MAJOR LAND RESOURCE STRESSES IN RELATION TO SUSTAINABLE AGRICULTURE IN ASIA

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ABSTRACT

Globally, there is enough high-quality land to support nearly double the current population. However, Asia already has an acute land shortage, and as a region it is already on the verge of a food deficit. Feeding the 4.2 billion people expected for the year 2025 cannot be achieved with available land resources. Under the low-input systems found in much of Asia, productivity will continue to decline as land degradation and other factors take their toll. Further, lack of political will, insufficient investment into modern agriculture, and a general indifference to sustainable land management, guarantee a food deficit and in some countries, contribute to poverty and famine. Local and regional food shortages are likely to continue to occur unless mechanisms for equitable food distribution, effective technical assistance and infusions of capital for infrastructure development are implemented throughout Asia.

INTRODUCTION

In the last two decades, a dramatic change has taken place in our thinking about research and development for agriculture in general, and utilization of the natural resources in particular. Even in the poorer third world countries, there is an increasing awareness of the need to maintain a healthy ecosystem and the quality of the environment. In many countries, especially in the affluent countries of the world, national priorities for environment management are in place. Donor countries that provide assistance to the developing world are requiring that this becomes an obligatory requirement for developmental assistance. The rationale for this approach is that the environment transcends national boundaries, coupled to the valid argument that environment and quality of life are linked. The concept of sustainable development was initiated by the Bruntlandt Commission (WCED 1987) and developed further by Agenda 21 of the United Nations Conference for Environmental Development (UNCED 1993).

Despite a political commitment to the concepts of AGENDA 21 by practically all countries of the world, implementation is still elusive in many third world countries. Lack of funds is a major impediment, but in addition there is the daunting task of showing resource-poor farmers the complexity of the environment. Even the scientific community is grouping with the "holistic approach" which, is the most popular "buzz-word" today. There is thus an atmosphere of uncertainty as to which approach should be taken.

Affluent countries have decided to reduce agricultural production, and research funding is given only to agricultural research with an environmental context. Unfortunately, this view is directly and indirectly (through assistance) imposed on third world countries, which must still face the challenge of increasing food and fiber production to satisfy the needs of a growing population.

The issue in third world countries, as exemplified by Asia (Eswaran *et al.* 1994), is "unsustainable crop yields, unacceptably high rates of soil erosion, deforestation, loss of germplasm diversity, and bewildered farmers who do not know what to do next to eke out a reasonable standard of living…".

Keywords: Asia, constraints, food deficit, land resources, soil map, soil stresses

This paper attempts to examine in this context the need for land resource assessment and monitoring. A major consideration is the diminishing budget that excludes many basic research activities (Mermut and Eswaran 1997). At the same time, recent technology permits rapid information management and delivery, and in a more client-friendly manner. Finally, an environmental orientation has different needs from the previous production orientation, and so requires a new agenda for land resource assessment and monitoring.

Method of Assessment

There are many stresses experienced by a land resource system and its soils (Buol and Eswaran 1994). However, there are frequently one or two major stresses that prevent the use of the land for most agricultural purposes. Some of these stresses cannot be corrected, e.g. low temperatures unless heated glass-houses are used. Others may be corrected, e.g., irrigation for areas with moisture stress. Correcting the major stress may or may not ensure sustainable use of the soil. Other stresses may be present, or correcting one stress may result in creating another stress. An example is irrigation in dry lands without adequate drainage. The result is salinity build-up within a short period of time, which reduces the quality of the land.

Using a soil map of the world which also includes information on soil climate is the first step in making a broad assessment of the major land resource stresses. On the map, each soil is assigned one major stress, if stresses occur. To do this, the stresses are listed in a priority ordering (Table 1) and each soil unit (polygon on the map) is tested to determine, if it meets any of the 24 (from number 2 to 25, in Table 1) identified stresses. If the soil fails to meet any of the 24 stress classes, then the polygon is indicated as having "Few Constraints" (class 1). To make the map easier to understand, multiple stresses are not depicted, though it is recognized that soils with multiple stresses may be the rule rather than the exception. Other stresses may be important locally. These can be represented on national or regional maps.

Each of the 24 stresses listed in Table 1 requires a different level of financial investment to correct for agricultural use. The cost of correcting the stress is the main factor used to define classes on the list. The cost of correcting the stress varies with the country and the kind of stress. For sustainable development, an understanding of the kinds of stresses and the costs involved for correction and maintenance is essential.

