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Upland Development Programme
in Southern Mindanao (UDP)

FOOD FOR THOUGHT

Some thoughts regarding sustaining food production in the uplands with a changing climate and land degradation

by

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"Agriculture must be made a respectable, dignified, and comfortable profession devoid of drudgery and undue misery. The approach adopted should be dynamic to replace labor-intensive systems with labor efficient technologies….

The scientific community must address the issue of human values and dignity. Tilling land with obsolete manually powered tools, controlling weeds with a back-breaking hoe, threshing grain by beating with a stick or trampling by human and animal is not an inspiring profession.

Concern about over-dependence on nonrenewable and rapidly dwindling fossil fuels is genuine but is not a justification for condemning resource-poor farmers to sub-human operations"

"With the world's highest rate of population observed in many countries of the humid tropics, low-input systems alone are obsolete, environmentally incompatible, soil degradative, and responsible for perpetuating low standards of living".

Rattan Lal (1995)[1].

"The case for reduced use of pesticides through integrated pest management, without any cost in yield, has now been amply demonstrated. IPM can make major contributions to the maintenance of yields while reducing human health hazards.

Nevertheless, the challenge of increasing food production will necessarily depend on yield-enhancing mechanisms. This makes the case for minimizing the use of commercial fertilizers much less secure".

Dennis Garrity (2000)[2]

THE VIEWS EXPRESSED IN THIS REPORT ARE PURELY THOSE OF THE WRITER AND MAY NOT IN ANY CIRCUMSTANCES BE REGARDED AS STATING THE OFFICIAL POSITION OF THE EUROPEAN COMMISSION

[1] Lal, R. (1995). *Sustainable management of soil resources in the humid tropics*. United Nations University Press, The United Nations University 1995. http://www.unu.edu/unupress/unupbooks/uu27se/uu27se0b.htm

[2] Garrity, D. P., (2000).Contour Farming based on Natural Vegetative Strips: Expanding the scope for increased food crop production on sloping lands in Asia, In: *Environmental Development and Sustainability,* 1(Special Issue):323-336. (an ICRAF Leaflet). www.worldagroforestry.org/sea/ph/02_pubs/papers/03_cons/cont_01.pdf

EXECUTIVE SUMMARY

The Upland Development Programme in Southern Mindanao (UDP) was created in response to the need for sustainable development in the uplands. UDP advocates people-centered development that will meet the economic, environmental and social needs of the upland people. UDP addresses not only unsustainable farming practices and natural resource management, but other upland concerns as well such as marketing and enterprise development, rural financial services, agricultural infrastructure support and community & institutional development and extension.

The climate of the Philippines is characterized by relatively high temperature, high humidity, and abundant rainfall. Rainfall distribution varies regionally, depending on the direction of the moisture-bearing winds and the location of mountain ranges. Four types of tropical and maritime climates are found: Type 1 - a dry and a rainy season; Type 2 - no dry season; Type 3 - not very pronounced seasons; and Type 4 - an even distribution of rain throughout the year.

Upland farmers in Southern Mindanao are noticing that rainfall patterns are changing to the extent they are confused about when to start planting crops as the dry and wet seasons appear to be changing positions. Damaging droughts have occurred in the last few years, and there are indications that humidity is decreasing. Erratic weather is causing fruit farmers and backyard owners to lose millions of pesos in income.

Scenarios for climate change in the Philippines predict an increase in average daily temperatures by as much as 4°C. Wet seasons will become shorter but more rain will fall, while dry seasons will be longer with less rain falling. There will be an overall decline in annual rainfall.
Sea levels, having risen 20 to 40 cm since the 1960s, will continue to rise by 2 to 10 cm per decade.

A 25-65% reduction in maize yields, and lowered nutritional value of crops is foreseen, while higher temperatures will increase the number of insects attacking a crop. Crop losses to disease could increase by 100% for some crops. Increased cloud cover, due to wetter rainy seasons, is projected to limit photosynthesis, retarding the growing process. A reduction in intercepted radiation lowers yields of crops such as palm oil.

At temperatures above 20°C organic matter decomposes faster than its rate of accumulation, which can be three to five times greater than temperate climates. Humid tropical conditions give pests and diseases a *continuous* growing season in which to breed. These factors have implications for fertilizer and pest control strategies, particularly in organic farming. The view of farming systems analysts is *that in a hot, humid tropical climate, manures and composts can replace fertilizers in exceptional cases only*:

Sea level rises will affect offshore fisheries, and a *one metre* rise in mean sea level will lead a landward retreat of shoreline of about 2.5 km on land forms characterized by low-lying coastal plains. A rise in groundwater, accompanied by the upward movement of subterranean salt, will result in saline damage to rice fields and farmland soils. Substantial areas of agriculturally productive land are projected to become too saline for conventional crop production, and mangrove forests and their associated fisheries, will be lost.

Governments need to develop coherent policies *now* to prepare for a hotter, drier world. For example, developing new crops, constructing flood defences, setting different building regulations, or banning building close to sea level.

The loss of more than 50 cm depth of topsoil in the past 20 years over extensive areas of the uplands will complicate the problem of adapting to changing climate in the Philippines. The reduced volume of soil available for storing moisture will make crops more vulnerable to drought.

Recommendations to deal with climate change

- Support the Department of Agriculture in setting up "climate change farms" on the different land forms (Land Management Units) in the four different climate types in the Philippines.
- Reduced stream flows, as a result of excessive damage to critical watersheds in Southern Mindanao, has limited the potential to expand irrigated agriculture to counter losses from future anticipated salinisation from rises in sea levels. The climate change farms can play an important role in showing upland farmers how to achieve food security from small areas.
- In upland LMUs such as hills and mountains, crops with lower moisture requirements worth trying out include: sorghum, millet, mung bean (monggo), pigeon peas, cashew and guava. Monggo, planted at the end of the rains as a "catch crop" (i.e. to catch the last rain storms) can extend the growing season well into the dry season.
- Grow sorghum to provide feeds for livestock as well as fodder. Sorghum has lower moisture requirements than maize, and can recover after seven days without any moisture in the soil. Its ability to ratoon provides nutritious green fodder well into the dry seasons.
- On coastal land forms/LMUs already suffering from salinisation, plant vegetable cultivars that can grow in brackish water.
- Plant orchards of drought-tolerant perennial crops such as guava, citrus and cashew, In regions with distinct dry seasons, teach farmers to manipulate water stress levels to improve the flowering of species such as lychee and mango.
- Develop markets and post harvest processing facilities for the substitute crops.

