to mitigate the impacts of climate change through the formulation of policy and guidelines for environment-related development programs. This will, however, require investment, planning, effective implementation, and strong monitoring mechanisms. The efforts taken to enhance agricultural productivity by introducing suitable varieties of crops, adopting appropriate technology, providing alternative land use, or engineering interventions to maintain the existing agricultural lands will result in a balanced environment.

ECO-FRIENDLY AGRICULTURAL DEVELOPMENT PROGRAMS FOR ENVIRONMENTAL SUSTAINABILITY IN SRI LANKA

Agricultural Research for Environmental Sustainability

The National Agricultural Research Plan of 1998 and the Agriculture Research Plan for the Ministry of Agriculture for 2000-08 have many research initiatives promoting agricultural sustainability in the food crop sector. They also take into account sustained agricultural productivity in harmony with the environment. Some of the key objectives of the latter plan have a direct bearing on environment-friendly practices for achieving agricultural sustainability. These include:

- using domestic as well as global genetic resources for crop improvement, which will ensure a higher value for local crop biodiversity.
- strengthening research in biotechnology, bio-fertilizers, protected agriculture, biodiversity, and management of ecosystems.
- conducting basic applied and adaptive research to generate cost-effective and environment-friendly technologies (including sustainable farming systems, nursery management, nutrient management, and pest and diseases management.)
- developing approaches for a better understanding of production systems, natural resources, the environment, and sustainability requirements geared to reduce environmental and human health risk.
- strengthening the existing research-extension-farmer linkage programs.

<Measures Taken on Agricultural Research>

- ✧ A separate institution is functioning (Council of Agricultural Research Policy [CARP]) for agriculture research policy.
- ✧ High priority is being given for research programs.
- ✧ All the agencies in the sector are requested to identify research needs.
- ✧ Special financial provision has been granted by the General Treasury to facilitate and encourage research programs.
- ✧ Institutional arrangements and information and technology transfer mechanisms have been identified and established to transmit new findings to the beneficiary groups.

Agronomic Practices

Appropriate agronomic practices are very important to minimize adverse impact on the environment. They include:

- *Selection of crops* – It is very important to have a proper mechanism to select correct crops for planting based on the ecological situation.
- *Seeds and planting materials* – Agriculture with quality seeds and planting materials is a strategy to minimize excessive usage of agro-chemicals.
- *Land preparation* – Land preparation for short rotational agricultural crops is the main reason for soil erosion and land degradation.
- *Cultivation pattern and timing* – To ensure optimal utilization of water and land, selecting the correct cultivation pattern and timely planting is important to help avoid the risk of pest attack.
- *Water management* – Water management is an important practice to save water and to ensure the availability of water throughout the season.

- *Soil conservation* – Soil conservation measures are required to prevent soil erosion, loss of soil fertility, and the siltation and sedimentation of water bodies. The Soil Conservation Act of 1951 governs the national policy for soil conservation. This Act calls for surveys in relation to erosion problems and conservation needs and for farming land use along with soil conservation regulations. Under the Upper Watershed Management Project, a study is being done to formulate watershed management policy by incorporating all other relevant policies and legislations. A series of official and public meetings have been conducted to discuss draft watershed management policies.
- *Fertilizer application* – The Department of Agriculture has sought to create awareness on the advantages of applying mixed-fertilizers rather than excessive use of inorganic fertilizers and to promote the use of locally available organic material such as paddy straw.
- *Pests, weeds and disease control* – The Department of Agriculture is currently conducting an Integrated Pest Management (IPM) program for paddy farmers with the aim of reducing the use of pesticides.

<Measures Taken on Agronomic Practices>

- ✧ Traditional knowledge and experiences of the farmers and new research findings are being applied together to select suitable crops.
- ✧ The Department of Agriculture has established a division for seeds and planting materials and another separate division for seed certification to provide quality seeds and planting materials to farmers.
- ✧ Legal authority has been given recently to the seed certification service of the Department of Agriculture to regulate the quality of locally produce as well as imported seeds.
- ✧ Facilitation of access to seeds and planting materials of indigenous varieties.
- ✧ Regulations enforced under the Soil Conservation Act are being applied to land preparation activities.
- ✧ Traditional knowledge and experiences of the farmers and new research findings are being applied together to identify appropriate cropping patterns and timing.
- ✧ Cultivation Committees (CC) and Water Management Committees (WMC) have been established under the Agrarian Services Act and Irrigation Ordinance to design cultivation models and to manage water for agriculture.
- ✧ Preparation of the National Watershed Management Policy by incorporating all other relevant policies is in progress. With the implementation of this policy, all land use and degradation issues will be addressed.
- ✧ Farmers are being encouraged to apply mechanical soil conservation measures such as stone terraces, contour buds, lock and spill drains and bench terraces.
- ✧ Agronomic soil conservation measures such as contour farming, mulching, zero tillage, and cover slips are promoted.
- ✧ Biological conservation measures such as hedgerows and grass strips are also introduced. These include the Sloping Agricultural Land Technology (SALT) system of farming.
- ✧ Under the Fertilizer Regularize Act, a separate unit has been established as National Fertilizer Secretariat.
- ✧ Island-wide monitoring mechanisms have been introduced to maintain the standards of imported fertilizers. Awareness programs are being conducted to promote application of organic fertilizer.
- ✧ The Office for the Registrar of Pesticides has been established in the Department of Agriculture to regularize and control agrochemical usage.
- ✧ Safety measures and precautions have been introduced to minimize adverse effects of agrochemicals.
- ✧ Sri Lanka has banned several persistent organic pollutants of which eight are pesticides.

Farming Systems

- *Organic farming* – Organic farming produces chemical-free products for local consumption and increases foreign exchange earnings by rapidly expanding foreign markets for such products.

- *Agro-forestry and cropping mixtures* – Agro-forestry systems are being practiced in Sri Lanka to optimize utilization of arable lands and space. Inter-cropping, by using perennial crops with short rotational crops, is one of the widely practiced agro-forestry systems.
- *Tree planting programs* – In Sri Lanka, uncultivated lands mainly found in the mid- and up-country regions, are extremely unproductive. Moreover, land utilization in the dry and intermediate zones is limited to rainy season except in the areas with supplementary irrigation facilities. Tree planting has been found to be an important safety measure to improve land productivity and to prevent the land degradation processes. Perennial crop varieties such as fruit species, timber species, and other tree species are commonly used for such programs.