The quality of the land shows great variation between and within countries. In this study, the quality of the land in countries of Asia was also assessed and from this, an estimate of the current population supporting capacity of each country was estimated. Each country has land of differing capabilities, according to the quality of the soil and its performance under the prevailing climate. Until recently, databases that provide such information were not readily available. The FAO/UNESCO Soil Map of the World (FAO 1971-1981), provides for the first time a computer database of global soil resources (FAO 1991). The authors compiled a global climate database, using data from about 25,000 stations. Using a water-balance model, the soil moisture and temperature regimes were computed. Using GIS, the soil climate information was overlaid on the soil map. The combination of soil and climate information was used to empirically assign land quality classes, using the matrix shown in Table 2 (Wang *et al.* 1990).

A country boundary overlay made it possible to compute land quality classes for each country. The error of such computation is estimated to be about 50 km^2. Population and arable land area data for 1995 and projections for 2025 were taken from FAO statistics. The terms and the characteristics of each of the nine classes are described in Table 3.

Land Resource Stresses in Asia

The first assessment of the major soil related constraints to land use in Asia was made by Dent (1990). In this assessment Asia includes all countries from Afghanistan in the west to Japan and Korea in the east (Table 4). It includes China and Mongolia, but excludes the Central Asian Republics and the eastern part of Siberia. Indonesia, Papua New Guinea, and the Solomon Islands form the southern limit. Australia is excluded from this assessment. The scale of the database also prevents a good assessment of the Pacific Island nations.

His assessment is based on a priority listing and multiple stresses are not considered. However, areas designated as "continuous moisture stress" may have soils with salinity problems and low water holding capacity.

There are about 58,000 km^2 of land in Asia with long cold periods, which precludes use of the land for most agricultural purposes. These are mainly in Mongolia, northern China and in the high mountains of Pakistan and India. The deserts of Asia are the Thar desert of India and Pakistan, and the

Table 1. Description of major land resource stresses or conditions

Stress class	Land quality class	Major land stress factor	Criteria for assigning stress
25	IX	Extended periods of moisture stress	Aridic SMR, rocky land, dunes
24	VIII	Extended periods of low temperatures	Gelisols
23	VIII	Steep lands	Slopes greater than 32%
22	VII	Shallow soils	Lithic subgroups, root restricting layers <25 cm
21	VII	Salinity/alkalinity	"Salic, halic, natric" categories;
20	VII	High organic matter	Histosols
19	VI	Low water holding capacity	Sandy, gravelly, and skeletal soils
18	VI	Low moisture and nutrient status	Psamments, Spodosols, ferritic & oxidic soils, aridic subgroups
17	VI	Acid sulfate conditions	"Sulf" great groups and subgroups
16	VI	High P, N, organic compounds retention	Anionic subgroups, acric great groups, oxidic, sesquic, ferritic families
15	VI	Low nutrient holding capacity	Ultisols, Oxisols. Dystric great groups; excluding soils with plinthite
14	V	Excessive nutrient leaching	Soils with udic, perudic SMR, but lacking mollic, umbric, or argillic
13	V	Calcareous, gypseous conditions	With calcic, petrocalcic, gypsic, petrogypsic horizons; carbonatic and gypsic families; exclude Mollisols
12	V	High aluminum	pH < 4.5 within 25 cm
11	V	Seasonal moisture stress	Ustic or Xeric suborders but lacing mollic or umbric epipedon, argillic or kandic horizon; excluding Vertisols
10	IV	Impeded drainage	Aquic suborders, "gloss" great groups
9	IV	High anion exchange capacity	Andisols
8	IV	Low structural stability	Entisols except Fluvents
7	III	Short growing season due to low temperatures	Cryic or frigid STR
6	III	Minor root restricting layers	Soils with plinthite, fragipan, duripan, petrocalcic, petrogypsic, densipan, petroferric contact, placic, < 100 cm
5	III	Seasonal excess water	Recent terraces, aquic subgroups
4	II	High temperatures	Isopherthermic and isomegathermic STR excluding Mollisols and Alfisols
3	II	Low organic matter	With ochric epipedon
2	II	High shrink/swell potential	Vertisols, vertic subgrops
1	1	Few constraints	Other Soils

Table 2. Matrix which defines land quality classes

Soil performance	Soil resilience Low	Medium	High
Low	IX	VIII	VI
Medium	VII	V	III
High	IV	II	I

Taklamakan desert of China extending into Mongolia. Water is limited unless irrigation is available. With good irrigation, as around Urumchi in China, the deserts are very productive. In the absence of appropriate drainage outlets, as in parts of Pakistan and India, there is rapid build-up of groundwater and salinity. Sustainable agricultural systems can be developed in deserts if good land management is practiced.