Strategies for sustaining agriculture on infertile upland soils

The dominant soil orders of the rainfed uplands are acidic, deficient in phosphorus, potassium, calcium and magnesium and are inherently infertile. The main physical constraints are low available water holding capacity, and their susceptibility to erosion.

Field observations of soil erosion indicate annual soil losses of 400 t/ha/year (equivalent to a reduction in depth of the soil profile by 3 cm a year due growing corn on sloping land. Truncating soil profiles through erosion reduces the volume of soil available for storing moisture to support perennial crops over dry seasons. This will seriously affect upland agriculture if annual rainfalls continue to decrease.

The inherent soil infertility of the upland soils in the humid tropics limits the availability of mineral nutrients to the plant and the soil's ability to prevent leaching of applied nutrients. If Ultisols and Alfisols are to be used for sustainable agriculture, it will be necessary to apply nutrients from external sources, such as chemical fertilizers, biological nitrogen fixation, and nutrient recycling. Al and/or Mn toxicity and deficiency of essential nutrients in acidic sub-soils restricts root growth and proliferation. Exposed acid sub-soils require heavy applications of lime to replace Al and Mn with Ca and Mg as well as fertilizers used in conjunction with management practices that help maintain soil organic matter, such as returning residues or other organic materials to the soil, and minimum tillage. More publicity needs to be given to the BSWM's Balanced Fertilization Strategy, which advocates the use organic fertilizer in conjunction with inorganic fertilizers.

A change from local varieties of corn to hybrid cultivars and using fertilizer doubled corn yields is a proven way to achieve food security from small plots of land and free large areas of the farms for planting with more profitable and environmentally sustainable small holder timber and fruit trees.

The scientific literature emphasises that applications of inorganic fertilizers, and liming, are essential if agriculture on the upland soils of the hot, humid tropics is to be sustainable. The use of commercial fertilizers is increasing the productivity of farming systems in many parts of the tropics. Applying these external nutrients boosts the production of crop residues which is then available for recycling to the following crops.

Zero- or minimum-tillage eliminates all seed bed preparation and provides a protective crop residue mulch covering to the soil while minimising exposure of the soi. In the UDP area, farmers obtained 70% savings in labour and got up to three times the corn yields from the same area of land by killing the weeds with herbicide, planting hybrid seeds and applying inorganic fertilizers.

Organic farming

The recent increase in costs of inorganic fertilizers has led to organic farming being promoted by local governments in the belief that it is a cheaper option for resource poor farmers. A review of the appropriateness of organic agriculture in the uplands suggests it is not a suitable farming system for upland farmers. Organic agriculture requires more labour, gives lower yields and upland farmers are not guaranteed premium prices for their produce in the markets.

Soil scientists consider low-input agricultural systems alone to be obsolete, environmentally incompatible, soil degradative, and responsible for perpetuating low standards of living. (See Annex VI which reproduces quotes from the scientific literature stressing the importance of applying artificial fertilisers and liming for sustainable agriculture on most of the upland soils in the hot, humid tropics). Surprisingly, there is reluctance in some quarters even to do trials to compare the effectiveness of inorganic fertilizers with organic ones.

It is doubtful that organic agriculture alone will achieve the Project Purpose of addressing the upland communities' subsistence needs and produce marketable surpluses". Upland farmers might be better off spending the P15,000 certification fee (to be obtained every 18 months) to be certified as an organic producer on inorganic fertilizers, with a certainty of higher yields and increased incomes.

Hedgerows

Woody, leguminous hedgerows, planted in upland farms as barriers against erosion and as an alternative source of nitrogen input for acid upland soils, have proved to be inappropriate SWC measures for the long, steep slopes found in much of the uplands. UDP experience with hedgerows on long, steep slopes supports the view of soil conservationists that hedgerow intercropping may be applicable on gentle to moderate slopes, but it has only speculative potential on steep slopes.

Hedgerows could be more effective if more attention is given to locating hedgerows on short lengths of gentle slopes on hill tops; recommending their use if there is a minimum of 100 cm of soil; matching the hedgerow species to soil types. Neglecting to relate hedgerow spacing to soil depth has resulted in the development of a soil fertility gradient caused by the redistribution of topsoil and nutrients from the upper zones of each individual alley downhill to the lower parts of the alley. In extreme cases, this has resulted in the formation of “skeleton soils” consisting of coarse sands, gravels and volcanic lahar, which are unsuitable for any useful plant production.

The costs of pruning hedgerows to add to the soil as nutrients are much higher than purchasing the same amount of inorganic fertilizers. Pruning hedgerows to feed small ruminants in stalls effectively “mines” the soils of residual fertility as goat manure is seldom returned to the corn plots in the hills.

The observations and studies in this “Food for Thought” report are supported by points raised in a review of conventional (i.e. using inorganic fertilizers) versus'alternative (i.e. organic) approaches, in the context of trends in world food production and future world food needs. For example;

- The challenge of increasing food production will necessarily depend on yield-enhancing mechanisms. This makes the case for minimizing the use of commercial fertilizers much less secure. Increased agricultural production requires increased export of nutrients from the farm.

- There are ecological limits to biological nutrient production and re-cycling of nutrients on-farm. And the relative costs to use organic inputs compared to inorganic sources often become quite high before these limits are reached.

Agriculture must be made a respectable, dignified, and comfortable profession devoid of drudgery and undue misery. The approach adopted should be dynamic to replace labor-intensive systems with labor efficient technologies.

The “ideological” approach of not giving upland farmers access to the full range of options and technologies for improving their agricultural production should take into the account the views of internationally respected soil scientists and agriculturalists. They consider low-input systems of agriculture in the humid tropics to be environmentally incompatible, soil degradative, and responsible for perpetuating low standards of living. Without a change in approach, the impacts of global warming may turn potentially productive upland farmers into environmental refugees.

Learning sites need to be set up in a range of climate types to test or pilot promising interventions. The results of these can be reasonably reliably extrapolated to similar areas by applying the land systems (or landscape) approach in which areas with similar geology, soil orders, slopes, dissection and climate, can be expected to have the same potential for agriculture. Enhancing BSWM’s existing LMU maps to make them of practical use to LGU staff is a simple way of doing this.

To ensure upland farmers don’t venture into non-viable farming activities gross margin analyses of all proposed interventions (corn patch, minimnum-tillage, organic agriculture, bio-dynamics, etc) should be undertaken using data obtained at the learning sites.

Recommendations for sustainable farming systems in degraded upland areas

This report identifies some proposed lines of action, based on the points raised in the foregoing sections, for each of the following recommendations of the *APO Study Meeting on Sustainable Farming Systems in Upland Areas*.

1. Design sustainable production systems for sloping lands based on new strategies that mimic the control mechanisms that occur naturally in these ecosystems".