<Measures Taken on Farming Systems>

- ✧ Programs to plant and maintain trees in home gardens, stream reservations and other public places have been introduced and are in progress.
- ✧ School children are being encouraged to develop their school gardens by planting trees.
- ✧ Seedling requirements for such programs, including indigenous varieties, are being given free of charge or at production cost by the government.
- ✧ State lands identified for forest plantations are being leased out for the period of 30 years with attractive financial packages to interested private parties in order to enlist their involvement for tree planting.
- ✧ Newly reforested state lands in selected areas are also being leased out with pre-negotiated conditions to the farmers to cultivate agricultural crops in between the planted rows of trees. Farmers receive benefits from the crops but are required themselves to maintain the tree seedlings planted.
- ✧ The Upper Watershed Management Project of Sri Lanka has launched a tree-planting program. This consists of buffer zone planting (4,000 ha,) timber tree farming with private smallholders (2,000 ha,) home garden development (15,000 families,) stream bank stabilization (134 km,) roadside planting (80 km,) and public land plantings (100 ha.)

Traditional Models – Home Gardens and Kandyan Home Gardens

The Sri Lankan home garden, irrespective of size, is the connection between people, land and society. It epitomizes the environmental consciousness of the Sri Lankan people. Therefore, the home garden is the most applicable model for environment-friendly agricultural and land use practices.

- *Home Gardens* – Home gardens play a major role in preserving crop biodiversity, particularly in respect of spice crops and fruits. It is estimated that there are around 1.33 million home gardens in Sri Lanka accounting for about 367,800 ha of cultivated land. Home gardens constitute a traditional system of perennial and short rotational cropping for a wide range of valuable crops and are considered important sites for in-situ conservation of crop germ plasm.
- *Kandyan Home Gardens* – Sri Lanka's Kandyan home gardens have evolved through generations as a strategy to restore the depleting resources and ecosystem functions that forests once provided. They are located on sloping terrain, which has undergone severe depletion of forest during the colonial era, and consequently become vulnerable to land degradation through soil erosion. Kandyan home gardens emulate natural forests of the region and are found to be ecologically superior to all other forms of land use systems located outside the forest. Structurally they have five layers such as emergent, the main canopy, the mid canopy, the shrub layer, and the ground layer. All strata have distinctly dominant species. As in a forest, these gardens have a predominance of woody perennials over herbs and climbers. These gardens differ from natural forest, however, in terms of ecological functions and species composition. Endemic and naturalized species make up nearly 40 percent of gardens. The species richness per garden ranges from 100 to 280, a feature influenced by garden size. Species with single stems, straight boles, and narrow canopies are found at the boundaries or demarcation areas. The more dense food producing species are located closer to the houses, while non-food-producing species are more abundant towards the outer edges of the garden. The main resources obtained from these gardens include food, raw timber for construction, mulch, fencing material, and a pleasant environment for

the dwellers. The ecological superiority of these systems is related to the contribution they make towards the conservation of soil, water, nutrients, and biodiversity in the environment.

<Measures Taken on Traditional Models – Home Gardens and Kandyan Home Gardens>

- ✧ National priority is being given to develop home gardens.
- ✧ Kandyan home gardens are recognized as a model to introduce to other areas with similar ecological conditions.
- ✧ Technical assistance is provided for mixed cropping in the traditional home garden pattern.
- ✧ Seedling requirements for such programs are being fulfilled mostly free of charge or at production cost.
- ✧ Facilitation of access to seeds and planting material of indigenous varieties is being provided.
- ✧ A subsidy scheme has been introduced for soil conservation measures to encourage farmers.
- ✧ A competition is being conducted annually to identify best home gardens in divisional levels and winners will be further encouraged by providing attractive prizes.
- ✧ Incentives are provided to farmers who demonstrate commitment towards conservation of biodiversity in their landholdings.

Modern Technology

- *Micro-irrigation systems* – Micro-irrigation systems are introduced as a system of drip irrigation instead of flood irrigation. This saves water, reduces the possibility of erosion, and allows a better, safer and more direct application of fertilizer and agrochemicals with water in a controlled manner.
- *Poly-tunnels* – This technique can control the microenvironment for production without exploiting natural resources. Also, it gives farmers more control of plant growth and harvesting times.
- *Machinery and equipment* – The use of machinery and equipment can increase farming efficiency and have a direct and positive relationship with reduction of cultivation and production costs. Farm mechanization is considered a matter of priority due to the labor shortage in the agriculture sector and increasing need for productivity enhancement.

<Measures Taken on Modern Technology>

- ✧ Through the private sector and reputed organizations, technical assistance is provided to construct and maintain micro-irrigation systems.
- ✧ Soft loan facilities have been introduced to help with initial costs of installing micro-irrigation systems.
- ✧ A unit has been established in the Department of Agriculture to provide technical assistance to construct and maintain poly-tunnels.
- ✧ Soft loan facilities were introduced to help with initial costs of constructing poly-tunnels.
- ✧ Duty concessions have been introduced for importing small- and medium-scale machines and agricultural equipment.

Physical Infrastructure Development

Agricultural physical infrastructure development has been identified as an important area to protect arable lands, maintain natural drainage patterns, prevent soil erosion, maintain natural and man-made irrigation systems, and assist water management. Construction of structures for soil conservation and to prevent stream bank erosion is the main focus.

<Measures Taken on Physical Infrastructure Development>

- ✧ Financial provisions are made available through the annual budget in order to construct physical infrastructures.
- ✧ Engineering units have been established under the Department of Agrarian Services and provincial councils to conduct physical infrastructure development activities.
- ✧ Farmer organizations are empowered to directly attend to or to offer contracts for agriculture-related construction work.
- ✧ Irrigation systems including tanks and water distribution networks are being maintained with necessary renovations.

Extension, Training and Awareness

- *Extension services* – Currently, there are four agricultural extension services in the country. Altogether there are about 5,000 field level extension staff, of which 20 percent belong to the Provincial Extension Services of the district administrations. Agricultural extension services were previously provided solely by the state. They have now been liberalized with a view to making the service more competitive. A fee-based extension service has been initiated as a pilot project under the Perennial Crop Development Project funded by the Asian Development Bank (ADB) in 1999.
- *Training and awareness* – Sri Lanka has realized the need for the involvement of communities in environment conservation and management while attending their development programs. Education and public awareness in environment-friendly agricultural practices are carried out by state, private, and community-based agencies.