Steep sloping land and shallow soils overlying rock are major constraints to agriculture. Most countries of the region certain such lands, and if the climate is favorable, they are generally under forest. In the semi-arid and arid parts of the region, the steeper terrain and shallow soils are generally used for grazing small ruminants. The four land resource constraints listed in Table 4 – continuous moisture stress, continuous low temperatures, steep slopes, and shallow soils – are land use constraints that cannot be corrected easily by technology. It would be very difficult to have any form of sustainable agriculture on such land.

Four other constraints are less severe. Soils with high shrink-swell potential are the Vertisols. India has the largest extent of Vertisols in the region. In a semi-arid environment as in India, the soils are hard when dry and sticky and plastic when wet. With traditional bullock-drawn plows, the soils cannot be tilled before or during the rainy season. Tilling is generally done at the end of the rainy season and the plants grow on the stored moisture, making them very susceptible to moisture stress. Yields are consequently low and production uncertain.

In the semi-arid and arid parts of the region, there are expanses of saline and alkaline soils. However, salinity induced by irrigation is also consuming large areas of land in the semi-arid regions. In addition to availability of moisture, salinity is a major problem of the semi-arid tropics.

In the humid tropics, two major groups of problem soils are the acid soils and those with low fertility. Acid soils are dominant in the humid tropics, and are common in coastal plains. Many of the "cat-clays" are being used for rice cultivation, with mixed success. Acidity in upland soils reduces crop production both directly and indirectly, due to its interactions with other soil components. In many of the acid soils of the humid tropics, exchangeable aluminum is the cause of acidity. Aluminum affects root elongation and has other physiological effects on most plants. In acid sulfate soils, the acidity is due to hydrogen. Acidity does not affect biomass production if the soil is flooded during crop growth. Only when there is insufficient water, particularly during the initial growing stage, is the plant susceptible to damage. The highly weathered and leached soils of the humid tropics – the Ultisols and Oxisols – have fertility-related constraints in addition to being acid (Eswaran *et al.* 1997). Phosphorous, together with calcium and potassium, is generally unavailable. Any kind of agriculture on these soils requires ample application of these nutrients plus nitrogen. Some of the Oxisols and Andisols have a net positive charge, and these soils cannot hold the basic nutrients if organic matter is low. Sustainable management of these soils implies organic matter management and appropriate nutrient management.

The other remaining major land resource stresses include poor internal drainage, which limits the soils to specific uses such as paddy cultivation. However, particularly if the soils occur on the coastal plains, acid sulfate conditions may prevail in the subsoil. This reduces the quality of the soils. High anion exchange capacity is a property of the volcanic ash soils and some of the Oxisols. They have a propensity to fix anions and make them unavailable to plants.

The peat deposits of the region represent the last constraint. These soils are dominated by organic matter, which presents different kinds of problems for cultivation and sustainable agriculture (Padmanbhan and Eswaran 1998).

Soils with few constraints are not the dominant soils in any country. These soils are generally considered to be prime agricultural land.

Table 3. Properties of the inherent land quality classes (Obtained by a combination of the performance and resilience attributes of soils in the context of their inherent stresses)