2. Base the choice of appropriate land modification technologies (biological and physical or mechanical measures) on the soil and climate conditions and socio-economic constraints of the site in question. Of paramount importance is maintaining an effective surface cover (live or dead) during the onset of the rainy season for controlling runoff and erosion

3. The introduction of onsite technological improvements must be supported by governmental and private institutions capable of implementing conservation policies, providing technical and financial assistance to steep land communities, and generating public awareness of the effects of upstream (onsite) land degradation (deforestation, soil erosion) on short term economic benefits and long-term ecological and environmental consequences downstream (offsite).

4. Alternative production systems leading to diversification need introducing if the food and livelihood needs of the upland farming families is to be met.

5. Provide appropriate policy support to promote R&D into marginal niches-based farming systems, products, market opportunities and intellectual property rights to upland communities over their indigenous knowledge and plant material.

6. Continue to support the training of extension services to create an awareness of the escalation in current rates of environmental degradation due to climate change, and to develop and introduce appropriate farming systems to offset the decline in soil fertility, increase in costs of cultivation and narrowing profit margins of small upland farmers

7. Reduce the risk of introducing non-viable farming systems into the uplands, to avoid increasing family food insecurity and poverty, by subjecting all proposed interventions (e.g. corn patch, zero- or minimum tillage, vegetable gardening in permanent raised beds, organic agriculture, cassava production, multi-storey tree cropping, etc) to gross margin analysis (GMA).

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FOOD FOR THOUGHT

SOME THOUGHTS REGARDING SUSTAINING FOOD PRODUCTION IN THE UPLANDS WITH A CHANGING CLIMATE AND LAND DEGRADATION

1 CLIMATE OF THE PHILIPPINES

1.1 FACTS AND OBSERVATIONS

1.1.1 Climate of the Philippines

The climate of the Philippines is characterized by relatively high temperature, high humidity, and abundant rainfall. Rainfall distribution varies regionally, depending on the direction of the moisture-bearing winds and the location of mountain ranges. A general description of the climate would be as follows:

Mean annual temperature:	26.5°C.
Coolest month:	January, mean temperature: 25°C
Warmest month:	May, mean temperature: 28°C

Tropical cyclones originating in the region of the Marianas and Caroline Islands in the Pacific Ocean have a great influence on the climate and weather conditions of the Philippines. They affect rainfall, humidity, and cloudiness.

Four types of tropical and maritime climates are found:

Type 1 - a dry and a rainy season;
Type 2 - no dry season;
Type 3 - not very pronounced seasons; and
Type 4 - an even distribution of rain throughout the year.

The amount of rainfall and its distribution is used to classify tropical lowland climates:

- A *humid climate* has seven or more humid months[3] (usually >1,500 mm/year).
- *Semi-humid climates* have distinct wet and dry seasons with 4.5-7 humid months[4] (and rainfall of 600-1,500 mm/year).

In terms of vegetation the boundary between humid and sub-humid tropics occurs where closed forest is replaced by open woodland and savannah

Agricultural strategies will tend to differ between the types of climate. For example:

Type 1 climate: Four to six-month dry seasons reduce the growing season for annual crops to 210-270 days a year. Two crops are possible. Sources of water for supplementary water must be available for high-yielding vegetables to be grown throughout the year. Dry seasons

[3] In a humid month rainfall exceeds evapo-transpiration.
[4] Troll. C (1966). *Seasonal climates of the earth. World maps of climatology*. Springer, Berlin, Heidelberg and New York

favour mango and guava production. Strategies, e.g. mulching, that conserve soil moisture will be increasingly important.

Type 3 climate: The absence of an extended dry season increases the growing season for annual crops to 270-320 days, making three harvests of rainfed annual crops a year possible. It favours the production of fruits such as bananas, lanzones, and rambutans, while rubber production requires well-distributed rainfall exceeding 2,000 mm/year. Soil conservation becomes important on slopes.

1.1.2 Rainfall patterns are changing

Upland farmers in Southern Mindanao are noticing that rainfall patterns are changing to the extent they are confused about when to start planting crops as the dry and wet seasons appear to be changing positions. Damaging droughts have occurred in the last few years.

Farmers recall early morning mist rising from the forests on the hillsides ten years ago. This phenomenon no longer occurs – perhaps an indication of a reduction in humidity as a result of a more open canopy from plantations of coconuts and fruit trees.

Erratic weather earlier in the year caused fruit farmers and backyard owners in North Cotabato to lose millions of pesos in income[5]. Heavy rains in February and March were followed by a dry spell in April. In May, the rains returned. Rain during flowering and fruit setting is harmful to production. The North Cotabato agricultural officer also blamed the delay of the fruit season in the failure of the farmers to follow proper application of fertilizer.

1.1.3 Climate change in the Philippines

Climate change scenarios prepared by CRU-WWF[6] show that the Philippines, and its coastal waters, have become warmer during the last century. It has also become drier with a 6% decrease in annual rainfall:

- *Temperature.* All the seasons of the year have become warmer, but the highest is the June-August season. Warming will continue at 0.1 to 0.4°C per decade.
- *Rainfall*. There has been an overall decrease in annual rainfall. The December to February dry season has become drier, while the June to August wet season has become wetter. In future the September to November wet season will also become wetter.
- *Sea levels*. Sea levels, having risen 20 to 40 cm since the 1960s, will continue to rise by 2 to 10 cm per decade.

1.2 SIGNIFICANCE

The humid tropics have consistently high average temperatures with few fluctuations, high rainfall and high relative humidity. These factors accelerate growth and decomposition processes, rapidly degrading organic matter and setting nutrients free.

[5] *Sarangani Journal*, Aug 26-Sep 1 2006, Vol. XXVII No. 23.
[6] Climate change scenarios for the Philippines (1999) (CRU-WWF report) ww.cru.uea.ac.uk/~mikeh/research/philippines.pdf

1.2.1 Implications of a hot, humid tropical climate for agricultural development

At temperatures above 20°C organic matter decomposes faster than its rate of accumulation, which can be three to five times greater than temperate climates. Humid tropical conditions give pests and diseases a *continuous* growing season in which to breed. These factors have implications for fertilizer and pest control strategies, particularly in organic farming. In Korea, for example, where "nature farming" is practiced, winter temperatures of -14° C kill many pests. Organic matter, added to the soil in the form of manures and composts in autumn, becomes available for plant growth as the soils warm up in spring.