<Measures Taken on Extension, Training and Awareness>

- ✧ An island-wide network of extension services from national level to village level has been established.
- ✧ Efforts have been made to incorporate environment, research, technology and marketing components in extension programs.
- ✧ Agriculture and environment topics have been introduced in school and university curriculum.
- ✧ Modules on environment management have been incorporated in social, physical, agricultural, and biological science degree programs in universities.
- ✧ Some universities offer Masters level degree programs in environment management.
- ✧ All environment-based NGOs are involved in education and public awareness programs on eco-friendly practices.
- ✧ Training and awareness programs on environment-friendly farming are being conducted for farmers and field officers.
- ✧ Publicity programs on environment-friendly agriculture through print and electronic media are in practice targeting a wide spectrum of beneficiaries.

Institutional Strengthening

Overall, there has been a lack of coordination between the institutions targeting environment-related issues. Services in general are based on commodities rather than farming systems and planning mitigation measures with adequate attention for cost-benefit analysis. Multiple agents with varied messages thus advise farmers. This has resulted in confusion among the farmers and a resultant loss of credibility in the state services.

<Measures Taken on Institutional Strengthening>

- ✧ A separate ministry and full-powered authority have been established for environmental conservation (Ministry of Environment and Natural Resources and Central Environment Authority).
- ✧ Natural Resources Management Units have been established in the relevant ministries and departments to handle environment-related matters.
- ✧ An Inter-ministerial Committee was established for policymaking process.
- ✧ A mechanism has been introduced to build up inter- and intra-agency linkages including public, private, and NGOs.
- ✧ District and Divisional Agriculture Committees were empowered to plan, implement, and monitor agricultural development programs to ensure environmental conservation.
- ✧ Agrarian Services Centers were strengthened to plan, implement, and monitor environment-friendly agricultural development programs.
- ✧ Mechanisms have been established to ensure active participation of farming communities in the decision-making process.
- ✧ Relevant institutions were strengthened to provide credit and technical assistance.

MAJOR CONSTRAINTS TO IMPLEMENT ECO-FRIENDLY AGRICULTURAL DEVELOPMENT PROGRAMS

The Government of Sri Lanka has introduced and implemented several eco-friendly agricultural development programs. However, the process has been found to be slow and the expected results have generally not been met. There are many reasons for this and remedial measures, such as below, are being taken to minimize these constraints.

- Heavy and irreversible damage to the environment in some cases.
- Difficulties to identify appropriate remedial remedies due to complex systems.
- Lack of understanding on the functions and the values of the environment.
- Lack of understanding on the environmental policies and legislations.
- Reluctance of the people to follow guidelines introduced under environmental policies and legislations.
- Insufficient attention to conduct training, awareness and publicity programs on conservation.
- Poor attention and response of the people to the training and awareness programs.
- High initial costs to conservation farming practices and modern technology.
- Weak or inadequate physical infrastructure facilities and high maintenance cost.
- Insufficient subsidies for soil conservation measures.
- Comparatively high production costs, high risk for insect attacks, high susceptibility for diseases, and low-income levels associated with organic farming systems.
- Reluctance of farmers to embrace new farming systems thus holding to comfortable, old systems that are environmentally destructive.
- Lack of alternative income sources for the farmers who are at present involved in environmentally harmful agricultural practices.
- Land tenure issues associated with land utilization.
- Land fragmentation due to increasing demand as population increases.
- Poor coordination among the agencies that are working for environmental conservation.
- Lack of appropriate and strong mechanisms to enforce laws in the environment sector.
- Insufficient attention to maintain equilibrium between environment and development.

ENVIRONMENT- AND AGRICULTURE-RELATED POLICIES

Provision is made in Article 27 (14) of the Constitution of Sri Lanka for the protection of the environment as follows: “The state shall protect, preserve and improve the environment for the benefit of the community.” Section 28 (f) emphasizes the need to protect nature and preserve its riches. Successive governments have affirmed their commitment to the protection of the environment. Therefore, the reviewing and revising of existing policies as well as formulation of new policies for the agriculture and environment sector is important to ensure environmental sustainability.

In order to minimize adverse environmental impacts of activities and development programs utilizing natural resources, several policies and legislations have been formulated. The following are the policies and legislation that are the most relevant and important for environmental protection.

National Agriculture and Livestock Policy – 2003

- Mobilize resources to conserve highlands and water catchments.
- Make soil conservation on cultivated highlands and slopes compulsory.
- Mobilize farmers for conservation.
- Make protection of land fertility a major responsibility of the extension service.
- Provision of scientific instructions for such protection without delay.
- Mobilize for joint decision-making on what to produce based on the conditions of land, weather, water, and market.
- Preparation of tract and village level plans. Implementation of these plans to ensure responsible cultivation of all cultivable lands.

- Mobilize farmers to market-based production systems avoiding the disadvantage of agricultural land fragmentation.
- Provisions of land to landless farmers, medium-, and large-scale farm enterprises.
- Facilitate conservation and utilization of rainwater, river, tank, and groundwater utilizing new technologies and water management policies under the theme of “less water-high yield”.
- Minimize water pollution from agricultural practices.
- Proper utilization of chemical fertilizers and agrochemicals.
- Popularize biological and bio-technical methods as far as possible to enhance soil fertility.

National Watershed Management Policy – 2003

- Continued and equitable economic and social benefits to local people and to the rest of the country while conserving watershed resources.
- With people’s participation, conserve, protect, rehabilitate, use, and sustainably manage the watersheds.
- Coordinate and monitor all activities in watershed areas and secure a system of integrated management.

National Water Resources Policy

- Conserve and develop watersheds to ensure optimum land use in relation to water and social well-being.
- Seek a careful balance considering the needs for water supply for humans, water quality protection, water management, and environmental protection and enhancement.

National Land Use Policy

- Coordination among government and other agencies entrusted with land resources and environmental management responsibilities will be strengthened.
- People’s participation in the sustainable use of land resources will be promoted and the role of the state will be limited to that of a trustee.
- Private sector investment and participation in land development will be encouraged by measures such as long-term leases of the land.
- Land use plans will be prepared at national and regional levels.
- Allocation of land by the state will be based on a land suitability evaluation.
- Effective and suitable conservation measures will be non-negotiable prerequisites for agricultural land use.
- Environmentally fragile areas will be identified, designated, and protected.
- Use of state and private lands in areas below 1,500 m elevation and with slopes exceeding 60 percent will be maintained in forest cover, converted to forest vegetation, or utilized for agro-forestry systems.
- Landslide-prone areas will be identified and established to permanent forest cover and protected. Human settlement activities will not be permitted in such areas.
- All natural and man-made watercourses and sources, whether private or state, will be demarcated and protected with appropriate conservation measures.