Land quality class	Properties
1	This is prime land. Soils are highly productive, with few management-related constraints. Soil temperature and moisture conditions are ideal for annual crops. Soil management consists largely of sensible conservation practices to minimize erosion, appropriate fertilization, and use of best available plant materials. Risk for sustainable grain crop production is generally < 20%.
II & III	The soils are good and have few problems for sustainable production. However, particularly for Class II soils, care must be taken to reduce degradation. The lower resilience of Class II soils makes farming more risky, particular for low-input grain crop production. However, their productivity is generally very high and consequently, response to management is high. Conservation tillage is essential. Buffer strips are generally required and fertilizer must be carefully managed. Due to the relatively good terrain conditions, the land is suitable for national parks and biodiversity zones. Risk for sustainable grain crop production is generally 20-40% but risks can be reduced with good conservation practices.
IV, V, & VI	If there is a choice, these soils should not be used for grain crop production, particularly soils belonging to Class IV. All three Classes require important inputs of conservation management. In fact, grain crop production must not be contemplated unless there is a good conservation plan. Lack of plant nutrients is a major constraint, and so a good fertilizer use plan must be adopted. Soil degradation must be continuously monitored. Productivity is not high, so resource-poor farmers must receive considerable support to manage these soils or be discouraged from using them. Land can be set aside for national parks or as biodiversity zones. In the semi-arid areas, they can be managed for ranching. Risk for sustainable grain crop production is 40-60%.
VII	These soils may only be used for grain crop production if there is a real pressure on land. They are definitely not suitable for low-input grain crop production; their low resilience makes them easily prone to degradation. They should be kept under natural forest or range, although some localized areas can be used for recreational purposes. As in Class V and class VI, biodiversity management is crucial in these areas. Risk for sustainable grain crop production is 60-80%.
VIII & IX	These are soils belonging to very fragile ecosystems, or which are very uneconomical to use for grain crop production. They should be retained in their natural state. Some areas may be used for recreational purposes but under very controlled conditions. On Class VIII land, which is largely confined to the Tundra and Boreal areas, timber harvesting must be done very carefully with considerable attention to ecosystem damage. Class IX is mainly desert, where biomass production is very low. Risk for sustainable grain crop production is > 80%.

Table 4. Idealized land use patterns

Land class	Agriculture (grain crops) crops)	Biodiversity zones		Urban/ industry/ infrastructure
		Forestry	Wilderness	
	% of land			
1	70	20	5	5
II	60	30	5	5
III	50	35	10	5
IV	45	40	10	5
V	40	45	10	5
VI	30	50	15	5
VII	20	50	25	5
VIII	5	60	30	5
IX	5	30	60	5

Land Quality Assessment of the Region

There is a debate on the quality and quantity of natural resources required for sustaining human life (During 1989, Pimentel and Hall 1989). The population of Asia is currently about 3.2 billion people. Of these, 1 billion persons are malnourished and an equal number live below the poverty level. Both categories are socially or economically disadvantaged people who eke out a living from a plot of land that does not belong to them. As pressure on land increases, these less fortunate persons move to more fragile ecosystems, permanently destroying their productivity in the process (Stewart *et al.* 1990). This group of land users is not amenable to modern conservation practices or technologies. In general, they do not contribute to the food and fiber needs of society as a whole. In many countries, they are also the forgotten persons, ignored by the bureaucracy and disowned by the affluent of the nation. However, in their struggle to survive, their long-term impact on soil resources and environment may be so damaging that in reality they may control the quality of life of the nation as a whole. Pimentel *et al.* (1994) pose the question:

"Does human society want 10 to 15 billion humans living in poverty and malnourishment or 1 to 2 billion living with abundant resources and a quality environment?"

We already have too many people for the second option. Our question today is, how many more persons can our land resources support so that most persons can enjoy a minimum quality of life?

The challenge is to find a way of feeding and clothing the population without degrading the land and water resources (Smil 1987, Postel 1989). The first step is to obtain a better estimate of the quality of land resources, and how many people it can support. In the absence of reliable national resource inventories, we must use cruder information, such as regional level data.

If we consider the amount of land in each land quality class in each country, we find that some countries do not have any class I land. Afghanistan also has an insignificant amount of class II land. Classes I to III lands are generally the most productive lands of a country, though their ability to withstand mismanagement varies. Of the three classes, class II is least resilient, implying that they are most prone to degradation. It is probably correct to assume that, with the exception of a few countries such as Papua New Guinea, class I to III lands are mostly under agriculture. Classes IV to VI are generally more prone to degradation, and are the lands now being occupied by the landless. These are mainly hilly lands, although some are swamps. Most governments are unable to prevent people from using these lands. The more astute governments try to help the farmers to implement some kind of conservation technology.

Land is a limited resource in all countries. With time, the situation will worsen as soil degradation reduces the productivity of the soil. The exponential growth of urban centers consumes large areas of prime land. Those countries which have adopted large-scale irrigation programs generally risk salinization or alkalization, which slowly but surely develops when arid and semi-arid environments are irrigated.

Waterways crossing national borders become reasons for conflict when limits of the resource is reached. Further, the increasing requirements of non-agricultural water use will inflate prices, resulting in stringent irrigation policies that will be reflected in efficiencies of production. Inadequate or inefficient irrigation continuously reduces the amount of land that can be used for food production. (World Bank/UNDP 1990).