The closed tropical forest system (i.e. no harvesting of products) maintains itself by recycling between 8-12 t of leaf litter and plant material /ha/year in Sarawak, and 20-25 t/ha/year in Thailand. Substantially higher amounts of organic matter will be needed to replace nutrients lost through harvesting. Further increases in day time temperatures over the next few decades will speed up the rates of decomposition, requiring more composts and manures to be added.

The view of farming systems analysts is *that in a hot, humid tropical climate, manures and composts can replace fertilizers in exceptional cases only*: "There are simply not enough nutrients in the available organic matter to sustain a vigorous crop vegetation[7]".

Soil scientists, e.g. R. Lal are unequivocal that "low-input systems alone are environmentally incompatible, soil degradative, and responsible for perpetuating low standards of living"[8].

1.2.2 Potential effects of climate change on agriculture

Detailed modelling of the potential impacts of climate change, undertaken by the national governments of Indonesia, Malaysia, Thailand and Vietnam, with the support of the United Nations Environment Programme (UNEP)[9], provides an indication as to how agriculture in the Philippines might be affected if atmospheric CO_2 doubles by 2030. These studies concluded that by 2050 there will be:

- A projected 3-4°C increase in mean annual temperatures across the region;
- Changes in rainfall patterns;
- A decrease in insolation (hours of sunshine) due to increased cloud cover;
- A 20-30 cm rise in sea levels.

1.2.3 Implications of climate change for agriculture

a) Increase in mean annual temperatures

Agricultural production will be adversely affected (see Box 1) as higher temperatures:

- reduce water availability for crops in the early part of the growing season leading to an overall reduction in yields of the major crops (rice, maize and soybean).

[7] Ruthenberg, H. (1983): *Farming Systems in the Tropics*. OUP (p. 363)
[8] Lal, R (1995) Sustainable management of soil resources in the humid tropics. United Nations University Press. www.unu.edu/unupress/unupbooks/uu27se/uu27se06.htm
[9] Parry, M. L., A. R. Magalhaes, and N. H. Nih. (1992). The potential socio-economic effects of climate change: A summary of three regional assessments. Nairobi, Kenya: United Nations Environment Programme (UNEP). http://www.ciesin.columbia.edu/docs/004-149/004-149.html

- shorten the maturation period for these crops and increase their demand for irrigation. One scenario indicates a 25-65% reduction in maize yields.
- Higher CO_2 levels reduce the uptake of N by plants, lowering the nutritional value of crops.

Rainfed crops near their maximum temperature tolerance (e.g. 32-34°C for maize) are projected to suffer up to 30% fall in yields in the 21st century for even small climate changes.
In addition, higher temperatures lengthen the breeding season of pests, increasing the number of insects attacking a crop. Crop losses to disease could increase by 100% for some crops.[10]

Such reductions in production are likely to mean that Vietnam and Thailand may not have rice surpluses to export to the Philippines.

BOX 1
INCREASE IN MEAN ANNUAL TEMPERATURES

Doubling of atmospheric CO_2 by 2030
↓
3-4°C increase in mean annual temperatures by 2050
↓
Higher evaporation rates
↓
Increase in water deficit in the dry season → shortage of water for irrigation
↓
Reductions in cultivable area for rice and higher risk of failure of maize crops
↓
Reduction in rice and maize yields
↓
Levels of farm income significantly lowered
↓
Many farmers forced to seek alternative income sources
↓
Poorest farmers may have to relinquish their land
↓
Increase in levels of rural poverty

b) Changes in rainfall patterns

Decreases in annual rainfall will adversely affect agriculture in some regions, while the amount of rainfall could double in some areas[11]. Any significant increases in rainfall during the rainy season will likely cause more flood damage, affecting a large proportion of the population, offsetting any beneficial effects (see Box 2).

BOX 2
CHANGES IN RAINFALL PATTERNS

Increase in rainfall		**Decrease in rainfall**
Irrigated agriculture ↓ Compensates for increase in evaporation	*Upland agriculture* ↓ 14-40% increase in rate of soil erosion	↓ Reduction in amount of water available for crops in the early

[10] Pimentel, D. 1993. Climate changes and food supply. *Forum for Applied Research and Public Policy* 8 (4): 54-60. http://www.ciesin.org/docs/004-138/004-138.html

[11] E.g. south-eastern Indonesia (Goddard Institute for Space Studies)

due to higher temperatures ↓ Increase in absolute levels of air humidity ↓ More water to fill the reservoirs ↓ Increase in amount of water for irrigation ↓ Extension of the irrigable area for rice cultivation	↓ Higher rates of leaching of soluble nutrients ↓ Increased land degradation ↓ 2-8% decline in soil fertility in some areas ↓ Lower farm incomes ↓ Increase in levels of rural poverty	part of the growing season ↓ Increased moisture stress ↓ Increase in demand for irrigation ↓ Average annual yield loss of about 4% for major crops ↓ Lower farm incomes ↓ Increase in levels of rural poverty

c) Decrease in insolation (hours of sunlight)

Increased cloud cover, due to wetter rainy seasons, will reduce the number of hours of sunshine each day. This is projected to limit photosynthesis, retarding the growing process and prolonging the ripening of the grain. Maize and rice yields will be lowered[12] (Box 3). A reduction in intercepted radiation lowers yields of palm oil[13].

BOX 3
EFFECT OF DECREASED INSOLATION
↓
More cloudy days during the wet season
(10% decrease in radiation → up to 20% reduction in maize biomass production)
↓
Further unavoidable reductions in crop yields (e.g. 25-65% for maize)
↓
Lower farm incomes
↓
Increase in levels of rural poverty

A summary of the impact of climate stresses, caused by climate change, on the economic contribution from the agricultural sector and the threat to national food security is given in Annex I.

d) The effects of a rise in sea-levels

Offshore fisheries will be affected if a substantial geographical displacement of areas of upwelling and down welling of waters, due to the El Nino Southern Oscillation (ENSO) phenomenon, causes a shift of the productive fishery areas.

The predicted effects on coastal fisheries and lowland agriculture, of an average rise on sea-levels of 20-30 cm by 2030, are indicated in Box 4. A *one metre* rise in mean sea level will lead a landward retreat of shoreline of about 2.5 km on land forms characterized by low-lying coastal plains[14]. Some

[12] S.G. Allen, et al., Effects of Air Temperature on Atmospheric C02-Plant Growth Relationships." (Washington, DC: DOE, Office of Energy Research, 1990) cited in http://www.ciesin.org/docs/004-138/004-138.html

[13] Arrifin bin Tawang, Tengku Arif bin Tengku Ahmad and Mohd, Yusuf bin Abdullah. (2001). Stabilization of Upland Agriculture in El Nino Vulnerable countries: Country Report of Malaysia. *Palawaji News*: Vol. 18, No. 3 www.uncapsa.org/Palawaji/pn0109.pdf

[14] As indicated by topographical surveys in Malaysia

low-lying parts of coastal areas could become permanent swamps or lakes due to a rise of the near coastal water table.