National Environmental Policy

- Good land management and sound agricultural practices will be adopted for all cultivated land in the island, particularly at low, mid and high elevations in the wet and intermediate zones where the problem of degradation has reached acute dimensions.
- State land shall be allocated for its appropriate function: productive, protective, or development.

CONCLUSION

The facts discussed in this paper make it clear that the agricultural development activities in Sri Lanka has a strong impact on the environment. Consequently, the environmental changes themselves in turn affect the agricultural production thus reducing its productivity. Therefore strong attention and

commitment is needed to maintain equilibrium between agricultural development and environmental stability.

There is a major need for continuous policy review and revision to ensure good structures for implementation of environment-friendly better agricultural practices. Moreover, there needs to be a better network and communication between government, NGOs, private organizations, and even the communities themselves in developing and implementing these policies. Most of all, there is a need to apply the multiple policies that exist.

In closing, the beauty and harmony of the Sir Lankan home garden should be a model and challenge to all who seek to endeavor in environment-friendly agriculture. The ideals of diversity, incorporation of indigenous knowledge, multi-leveled resource management and environment-friendly pattern found in each home garden should serve as an encouragement to see us develop our countries and agricultural programs along the same lines.

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8. THAILAND

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INTRODUCTION

Agricultural development during the last four decades has had an adverse effect on Thailand's rich natural resource base, social structure as well as economic system. Environmental degradation, epitomized by rapid deforestation, is widespread. Moreover, much of Thailand's agricultural labor has migrated to the cities. In spite of a rapid economic growth rate of 8-10 percent (prior to the economic crisis in 1997,) there has been a widening gap between the poor and the rich as seen in an income ratio of 1:13 between agriculture and non-agriculture workers. Additionally, there has been an increase of the poor population, which approached 10 million in 1999.

Under the recent economic crisis, the agriculture sector has been regarded as the major strength for economic recovery. Food security and a self-reliant economy have received a high priority in order to cope with this crisis. Sustainable agriculture was thus included in the Eighth National Economic and Social Development Plan (1997-2001.)

INNOVATIVE ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES

Currently, there are several innovative environment-friendly agricultural systems implemented in Thailand. These include New Theory farming, integrated farming, organic farming, natural farming and agro-forestry. There are also numerous environment-friendly technologies such as integrated pest management (IPM,) integrated soil nutrient management, soil and water conservation techniques, green manuring and cover cropping. Moreover, there are some environment-friendly practices such as bio-pesticide and bio-fertilizer, which have been generated from local knowledge.

The New Theory Farming: An Integrated Farming towards Self-reliance Economy

A New Theory approach was initiated and proposed by His Majesty the King and was firstly implemented in 1989 under a rainfed paddy condition in central Thailand. The concept involves an approach for the efficient management of natural resources and proposes a method and procedure for self-reliance of smallholders (landholding of about 2.5 ha with 5-6 family members per household.) The success of the New Theory is based primarily on a hypothesis that should be accepted by the farmers and involves farm management according to 30 percent land area for paddy, 30 percent for fruit trees and vegetables, 30 percent for farm pond or water reservoir and 10 percent for residential or homestead. However, this proportion of farm management is not an absolute ratio but it is adjustable owing to biophysical and socioeconomic factors (landholding, labor, rainfall, etc.)

A key feature of the New Theory emphasizes a self-reliant sustainable production system through integrated farming. This system helps to stabilize food production and to enhance the income-generating capacity through the production of surpluses. The second stage is concerned more on capacity building at the community level to enable the community to be independent through self-help civic programs (rural healthcare, education, rural enterprise, saving funds, etc.) This stage advocates strong links among rural households through farmer groups, networking and cooperatives. The final stage is for the community to provide incentives for the external private sectors to join and form partnerships in trading activities, delivery systems for the farm products, and to help expand the market so that both parties become more interdependent.

The New Theory approach to a self-reliant economy has now been adopted and implemented nationwide by various government agencies. In the Chiang Mai valley, since 1998, the New Theory approach has been implemented as a pilot site in a lowland paddy area of San Sai district. The pilot

project was started with a farmer cultivating 1.6 ha of land who grew rice and potatoes before transitioning to the New Theory farming practices. Under the new system, 0.8 ha (50 percent of total area) is designed for glutinous rice cultivation for household consumption of the six family members. Potato is commonly grown as a cash crop after rice harvest. Fruit trees such as mango, longan and guava are mainly grown for cash in a 0.6-ha (40 percent of total area) portion of land. A farm pond covers an area of about 0.1 ha (5 percent of total area) where catfish, tilapia and frog are raised for food and additional income. The farmer's residential portion covers an area of about 0.1 ha (5 percent of total area) where native chicken and swine are raised for food and extra income. This integrated farm with the New Theory approach generates an annual income of US\$1,450-2,000. In addition, this approach enhances self-reliance through the use of internal inputs and bio-resources recycled from within the farm. This particular New Theory farm has shown to be a good strategy of soil and water management for food security and self-sufficiency under erratic environmental conditions.

Organic Farming: An Alternative for Sustainable Agriculture and Food Safety

The demand for organic agricultural products from international markets has been increasing at the rate of 10 percent annually in Thailand. In order to enhance the capability and competitiveness of Thai organic agricultural products in the world organic market, the government has included organic farming in its national agricultural development policy. A national standard for organic crop production was formulated in 2000 in compliance with international standards. Currently, there are various international organic standards that are enforced in different countries such as the American Organic Food Production Act (OFPA), the European Union-EEC No.2029/91, the World Trade Organization-Codex Alimentarius and IFOAM (the International Federation of Organic Agriculture Movement.) With government support and the cooperation of local producers, a pilot project was launched to export several organic farm products including Thai jasmine rice, asparagus, baby corn, dainty banana, okra, ginger, spinach, green soybean, and pineapple.

In the case of organic rice, production has steadily increased since 1991 through the cooperation between private companies, the Department of Agriculture (DOA) and the farmers. The main production area is in upper northern Thailand, covering an area of approximately 1,000 ha with about 3,000 mt of production annually. The area is in a rainfed condition and rice is commonly grown once a year. The superior fragrant rice, *Khao Dawk Mali 105*, is commercially grown in the area whereas glutinous rice, *RD 6*, is grown for home consumption. The private sector is responsible for farm registration and marketing, while the DOA provides production technology, field inspection and laboratory analysis. The cooperating farmers have to follow the production guidelines as well as technical recommendations throughout the production cycle. During the growing period, the DOA field inspectors do periodical field inspections.