Another factor that prevents efficient use of land in many countries is the low purchasing power of the land users, the result of poverty (Swaminathan 1986). Appropriate inputs can double production. However, farmers may have no capital to invest in the land, or no incentive when they do not own the land. Sustainability and the efficient use of land can result only from the appropriate application of modern knowledge. Rein-carnating past technologies is not a solution to the challenges of today; it is an excuse for a lack of national will.

Population Supporting Capacity of Land

Land must also be used for purposes other than agriculture, such as forestry, recreation, and urban needs. The ideal partitioning of land for its multiple uses is based on social values and economic considerations. Table 4 is an idealized partitioning of land, based on its quality and its potential uses. There is always strong competition for land for multiple uses, and economic factors determine the final land use. In societies with strong social commitments, the economic forces are frequently required to compromise. In many parts of the world, large amounts of Class I land are being converted to non-agricultural uses. Table 4 shows the amount of land used for grain crop production, while Table 5 shows the population supporting capacity based on this figure.

The current population of Asia is already about 3.2 billion and is expected to grow to 4.5 billion by the year 2025. If we apply these estimates to the actual land area of each country in its various classes, it is clear that Asia as a whole will not be able to feed its population. Only a few countries such as Papua New Guinea, Myanmar, and Laos have land to spare. Others such as Malaysia and Indonesia, have enough land for grain crops but prefer to use it for cash crops such as rubber and oil-palm, and import food. Rich countries such as Taiwan, Singapore, and Japan rely on industry and services to earn money to pay for food. The remaining countries, which are not industrialized, will continue to exploit fragile land resources. Pakistan, India, Bangladesh, and China will continue to irrigate large parts of their arid or semi-arid lands and increase the proportion of lands under agriculture, thereby endangering the environment and permanently damaging biodiversity.

A NEW AGENDA

The attention given to soils from the point of view of research and development funds, does not match their significance. Governments seem to feel that much is already known about soils, and that generalizations made for one site are applicable everywhere. They also fail to recognize that agriculture is one of the major “stressors” of the environment.

The purpose of this Bulletin is to drive home the point that soils are a **“non renewable resource”**. Society has an obligation to protect them and their quality for future generations.

To help convince others, we have to evaluate past paradigms that brought some of the countries of the region to agricultural affluence. From here, we need to go onto current concerns, and the urgent need to develop new paradigms that will take us into the next millenium. We have to demonstrate clearly why some of the valid arguments of the past have little validity in the modern age of environmental degradation.

Ecosystem Based Assistance

Ecosystem Based Assistance (EBA) is a strategic initiative to enhance the quality of the ecosystem. It integrates biophysical, socioeconomic, and political considerations into relevant land use and management options for decisions on sustainable land use. It stems from the vision of a productive nation in harmony with a quality environment’.

In this approach, not only the individual components of the system are given attention as in the past, but more importantly, the interactions between the components are also considered. EBA enables us to provide assistance that considers the space-time dimensions of technical intervention.

To implement this strategic initiative, national institutions should:

- Maintain a strong science base;
- Enhance the linkages between the international institutions, national institutions, and land users to foster the collaborative spirit which must be the basis of all land management activities;
- Initiate appropriate structural changes

Table 5. Idealized population supporting capacity (persons/ha)

Level of inputs	Land quality class								
	I	II	III	IV	V	VI	VII	VIII	IX
Low	4	3.5	3.0	2.0	1.5	1.0	0	0	0
Medium	7	6	5	4	3	2	0	0	0
High	10	9	8	7	6	5	0	0	0

within national institutions to implement sound land use policy;

- Be proactive in information dissemination, to ally support and cooperation from farmers.
- Make necessary changes to procedures to facilitate implementation.

Land Quality and Early Warning Indicators of Land Degradation

The FAO/UNESCO/UNEP "Global Assessment of Soil Degradation" provides data to quantify the current magnitude of the soil degradation problem, as does (Oldeman *et al.* 1991). UNEP and WRI provide further analyses of these, and of other aspects of land degradation. Efforts to restore productivity to degraded lands must be coupled with the ability to monitor all stresses before productivity is significantly impaired (Greenland *et al.* 1998).

Causes of stressed systems are numerous. They include removal of nutrients, deve-lopment of acidity, salinization, alkalization, destruction of soil structure, accelerated wind and water erosion and loss of organic matter. In some regions of the world, a combination of these results in such degradation that the term "desertification" is popularly used.