A rise in groundwater, accompanied by the upward movement of subterranean salt, will result in saline damage to rice fields and farmland soils. Substantial areas of agriculturally productive land are projected to become too saline for conventional crop production, and mangrove forests and their associated fisheries, will be lost.

The Western Visayas water supply profile indicates that coastal areas of Panay Island are already prone to saltwater intrusion[15]. Contributing factors include the destruction of the forest cover in the watersheds, aggravated by the pumping of ground water for fishponds and prawn farms. A small rise in sea levels is likely to have severe effects on fresh water supplies for the centres of population.

BOX 4 **AVERAGE RISE IN SEA LEVELS OF 20-30 CM BY 2030**	
IMPACT ON FISHERIES	IMPACT ON LOWLAND AGRICULTURE
↓	↓
Rise of the near coastal water table	Upward movement of subterranean salt
↓	↓
Low-lying parts of coastal areas become lakes or permanent swamps	Saline damage to rice fields and farmland soils
↓	↓
Important breeding grounds for fish, threatened	Massive land losses due to inundation adversely affect agriculture
↓	↓
Mangrove forests backed by bunds prevented from landward migration	Severe reductions in local rice and maize supplies
↓	↓
Inundation of prawn and fish farms	Tens of thousands farmers have to look for other sources of income
↓	↓
Extensive damage to the fish and prawn industry throughout South-East Asia	Lower farm incomes
↓	↓
Thousands of labourers lose their jobs	Increase in levels of rural poverty

Climate change and marine pollution may also be threatening the survival of oyster-farming. Marine scientists believe that global warming, and illegal discharges of water ballasts from ships, may be responsible for the upsurge of unknown, toxic micro-algae across the world, which can make oysters and other shellfish dangerous to humans[16].

Strategies for off-setting a rise in sea-levels are outlined in Annex II.

e) Anticipated effects of climate change on some agricultural crops in SE Asia

Rubber. Increased rainfall would interfere excessively with rubber tapping in wet areas, while it may become too dry for rubber production in areas currently near the lower rainfall margins for rubber.

[15] http://www.lwua.gov.ph/prov_ws/area_5_05.htm
[16] Shell shock: is this the end for France's oyster farmers? 09 September 2006 The Independent

Oil palm. Oil palm yields *on alluvial* soils are not expected to be substantially altered under the projected changes of climate, but these plantations in inland regions of sedimentary soils may suffer.

Durian. Nectariferous bats, particularly *Eoncyteris spelea*, are believed to be the main pollinators of durian flowers transfer pollen when they visit the flowers for nectar. Mangrove forests are the main source of nectar for these bats as they produce flowers throughout the year. Loss of the mangroves from rising sea levels is likely to be followed by a reduction in the numbers of bats available to pollinate the durians. Hand pollinating may become necessary (as is done in Hawaii).

Rice. Limited water supplies will be unable to meet the nationwide increase in the demand for irrigation for rice. The practice of growing rice two times a year would need to be limited to a much smaller area than today. The effect on national rice output could be substantial. Continued logging and damage to watersheds in the Philippines will make this scenario worst.

1.3 IMMEDIATE REQUIREMENTS

1.3.1 Obtain better coverage of temperature change and rainfall

The impact models used to estimate the response of crop growth to an altered climate in South-East Asia require daily weather input for precipitation, maximum temperature, minimum temperature and solar radiation. The 58 or so Pagasa meteorological stations throughout the Philippines do not provide sufficient coverage to produce accurate isohyet maps showing rainfall distribution or changes. Many municipal agriculture offices have rain gauges but either stopped collecting rainfall data because, for example, there is no measuring stick to go with the rain gauge. The agricultural stations tend to be based in the main towns close to sea level. Rainfall data for barangays at higher elevations is virtually non-existent.

- Expand the coverage of the 58 or so PAGASA weather stations, currently providing this data for lowland areas, by requiring the municipal agricultural offices to upgrade their meteorological stations and submit electronic copies of monthly rain data to PAGASA. Maximum-minimum thermometers should be provided. See Box 5 for a model system.
- Ask plantations and agencies (e.g. the Philippines Sugar Research Institute Foundation) to make their weather data available to PAGASA.
- Provide upland barangays with rain gauges (approximate cost P800 each) and train staff to collect and record the daily rainfall (including on weekends and public holidays).

1.3.2 Collate and analyse historical data

In 1993, when the author was looking for rainfall data for the four provinces affected by the eruption of Mount Pinatubo, the Meteorology Department HQ in Manila produced a box full of records from dozens of small towns around Pinatubo e.g. for 1880-1898, 1904-1912, etc. The handwritten pages were being eaten by cockroaches and termites.

- Encode any surviving historical rainfall data from around the Philippines onto computer before they are lost.
- Analyse the results to determine the extent of changes in the length of growing seasons, number of rain days per month, increases or decreases in size of rainfall events, etc. compared with the last 10-20 years.

BOX 5
The Philippines' Agro-Met Pilot Area: Iloilo Municipality of Dumangas[17]

Dumangas has seen much of its resources go to waste because of natural disasters and calamities. For years, the impact of climate change was felt by farmers, fishermen and fish producers due to very limited access to specific local weather and climate information to guide their daily and long-term activities. As a result, most constituents were unprepared for droughts and storms that lowered production, or washed-out of crops and cultured fishes, destroyed lives, property and infrastructure. The LGU's resources were strained by repeated reconstruction and rehabilitation.

A solution was to provide local weather and climate data to constituents for disaster preparation and mitigation purposes. PAGASA agreed use Dumangas as pilot area for the Agro-Met project for the Philippines. The project is in partnership with the Asian Disaster Preparedness Center and the International Research Institute for Climate Prediction.

Seminars and trainings were conducted and equipment set-up at the Agro-Met site (Municipal Demonstration Farm and Research Center at Barangay P.D. Monfort South). Afted assessing the project site, representatives from the Asian Disaster Preparedness Center and the International Research Institute for Climate Prediction committed to support the project for five years.

Daily observations and data gathering are done at the Agro-Met by municipal employees designated as observers, who transmit the data to the PAGASA Central Office for analysis. The interpreted form is transmitted back to the Agro–Met Office for dissemination purposes.

The constituents of Dumangas, informed of future local weather are now able to prepare mitigation measures to minimize the grave impacts of disasters and calamities. The application of weather information provided by the Agro-Met is expected to be the effective tool of the municipality in boosting agricultural and fishery production and most of all for the protection of the property and lives of the people.