During the years 2000-02, the Sustainable Agricultural Development Project (SADP,) funded by the Danish Cooperation for Environment and Development (DANCED,) was introduced to support organic rice production. Participatory Technology Development (PTD) has been implemented with emphasis on farmer group involvement. The main objectives were to generate technologies through the combining of indigenous knowledge with modern ideas, as well as to strengthen farmer group and networking for self-reliance purposes. The on-farm trials with farmer participation were conducted with bio-fertilizers such as *sesbania* and mung bean as green manure crops to improve soil fertility and soil structure. Also, the application of bio-pesticides such as neem extract in combination with other local herbs has been used to control major pests in the rice field. Group establishment and networking are encouraged through saving money and the management of a revolving fund.

After 12 years of organic rice production, it has been observed that the environmental condition of the village has been largely improved. One indicator is an increasing predator population in rice fields such as birds, frogs, spiders, dragonflies, etc. Similarly, paddy soil and water quality are relatively improved as indicated by the numbers of earthworms and aquatic fauna. In addition, farmers are self-sufficient and independent from external chemical inputs. Currently, there are three farmer groups concerned with organic rice production and they have a good networking relationship. At present, farmers are trying to initiate a small community enterprise through the processing of brown organic rice for value-added purposes.

Good Agricultural Practices: An Integrated Management Practices for Quality Improvement

The Good Agricultural Practices (GAP) program was initiated in 1999 and is being implemented through the DOA regional offices nationwide. The main objective is to improve the quality of major export crops through promoting correct farm and crop management techniques, including IPM, and integrated nutrient management practices. Currently, the DOA is planning to certify 325,000 farms and 27 different crops in conjunction with the 2004 campaign for Food Safety Year. At present, GAP emphasizes longan, lychee, durian, mangosteen, asparagus and okra. Again the goal is to improve quality and enhance exportation, particularly under the free trade framework of the World Trade Organization (WTO.) The procedures of GAP include farm registration, training of cooperating farmers, farm inspection, analysis of farm products and farm certification. The ultimate goal of GAP is supreme quality agricultural products, which are free from pests and pesticide residues.

In case of longan, the production area is mainly located in upper northern Thailand covering an area of about 50,000 ha with a production of 214,000 mt annually. Sixty percent of this is exported in terms of fresh and dried longan. The major markets for Thai longan are China, Hong Kong, Malaysia, Singapore, Japan, U.S.A. and the European Union. The main constraints to longan exportation are mainly aphid infestation and an excess limit of SO₂ as well as some prohibited pesticides in fresh longan. The DOA has initiated GAP for longan in order to solve these problems.

Under GAP, longan farmers are categorized into three different groups: GAP 1, GAP 2 and GAP 3. GAP 1 is a pilot project comprising 120 registered farmers where full requirements of GAP are strictly implemented. Emphasis is placed on production systems, quality as well as safety. In the case of GAP 2, where 3,500 farmers are registered, the emphasis is mainly on quality and safety. Similarly, GAP 3, where 600 farmer groups are registered with 20,000-30,000 members, the emphasis is mainly on safety. However, for all groups of GAP, the final product will be sampled for laboratory analysis and certification will be issued to the qualified products for exporting if they meet the requirements of GAP.

The implementation of GAP is relevant to the government campaign of promoting 2004 as a Year of Food Safety. This is to ensure consumers, whether national or international, of the quality of Thai products. Additionally, it is an aim to strengthen the competitiveness of Thai agricultural products in the world market, particularly under a free trade framework of WTO.

Integrated Pest Management: Strengthening Farmers' Management Practices in Pesticide-intensive Area

The IPM project is a collaboration between the Danish and Thai Governments. It has a 3-year implementation time frame (2001-04). The Ministry of Agriculture and Cooperatives (MOAC) organized the project with the implementation by the DOA and the Highland Agricultural Development Office (HADO) in cooperation with the Royal Project Foundation (RPF). The goals of the project are to improve environmental conditions and enhance the safety of farmers as well as consumers through appropriate management practices. The target areas are in northern, central and eastern parts of Thailand where pesticides are intensively used in particular crops such as fruits and vegetables. The main activities are training on IPM, on-farm trials, enhanced bio-pesticide use, laboratory analysis, farm certification promoting green produce, and developing residual test kits.

In upper northern Thailand, the IPM project is concerned mainly with longan, lychee, citrus and vegetables. The farmers normally apply pesticides and in most cases use them inappropriately. The IPM project plays an important role in reducing the hazardous effects of improper chemical application through training programs and on-farm trials with bio-pesticide as an alternative to replace chemical pesticides. Currently, a 3-month training of the trainers (TOT) course with the use of a farmer field school is conducted under cooperation between FAO, the Danish and the Thai Governments.

MAJOR OBSTACLES TO EXPAND THE SELECTED INNOVATIVE ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES

Despite implementation of selected innovative environment-friendly agricultural practices, the expansion of these practices has been relatively sluggish owing to some major constraints.

1. Technical Factors

The main technical factors concern some impractical techniques such as the preparation of bio-pesticides and bio-fertilizers in organic farming as well as in IPM. Also, most environment-friendly agricultural practices need a longer-term period in order to be proved viable at the farm level. Therefore, farmers who are already familiar and comfortable with conventional agriculture are reluctant to adopt them.

2. Economic Factors

The major economic obstacles are inadequate capital of smallholders, particularly for pond excavation, in New Theory farming. Prices and marketing are also another constraint. This affects organic farming, GAP and IPM, which are market-oriented. Moreover, debt is considered as another main obstacle for farmer adoption of innovative environment-friendly agricultural practices.

3. Social Factors

The main social factor is the attitude of both farmers and consumers, particularly in organic farming and IPM, where agricultural products are less attractive as compared to those from conventional agriculture. In addition, farmers need to fully understand the main concepts and principles of innovative environment-friendly agricultural practices to be adopted.

4. Political Factors

The major political obstacle is a fragmented and discontinuous government policy, particularly in an unstable political status as well as under coalition government, of which policy is an integration of coalition parties. In addition, agro-ecological zoning needs to be identified coupled with legislative measures and other technical incentives to promote innovative, environment-friendly agricultural practices.

POLICIES AND REGULATIONS TO MITIGATE THE NEGATIVE IMPACT OF AGRICULTURAL PRACTICES AND THE MAJOR CONSTRAINTS OF IMPLEMENTATION

The current Thai Government has embraced an agricultural policy to promote integrated farming and organic farming as well as to enhance learning processes that strengthen farmer capability. A national standard for organic crop production has been formulated and is in compliance with international standards. Presently, there are 14 certified private companies concerned with 10 exportable organic products. Moreover, the government has planned to promote the country as a center for organic food production in the region.