Finally, it must be appreciated that there is an important interaction between the causes of degradation. Erosion, for example, may be seen as the major problem where chemical degradation of the soil prevents establishment of vegetation and thus the inability of the soil to stabilize against erosion (Dumanski *et al.* 1992). In this example, lack of appropriate vegetation becomes an early warning indicator. Very few studies have been conducted on this linkage between factors. There is an urgent need to look into this.

Land Productivity and Land Use Options

Sustainable land management (SLM) is the key to harmonizing the environmental concerns of society with the economic realities of producing adequate food and ensuring a minimal quality of life (Dumanski *et al.* 1992). SLM can only be realized if land users understand the impacts of land management options, so that they can optimize the benefits of their choice. Insufficient attention is given to this aspect of SLM. In addition to developing concepts and mechanisms of SLM, it is necessary to make a concerted effort to link SLM to the socio-economic realities of the farmer.

A framework for sustainable land management (Dumanski *et al.* 1992) may emerge as one of the most powerful tools for the sustainable management of land. It will provide the scientific basis for evaluating the environmental impact of proposed land use changes.

Research on land has traditionally been driven by agricultural imperatives. Although these are still important, the ecological concerns are increasing as a result of environmental problems (Szaro and Johnston 1996). The situation is made worse in developing countries by the lack of any kind of resource monitoring system. Knowledge of the resource base and the impact of different kinds of land use are the foundation of informed policy decisions (Tinker 1998).

Agrotechnology transfer to developing countries has generally had mixed success (Eswaran et al. 1997). Germplasm transfer has been more successful, but land management technology has often been a failure. Part of the reason has been the inability to integrate scientific techniques with conventional farming practices. Acceptance is generally greater when farmers have participated in the technology development. How to involve farmers in developing and implementing technology is a major challenge.

Soil and Environment Databases

Technology transfer demands changes, not only in the way materials and people are used in production, but also in the way information is managed. Agenda 21 of the Rio Conference in 1992 emphasized the need, particularly countries with limited natural resources, for technical decisions that are ecologically, economically, and socially acceptable. The information sources for making such decisions must be easily available, timely and accurate (FAO 1994). One approach for structuring and judging the value of information for decision making is a "decision support system (DSS)".

The decision support system (Beinroth *et al.* 1994) integrates information so a user can confidently make strategic and short-range decisions. A fully-developed DSS is a number of linked software packages that permits a user to access global, national, and local sources of information for decision making. Needless to say, appropriate data must be available at each level.

There are no reliable DSS systems that capture the wealth of information currently available. Many decisions are being made with minimal data, or data of low reliability. The user has few ways to determine the reliability (risk) of the proposed solutions. In addition to supporting decisions, a functional DSS also gives a measure of the risk associated with the output.

CONCLUSION

Everybody has endorsed the concerns and recommendations expressed in AGENDA 21. We are all aware of the fact that the finite global land resource base cannot easily provide for the increasing population and the increasing intensity of human activity.

In some parts of the world, production has exceeded increases in population, despite losses due to land degradation (Ehrlich *et al.* 1993). However, in other areas, particularly in the tropics, the situation is less encouraging. The current challenge is to maintain production in the well-endowed areas, and to manage the natural resilience of soils to establish sustainable production in unimproved and/or degraded systems.

To achieve this, the following action is needed:

1. There is a need to quantify soil resilience, and develop national and regional databases of soil resilience attributes and potentials for recovery.
2. To implement some of the recommendations of AGENDA 21 in the area of land resource planning and management, an assessment of current land use should be made at national and regional levels. This assessment will:
   - Define practices that are non-sustainable;
   - List practices that are not compatible with the resilience characteristics of the soil;
   - Identify those areas where efforts to increase production may collapse, the system;
   - Identify those areas where efforts to increase production may have negative off-site effects;
   - Identify those areas that are similar in terms of agriculture, ecology and economy.
3. To support the initiatives on ecosystem management of AGENDA 21, the following must be considered:
   - That research and development activities on land management should be holistic and consider the land unit (water-shed, catchment etc.) as a whole
   - That the knowledge of farmers and other land users should be utilized in all stages of projects;
   - That sustainability should be monitored during the whole duration of the activity.

Countries in Asia must realize that they are unsustainable, and that now or in the near future they lack food security. Local and regional food shortages are likely to occur at an increasing rate, unless mechanisms for equitable food distribution, effective technical assistance and infusions of capital for research and infrastructure development are implemented (Swaminathan 1986).

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