Currently, the Agro-Met station is equipped with an automatic weather station (MILOS 200) and is hooked to the internet for ready access to weather and climate information from the PAGASA for end-users and stakeholders.

1.3.3 Start trials with new crops or cultivars

A leading economist says world leaders need to think about adapting to climate change rather than focusing only on trying to fight it[18]. Governments need to develop coherent policies *now* to prepare for a hotter, drier world. For example, developing new crops, constructing flood defences, setting different building regulations, or banning building close to sea level. For example, in southern England, where temperatures have risen 1°C in the last 100 years, orchards of apricots, almonds and olive trees have been planted on a "climate change farm" to take advantage of the warmer temperatures expected by 2020[19].

The problem of adapting to changing climate in the Philippines has been complicated by the loss of more than 50 cm depth of topsoil in the past 20 years over extensive areas of the uplands. This has considerably reduced the volume of soil available for storing moisture from the rainy seasons for use

[17] http://www.nscb.gov.ph/ru6/municipality_of_dumangas_economy.htm

[18] Frances Cairncross, Chairperson of the Economic and Social Research Council, quoted in *The Independent* 04 September 2006: Adapt to climate change world leaders warned, by John Von Radowitz, PA Science Correspondent

[19] Britain's first olive grove is a sign of our hotter times, by Michael McCarthy, Environment Editor. *The Independent* 26 June 2006

during the dry seasons, making current cropping systems more vulnerable to drought. In addition, the soils of the Philippines are inherently infertile (see Section 2. Soils).

1.4 RECOMMENDATIONS

- Support the Department of Agriculture in setting up "climate change farms" on the different land forms (Land Management Units) in the four different climate types in the Philippines.
- Reduced stream flows, as a result of excessive damage to critical watersheds in Southern Mindanao, has limited the potential to expand irrigated agriculture to counter losses from future anticipated salinisation from rises in sea levels. The climate change farms can play an important role in showing upland farmers how to achieve food security from small areas.
- In upland LMUs such as hills and mountains, crops with lower moisture requirements worth trying out include: sorghum, millet, mung bean (monggo), pigeon peas, cashew and guava. Monggo, planted at the end of the rains as a "catch crop" (i.e. to catch the last rain storms) can extend the growing season well into the dry season.
- Grow sorghum to provide feeds for livestock as well as fodder. Sorghum has lower moisture requirements than maize, and can recover after seven days without any moisture in the soil. Its ability to ratoon provides nutritious green fodder well into the dry seasons.
- On coastal land forms/LMUs already suffering from salinisation, plant vegetable cultivars that can grow in brackish water.
- Plant orchards of drought-tolerant perennial crops such as guava, citrus and cashew, In regions with distinct dry seasons, teach farmers to manipulate water stress levels to improve the flowering of species such as lychee and mango.
- Develop markets and post harvest processing facilities for the substitute crops.

While a rise in temperature and a shortening of the rainy season will reduce a crop's productive growing season and reduce yields, the yields of substitute crops is likely to be lower because they usually produce less harvestable food than corn. They may also be less nutritious.

2. SOILS OF THE UDP AREA

2.1 FACTS/OBSERVATIONS

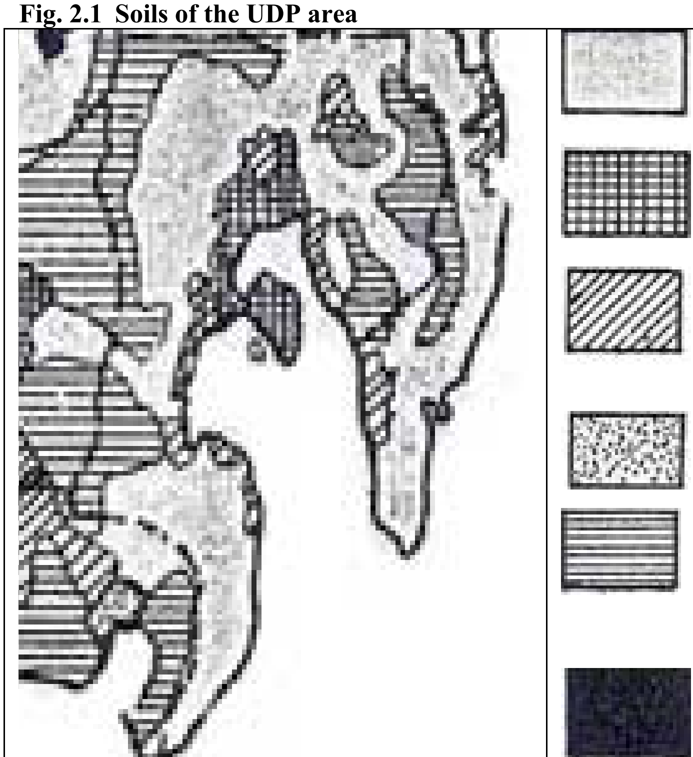
2.1.1 Characteristics of upland soils

The dominant soil orders of the rainfed upland soils extensively used for traditional food crop production in the humid and sub-humid tropics are Alfisols, Ultisols, Oxisols, and associated soils[20]. As well as being acid, upland soils tend to be deficient in phosphorus, potassium, calcium and magnesium and are inherently infertile. Organic matter content and soil CEC[21] in the subsoil are generally low. The main physical constraints are low available water holding capacity, and susceptibility of these soils to erosion, exacerbated by the very steep slopes in the uplands. The soils of the hills and mountains in the Davao Gulf States, where the poorest farmers strive to make a living from the land, are described as shallow, acidic, fragile, and inherently infertile, and classified as “unsuitable for upland agriculture in any context”.[22]

2.1.2 Soil orders of the UDP area

The FAO soil map of the Philippines (Fig. 2.1) shows the main soil orders in the UDP area to be Ultisols, Alfisols, Inceptisols and undifferentiated mountain soils[23]. (See Annex III for full map).

Fig. 2.1 Soils of the UDP area



ULTISOLS: Soils with a subsurface horizon of clay accumulation and low base supply. Usually moist or moist for 90 consecutive days during a period when temperature is suitable for plant growth

ALFISOLS: Soils with a subsurface horizon of clay accumulation and medium to high base supply. Either usually moist or moist for 90 consecutive days during a period when temperature is suitable for plant growth

INCEPTISOLS: Soils with pedodgenic horizon or alteration of concentration but without accumulation of translocated materials other than carbonate or silica. Usually moist or moist for 90 consecutive days during a period when temperature is suitable for plant growth

ENTISOLS: Soils without pedogenic horizons. Either usually wet, usually moist or usually dry.