Under recent restructuring programs, there were large institutional changes in governmental organizations, particularly at the ministry and department level. The Ministry of Natural Resource and Environment (MNRE), a newly established ministry, is responsible for the sustainable management and conservation of natural resources and environment. Also, the Office of National Standard for Agricultural Commodities and Food (ONSACF) has been established under the MOAC, in order to protect consumers and ensure them of high quality agricultural products.

Since March 2003, the government has required exporters to declare certification of laboratory analysis for the export of 12 major fruits and vegetables to seven main importing countries. This is being currently implemented with longan and durian. This policy is implemented in combination with the GAP campaign so as to ensure food safety for importers and consumers.

In order to protect consumers, farmers, and the environment, the government has recently banned *methamidophos*, an organophosphate pesticide commonly used among farmers. To date, over 100 toxic pesticides have been banned and some additional ones are currently under a blacklist.

The major problems and constraints to implementing these policies and regulations are listed as follows:

- The success of organic farming depends largely on farmers, consumers, researchers, and inspectors. Presently, the number of field inspectors is limited. There is an urgent need for the training of more inspectors to implement the policy.
- The current staff of ONSACF is limited in contrast to its mission, which covers the whole nation. Therefore, regional offices and staff are required.

- In relation to the regulations for exporting of the 12 major fruits and vegetables, regional laboratories need to be equipped to offer full services.
- The success of toxic pesticides prohibition depends heavily on farmers and pesticide importers. Thus, there is a need for training of farmers coupled with legislative measures.

CONCLUSION

The adverse impact of agricultural practices on environmental sustainability needs to be viewed in a holistic approach with system-based perspectives. Therefore, a solution for the problems facing us needs a strong collaboration of all stakeholders including both governmental and non-governmental organizations. Moreover, there must be a strong political will with sustainable financial support to minimize the negative impacts of agricultural practices on environmental sustainability.

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9. VIETNAM

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INTRODUCTION

During the past 16 years, Vietnam's economic growth rate has averaged 8 percent per annum with agricultural growth being 4-5 percent. In this time period, agricultural production has adequately met domestic consumption demand and yielded surplus for exportation. Vietnamese output of foodstuffs has increased 5.6 percent annually in the past decade from 18.2 million mt (1986) to 30.6 million mt (1997.) Vietnam exports rice only second to Thailand on the world market. Also, Vietnam is an exporter of aquatic products as well as coffee. Other significant exports include rubber and forestry products.

Most of these achievements can be attributed to the policies set by the Vietnamese Government in the past decade. The government policies were designed to develop a multi-sectional commodity economy. This development of commodity production by households is based on entrusting forestlands to long term, private management of the country's natural resources. Also, better incentives, legal conditions and business environments as means of support and encouragement for the development of agricultural production has had a positive effect on Vietnam's growth. A focus for rural areas has been industrialization and modernization, food security and poverty elimination. On the negative side, as the Vietnamese economy and agriculture sectors have advanced, there has been a corresponding change in the natural environment, namely; a degradation of natural resources.

IMPACTS EXERTED BY POLICIES AIMED TO PROMOTE PRODUCTION AND DEVELOPMENT ON THE ENVIRONMENT AND NATURAL RESOURCES

Impacts on Forestry and Forest Products

Deforestation has slowed in the last few years in Vietnam but the amount of denuded uplands is still alarming. The country's forest cover has been reduced to 9.3 million ha. Abuse of exploitation (exceeding permitted quantity, not following right processes, exploiting in a destructive manner, etc.) has led to upland degradation manifesting itself in low production, siltation of the country's waterways and coastal areas, and poverty.

Afforestation and reforestation cannot only help replenish needed timber and forest products, but also give environmental benefits for society through the process of tree planting. Therefore, support provided by the State to reforestation schemes is needed, especially for protective and specialized forests. These forests are beneficial to safeguard the environment through conservation of biological diversity. Production forests specialized in delivering timber and other forest products for profit also needs assistance from the Vietnamese Government.

Impacts on Aquatic Production

Aquatic production is impacted by a polluted environment and also serves as a major causative factor in water and sea pollution itself. Pollution caused by industrial waste has seriously affected Vietnamese aquatic resources. At the same time, agricultural growth with more intensive cultivation and more application of insecticides, chemicals, etc., has contributed to degradation of water sources, environment, and many aquatic flora/fauna. This has affected mangrove forests and coral reefs in coastal areas. Shrimp production, a major export commodity, has shown to be economically viable but an environmental hazard to coastal ecosystems. Moreover, farmers and fishermen, using improper techniques (e.g., dynamite, chemicals, electricity, etc.) have taken their toll on aquatic resources.

Impacts on Agriculture and Animal Husbandry

Agriculture

The Vietnamese policy regarding production and export of vegetables and fruits has affected certain aspects of the natural resources and environment. Vegetable and fruit producers have used thousands of tons of insecticides, plant protective chemicals, and stimulants without following the proper technical processes. Insecticide residues in vegetables and fruits are commonly high.

Animal Husbandry

The pollution from husbandry waste is extremely high and a large part of it penetrates into the ground and underground water sources. According to an assessment made by the Health Preventive Department, Ministry of Health, environmental hygiene problems in rural areas of the country is alarming. The increasingly polluted environment has contributed to various kinds of diseases such as eyesores, diarrhea, and especially dangerous epidemics like cholera and typhoid.

PRINCIPAL CAUSES OF NEGATIVE IMPACTS BY DEVELOPMENT POLICIES ON NATURAL RESOURCES AND ENVIRONMENT

1. Policymakers, producers, business people and even consumers do not understand that Vietnam's natural resources are not limitless. This causes excessive use, which impacts sustainable development and will be a price that future generations have to pay.
2. Producers, for immediate profits, while forgetting their responsibilities in safeguarding environment, have excessively used more resources than expected and at the same time freely discharged waste materials onto lands, into water sources, and to the atmosphere. In addition, as the State's role blurs due to privatization, more arbitrary activities will occur as people are less responsible to the environment.
3. Policies designed to promote development have not paid enough attention to preserving natural resources and the environment. This is especially seen in regards to agricultural, forestry, and aquatic production, which are closely connected to resources and environment.
4. Increasing and enormous population pressures (79 million in 2002,) 80 percent of whom must depend on agriculture with limited land resources, has led to increased pressures on employment, incomes, and the living conditions of each family. This has resulted in direct and indirect detrimental impacts on natural resources and the environment.
5. Population growth and the difficult conditions in certain regions has resulted in free immigration into larger cities like Ho Chi Minh, Hanoi, etc., or into provinces with large, vacant lands such as those of the High Plateau, Mekong Delta, South-Eastern Vietnam, etc. This has led to more pollution, forest burnings, unlawful land cultivation, greater animal hunting, etc., all of which are detrimental to the environment.
6. Economic growth may lead to excessive use of natural resources, such as land, water, and minerals of all kinds. This contributes to environmental degeneration because investors generally are concerned with short-term profits, while neglecting long-term socioeconomic and environmental considerations. Development policies, in which there are cheaper, protective measures with protective elements for the environment, have not yet been given priority. They are not yet integrated into overall socioeconomic development programs. Sanctions for violators have not been thoroughly enforced at all levels. Instead, numerous measures and policies may have actually encouraged excessive abuse of natural resources as production inputs.

RECOMMENDATIONS

- *On policies governing development and protection of resources and the environment:* Besides having the objective of production development and output and product growth, policy must also aim at preserving and regenerating natural resources and the ecological environment for the sake of sustainable development.
- *On profits enjoyed by producers and consumers of agricultural products:* It is necessary to require State intervention at policymaking and local levels which are responsible directly to production in order that producers may understand the harms caused by toxic chemicals. Timely and strictly

imposed punishment should be given to people who abuse toxic chemicals. We cannot let the market modify this situation.

- Development planning of products in any field must be closely connected with measures and sanctions aimed at protecting natural resources and environment.

ENVIRONMENT-FRIENDLY AGRICULTURAL PRACTICES

At present, some Vietnamese farmers use environment-friendly technologies such as organic farming, green manuring, cover cropping, integrated pest management (IPM), integrated farming, integrated soil nutrient management, soil and water conservation techniques, etc., to protect natural resources and environment. Some are discussed below.

Organic Farming

Practices involved in organic farming appear highly complementary to sustainable agriculture. Such organic practices as crop rotation, crop spacing, intercropping, mulching, resistant cultivars, and tillage have pest control benefits. These practices also offer energy savings and soil improvement.

Integrated Pest Management

There are many indicators that pesticide use is increasing in Vietnam and the trend is likely to continue. This means the problem of using different types of pesticides will also increase. Despite recommendations and suggestions, farmers are using highly toxic and persistent pesticides because they want to see immediate and long-lasting results. They have little knowledge about the safe use and handling of pesticides and do not understand safety measures provided on the labels of the pesticides. Together with promotion, advisement, checks, selection, and registration of pesticides, Vietnam has applied IPM on rice. With the assistance of various international organizations, this program has helped farmers to understand the proper use of chemical pesticide in such away as to be rational, effective and safe.

In order to minimize incidents caused by pesticide mishandling, management of pesticide utilization has been considered as important measure. Plant protection networks, from central to local institutions regularly carry out promotion, guidance, training, and education activities in pesticide application. Simultaneously, plant protection organizations execute constant inspections and test activities to discover violators in the field of pesticide usage. Results are still limited, but it will take considerable time to raise the knowledge of correct pesticide utilization and decrease the damage of pesticide usage caused by lack of sufficient knowledge of farmers.

Integrated Farming

In Vietnam, a country of mainly small-scale farmers, an indigenous integrated farming system called VAC has rapidly gained interest. Although plots are small, most farmers can achieve a surplus for the market within six months to two years after starting the work (X. N. Pham, undated.)

The VAC system is a highly intensive method of small-scale farming in which food gardening, fish rearing and animal husbandry are integrated. Developed from traditional gardening in the fertile Red River Delta, which is a major rice growing area, VAC farming is now practiced in most regions of Vietnam. In 1986 the Association of Vietnamese Gardeners, VACVINA, was founded to promote this system.

VAC produces a diversity of easy-to-grow nutritious vegetables, fruits and animal proteins. Thus it is a very effective approach to combat malnutrition and increase income. Research has shown that in many communities in the Red River Delta where VAC farming is practiced, income from VAC constitutes 50-70 percent of farmers' income. Annual income through VAC farming is 3-5 times higher than that derived in the same area from growing two rice crops per year. For this reason, VACVINA gets support from the government and international organizations such as UNICEF.

1. The Basic Design

First, a hole is dug in the ground. The soil from the hole is used for the foundations on which the house and the animal sheds are built and to raise garden beds. House and gardens need to be protected from rising water, as the Red River Delta is flooded each summer. Rainfall and the high water table turn

the hole itself into a pond. In this way a small area is created where animal husbandry, gardening and fish rearing can be combined adjacent to the house.

Crops are grown in the garden in a bio-intensive way without the use of chemicals. Various species are intercropped and overlapped to make full use of moisture, solar energy and soil nutrients. Fruit trees are interspersed with vegetables, beans and tuber crops, which grow in the shade. Other legumes are grown along the edge of the garden and timber trees and rattan are planted to form green fences.

A variety of fish is raised in the pond so that different water depths are fully used for producing food. Taro (*Colocasia* sp.) is planted around the pond and marsh-lentils cover part of its surface. Gourds are grown on a trellis just above the water.

Swine and poultry sheds are situated close to the pond. Pig manure is used for plant and fish food and various garden by-products are used to feed the livestock and fish. During the dry season, the pond provides nutrient-rich water and sludge to irrigate and fertilize the garden.

The whole family operates the VAC system. They consume or sell the products, and in return, they contribute organic waste to the system. VAC farming allows women to work in a healthy environment close to their homes and children, instead of going to distant rice fields or off-farm construction work.

2. Modifying VAC

The original VAC model has been modified to suit Vietnam's three principal ecological regions: the coastal areas, the deltas, and the foothills and mountains. Further modifications are being made to suit particular conditions such as in cyclone-susceptible dune areas.

In the coastal areas, a typical VAC garden is bordered by a row of *Casuarina equisetifolia* acting as a windbreak hindering drifting sand and filtering salt. Other trees and rattan are densely planted on mounds built up around the garden as protection. Within the garden, a variety of fruit trees are grown. Fish and prawn are raised in brackish ponds and canals.

In the delta areas, especially the Mekong Delta, people dig canals around and between their gardens to achieve better drainage and to wash salt from the soil. Fruit trees grown here are selected according to their suitability to water quality and soil type. On land close to the coast, coconut palms are intercropped with rambutan, mango, citrus, banana, guava, and pineapple. A little further inland, citrus species dominate and are intercropped with coffee, cacao and pepper.