.SOILS IN AREAS WITH MOUNTAINS:
Soils with various moisture and temperature regimes; many steep slopes; relief and total elevation vary greatly from place to place. Soils vary greatly within short distances and with changes in altitude. Vertical zonation common

VERTISOLS: Soils with high content of swelling clays; deep wide crack develop during dry periods

[20] *Management of low-activity clays (LAC) soils.* http://www.fao.org/Wairdocs/ILRI/x5546E/x5546e04.htm#1.7%20management %20of%20low%2activity%20clays%20(lac)%20*soils*

[21] CEC is a useful indicator of soil fertility because it shows the soil's ability to supply three important plant nutrients: calcium, magnesium and potassium.

[22] Japan International Cooperation Agency (JICA), March 1999. *Davao Integrated Development Project (DIDP), Planning Atlas*. Pacific Consultants Internatonal.

[23] www.fao.org/ag/aGp/agpc/doc/Counprof/Philippines/phfig4.htm

BSWM produces soil maps at the municipal level. The complex patchwork of soil series on these maps limits their usefulness for planning agricultural strategies over broad areas. The minimum area covered by 1:25,000 scale maps is 10 ha (about 3.16 x 3.16m), which is too small to cater for the 1-7 ha upland farms. The data provided is based on soil sampling and analyses, which makes it an expensive exercise on a provincial scale.

a) Ultisols[24]

Ultisols occur in warm humid climates with annual rainfall of 1,500-2,000 mm, and a marked dry season. Due to intense weathering and leaching, they are highly acidic (pH 4 to 5), often with toxic concentrations of Al and Mn in the sub-soil, are low in organic carbon, and have relatively low quantities of plant-available N, P, Ca, Mg, and K. The accumulation, decomposition and humification of organic matter in the topsoil is limited[25]. As a result they are poorly suited for continuous agriculture under low input systems. With inputs of fertilizer, particularly phosphorus, and lime, these soils can be very productive.[26]

Recommended land use

- Acid-tolerant root crops (cassava and sweet potato), intercropped with corn or upland rice, on flat to gently sloping gently sandy coastal ultisols. These systems can be sustainable if residues are returned to the soil to recycle nutrients.
- Corn and beans on flat to gentle sloping land, with liming to correct Al and/or Mn toxicity, and to supply Ca and Mg as plant nutrients. SWC needed to prevent further soil deterioration.
- In areas with significant slopes, the land must be revegetated. Forestry plantations, and plantations of banana, rubber and oil palm are more stable than cereal crop systems on low-base-status and acid Ultisols and Oxisols.[27]

b) Oxisols[5]

Oxisols are acidic, permeable, and well-drained soils, with extremely low inherent fertility, occurring in regions without a marked dry season. Faunal pedoturbation, the intense disturbance and mixing of soil due to activity by insects, particularly termites, is a major process in most Oxisols and Alfisols. This contributes to the rapid recycling of nutrients. Numerous mounds may be formed at the soil surface as a result of pedoturbation, as can be seen under the tree crops at the Mamangan learning site in Davao del Norte. As a result, most of the nutrients in Oxisol ecosystems are contained in the standing vegetation and decomposing plant material. Despite low fertility, Oxisols can be quite productive with inputs of lime and fertilizers.

Recommended land use

- Subsistence farming and low-intensity grazing.
- Soybeans, corn, and coffee plantations can be grown if lime and fertilizers are used[6].
- Corn and beans as for Ultisols above.

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[24] http://soils.ag.uidaho.edu/soilorders/orders.htm

[25] Sabine Grunwald Soil and Water Sciences http://grunwald.ifas.ufl.edu/Nat_resources/soil_orders/oxisols.htm

[26] International Institute of Tropical Agriculture (IITA). 1984. Farming system program research highlights 1981-1984. Ibadan, Nigeria. IITA

[27] Hossner, L R and Juo, A S R, (1999). Soil nutrient management for sustained food crop production in upland farming systems in the tropics. Soil and Crop Sciences Department College Station, Tennessee, 77843, USA (http://www.agnet.org/library/article/eb471.html)

c) Alfisols[5]

Alfisols are moderately leached forest soils with favorable soil fertility and nutritional properties. Often found on steep to very steep slopes and are susceptible to soil erosion. Although more productive, they have more severe soil physical constraints than Oxisols and Ultisols, such as a rapid decline in soil structure, crusting, compaction, hard setting, high losses due to surface runoff, and accelerated soil erosion. These soils contain a greyish subsurface horizon in which clays have accumulated (as can be seen in exposed profiles in Maasim, Sarangani Province).

Recommended land use
With judicious fertilizer use and crop rotations, high and sustained crop yields can be obtained[28].

d) Inceptisols and Entisols[5]

The younger Inceptisols and Entisols range from highly fertile soils of alluvial and volcanic origin to very acidic and nutrient-poor sands.

Inceptisols can be highly productive soils with only slight or moderate constraints to intensive agriculture. These fertile soils of alluvial and volcanic origin are extremely productive. However, the distribution of these soils is extremely limited. Although these soils are less prone to soil physical and nutritional problems, mismanagement and inappropriate land-use systems can lead to compaction, erosion, and nutrient depletion.

Although *Entisols* occur on steep and rocky land, they can be important soils of agricultural land in large river valleys and associated shore deposits.

Recommended land use
Inceptisols are very susceptible to erosion, so maintain them under natural vegetation: in hilly areas – plant fruit trees and bananas; in mountainous areas: forestry, recreation, and watershed.
Entisols of large river valleys and associated shore deposits: a wide range of crops.

Annex IV summarises the characteristics of the soils in the UDP area.

2.1.3 Massive soil erosion has reduced soil depths and exposed acid and toxic subsoils

Field observations of soil erosion[29] confirm World Bank estimates (c. 1989) of annual soil losses of 400 t/ha/year (equivalent to a reduction in depth of the soil profile by 3 cm a year). Mono- and inter-cropping annual crops, such as corn, on sloping land has reduced soil depths by over 50 cm in the past 20 years. Truncating soil profiles through erosion reduces the volume of soil available for storing moisture to support perennial crops over dry seasons. The reduction in depth of Alfisol soil profiles from erosion increases the susceptibility of crops to drought.