In the foothill and mountain VAC system, the higher and steeper slopes are covered with timber trees intercropped with nitrogen-fixing plants and trees. Further down the slope timber trees are mixed with coffee or tea or with fruit trees such as apricot, plum, persimmon and longan. Peanuts, pulses, medicinal herbs and tuber crops are planted underneath. A series of small ditches and contour banks are built along the slopes to prevent erosion. Pineapples are often grown along the contour banks. Near the foot of the hill, close to the house, the vegetable garden, animal shed and fishpond are situated.

3. Spreading VAC

To extend its activities, VACVINA applies the strategy of "from model farms to extensive fields." This starts from the experiences gained on selected pilot farms situated in each typical ecological region. Pilot families are selected and then VAC techniques are introduced through on-farm training, seminars, field practice and VAC club practitioners. On the basis of this information the pilot families design their own local VAC system.

With support of technicians and supplies (tools, animals, fishes, improved seeds and documents) from VACVINA, they create their own VAC garden. When the first results are achieved, a meeting is organized for trainees and activists in neighboring communities to assess the work done and to exchange experiences. When results and benefits are evident and understood by the local people, VAC practices are extended to the surrounding areas. With the new policy of the Vietnamese Government to encourage promotion of family self-reliance and income, the VAC movement is becoming stronger and playing an important role in improving people's lives as well as diversifying Vietnamese agriculture and protecting natural resources and the environment to ensure sustainable development.

PRIORITY ACTIVITIES FOR SUSTAINABLE DEVELOPMENT IN AGRICULTURE

In closing, there some activities should be given priority for developing sustainable agriculture in Vietnam. Basically, they fall into three categories:

Legislative Aspects

- Improve the legal framework and policies relating to land and water management and protection. Protective measures for the protection of plant and animal varieties need to be improved, including import and export regulations. Farming methods need to further encompass environmental management and protection methods. Further improvement is needed with the system of legislation and policies on land, water and other natural resources used in agriculture, forestry and fishery sectors.
- Strengthen the coordination between section, agricultural, rural and environmental management agencies with other management bodies. Provide further training to managers at central and local levels to improve their management capacity in sustainable development.
- Formulate rural development master plans, encouraging rural urbanization in a proper manner via financial policies, technological development policies and population policies to enable sustainable development in both urban and rural areas.

Economic Aspects

- Speed up the process of land consolidation and transformation in the areas where land is divided into small lots in order to facilitate modern farming methods.
- Formulate and implement programs for the improvement of land productivity and the responsible use of water resources. Apply agriculture, forestry and fishery combined production systems relevant to the conditions of each region for improved and integrated efficient use of water, land and climate resources.
- Expand the production of and the market for clean agricultural products, paying attention to product quality control in order to create consumer confidence in food safety.
- Develop the processing industry for animal and aquaculture products, edible oil, sugar, fruit and vegetables to improve food and foodstuff categories and production efficiency. Improve environmental quality in the processing industry. Improve the systems of food preservation, warehousing, processing and distribution at all levels.
- Strengthen the process of transformation and labor utilization in the rural economy. Diversify the structure of production and business in order to create more employment on the spot. This will improve income and redistribute rural labor, thus facilitating stable human settlement and reducing the pressure of urban-rural migration.
- Consolidate and further improve the existing system of technical services in agriculture, forestry, animal husbandry and fishery. Establish a system providing guidance on agricultural product production and consumption.
- Construct rural infrastructure and develop irrigation facilities to expand irrigated areas. Provide clean water supplies in poorer regions.

Technical and Technological Aspects

- Study and apply biotechnology in developing high yield and high quality crop and animal varieties. Establish high quality breeding centers and selectively import crop and animal varieties.
- Establish a network of agencies providing consulting services, training, and technical support for developing industry, small and handcraft industries and traditional trade villages in rural areas.
- Develop the production of organic and time-released fertilizers for ecological agriculture.
- Extend the application of organic agricultural production. Practice IPM universally.
- Preserve the local genetic resource base.
- Promote R&D (research and development) of advanced technology preservation and processing for agro-products.

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2. PROGRAM OF ACTIVITIES

(6-13 August 2003)

Date/Time	Activity
<i>Wed., 6 August</i>	
Forenoon	Opening Ceremony Presentation and Discussion on Topic I: <i>The Global Nitrogen/Carbon Cycles and Agricultural Practices for Environmental Sustainability</i> by Dr. Katsuyuki Minami
Afternoon	Presentation and Discussion on Topic II: <i>Appropriate Agricultural practices for Environmental Sustainability: Lessons from the Oil Palm Industry</i> by Mr. Cheng Hai Teoh Presentation and Discussion on Topic III: <i>Overview of Environment-Friendly Agricultural Practices and Technologies in Tropical Asia</i> by Mr. Koji Tanaka
<i>Thurs., 7 August</i>	
Forenoon	Presentation and Discussion on Topic IV: <i>Case Study on Farm/Household-level Environment-Friendly Agricultural Practices: Organic Farming</i> by Mr. Michio Uozumi Presentation and Discussion on Topic V: <i>Village Level Environment-Friendly Agricultural Practice: The Sloping Agricultural Land Technologies (SALT) of the Southern Philippines and Asia</i> by Mr. J. Jeffrey Palmer
Afternoon	Presentation and Discussion on Topic VI: <i>National and Regional Level Environment-Friendly Agricultural Practices: Integrated Watershed Management in India</i> by Dr. V. Anbumozhi Presentation of Country Papers by Participants
<i>Fri., 8 August</i>	
Forenoon	Presentation of Country Papers by Participants
Afternoon	Presentation of Country Papers by Participants
<i>Sat., 9 August</i>	
Forenoon	Presentation and Discussion on Topic VII: <i>Sustainable Agricultural Practices and Farming System: Comprehensive Understanding and Future Directions</i> by Dr. Vo-Tong Xuan Workshop 1: Constraints on Expansion/Extension of Environment-Friendly Agricultural Practices
Afternoon	Continuation of Workshop
<i>Sun., 10 August</i>	Free
<i>Mon., 11 August</i>	
Forenoon	Leave Tokyo for Kooriyama, Fukushima Prefecture
Afternoon	Visit Atsushiokanou Village Office (Yama-gun, Fukushima Prefecture) Visit JA Aizu-ide Atsushiokanou Village Branch Office (agricultural cooperatives)

Tues., 12 August

Forenoon

Afternoon

Leave hotel

Leave Kooriyama for Tokyo

Wed., 13 August

Forenoon

Workshop 2: How to Reorient Agriculture Practices toward Environmentally Sustainable Development: Role of Stakeholders

Summing-up Session

Closing Session