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[28] Kang, B.T. and Juo, A.S.R. 1986. Effect of forest clearing on soil chemical properties and crop performance. pp. 383-394. In: Lal, R. Sanchez, P.A., Cummings, R.W. (eds.). Land clearing and development in the tropics., Rotterdam, Netherlands: A.A. Balkema
[29] Proud, KRS (2004). *The reduction in depths of upland soils in Southern Mindanao, their causes and consequences*. Report for the Upland Development Programme in Southern Mindanao, The Philippines. 16 October 2004

2.2 SIGNIFICANCE

2.2.1 Sustainable agriculture on infertile upland soils requires artificial fertilizers

The inherent soil infertility of the upland soils in the humid tropics limits the availability of mineral nutrients to the plant and the soil's ability to prevent leaching of applied nutrients. Crop yields are low as energy, better used for growth, flowering, seed production or root development, is diverted to scavenging mineral nutrients from the soil[30]. If Ultisols and Alfisols are to be used for sustainable agriculture, it is necessary to apply nutrients from external sources, such as chemical fertilizers, biological nitrogen fixation, and nutrient recycling[31].

Al and/or Mn toxicity and deficiency of essential nutrients in acidic sub-soils restricts root growth and proliferation. Exposed acid sub-soils require heavy applications of lime to replace Al and Mn with Ca and Mg (provided lime is available locally at economic rates), as well as fertilizers and the addition of organic matter (see below). Ammonium-based fertilizers can make soils more acid (see Annex V for list of acidifying fertilizers and rates of lime applications to raise soil pH), and Annex VI for how increased crop biomass, as a result of adding fertilizers, also increases soil acidity.

Soil-related constraints to crop production for different soil orders are shown in Table 2.1.

Table 2.1 Soil-related constraints to intensive agriculture in the humid tropics

Soil	Nutrient deficiency	Nutrient toxicity	Structural deterioration	Compaction	Erosion/ landslides	Effective rooting depth
Oxisols & Ultisols	N. P. Ca Zn	Al. Mn	Crusting. hard setting	Surface and sub-soil compaction	Sheet/rill erosion	Shallow to medium
Alfisols	P	-	Crusting. hard setting	Surface and sub-soil compaction. Erosion. Drought stress during the dry season		
Entisols	P	-	Single-grained loose structure	-		
Inceptisols	P	-	-	-	Gully erosion	-

Source: Lal, R (1995) *Sustainable management of soil resources in the humid tropics*. United Nations University Press TOKYO • NEW YORK • PARIS. www.unu.edu/unupress/unupbooks/uu27se/uu27se04.htm

However, while fertilizer is needed to maintain soil productivity, it must always be used in conjunction with management practices that help maintain soil organic matter, such as returning residues or other organic materials to the soil, and minimum tillage[32].

The Bureau of Soils and Water Management (BSWM) advocates a balanced fertilization strategy, which advocates the use of proper grades and amounts of organic fertilizer in conjunction with inorganic fertilizers, to supply the correct ration of plant nutrients, to ensure soils will sustain high crop yields over long cropping seasons (see 3.1.2).

[30] Source: http://www.microsoil.com/CEC.htm
[31] Lal, R (1995) *Sustainable management of soil resources in the humid tropics*. United Nations University Press TOKYO • NEW YORK • PARIS
[32] Integrated nutrient management in the tropics. http://www.agnet.org/library/article/eb471.html

2.2.2 Achieving food security more efficiently releases land and labour for tree crops

a) Experience from northern Mindanao

In the strongly acidic soils in Claveria, northern Mindanao, a change from local varieties of corn to hybrid cultivars and using fertilizer doubled corn yields. Large areas of many farms, formerly used for growing food, were freed for planting with more profitable and environmentally sustainable small holder timber and fruit tree production systems[33].

b) Experience from Southern Mindanao

Corn and cassava are not suitable as cash crops in the uplands and promoting them may be contributing to poverty. The cost of producing the crop is often 50% more than they earn from selling it. However, there is a detectable trend of UDP farmers moving, or intending to move, from mixed farming, towards dualistic systems of cropping, with an increase in the area under tree crops. In some areas, farmers have largely abandoned growing corn as a cash crop and switched to bananas and fruit trees.

2.2.3 Eroded soils will exacerbate the effects of climate change

Scenarios for climate change in the Philippines predict an increase in average daily temperatures by as much as 4°C. Wet seasons will become shorter but more rain will fall, while dry seasons will be longer with less rain falling. There will be an overall decline in annual rainfall.

Oxisols, Ultisols, and Alfisols are all susceptible to crusting and hard setting. Higher run-off rates can be expected from exposed soil surfaces during the wet seasons. The implication is less water will be absorbed and stored in the soil for plant use during the dry seasons. If soil losses equivalent to 3 cm depth a year continue to add to the current loss of 50 cm depth over the last 20 years, then there will be an insufficient volume of soil to store enough water to meet the demands of bananas and perennial crops through the extended dry seasons.

Under normal circumstances, crops grown on Alfisols frequently experience drought stress due to low available water reserves, and high surface soil temperatures[34]. Increased daily temperatures and longer dry seasons will increase the incidence of drought stress, which will be exacerbated by shallower soils.

2.2.4 Maintenance of soil organic matter

a) Nutrient recycling

The scientific literature emphasises that applications of inorganic fertilizers, and liming, are essential if agriculture on the upland soils of the hot, humid tropics is to be sustainable (see Annex VII). The use of commercial fertilizers is increasing the productivity of farming systems in many parts of the

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[33] Garrity, D. P., (2000).Contour Farming based on Natural Vegetative Strips: Expanding the scope for increased food crop production on sloping lands in Asia. *Environmental Development and Sustainability,* 1 (Special Issue):323-336. (in ICRAF Leaflet). www.worldagroforestry.org/sea/ph/02_pubs/papers/03_cons/cont_01.pdf

[34] Lal, R. (1985). No-till in the lowland humid tropics. Proceedings of the 8th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. 16-17 July, 1985, Griffin, Georgia

tropics. Applying these external nutrients boosts the production of crop residues which is then available for recycling to the following crops.[35]

b) Zero or minimum tillage

Minimizing soil disturbance and keeping the soil surface covered is an effective erosion-control strategy. Basing seedbed preparation on a minimum of soil disturbance and maintenance of crop residue mulch is called "conservation tillage". Weed control, usually done by ploughing (which inverts the soil), is achieved by applying herbicides (which doesn't loosen the soil) and leaves a dead organic mulch to suppress the weeds; or smothering by cover crops.

Zero- or minimum-tillage eliminates all seed bed preparation and provides a protective crop residue mulch covering to the soil while minimising exposure of the soil. The greater the surface area is covered with a crop mulch the better the protection it gives to easily dispersible soil beneath. The benefits of mulch-based agriculture systems in relation to plough-based ones include: improved soil and water conservation, reduced soil compaction, and savings in labour.[36] Compared to ploughing for a legume-corn crop, the no-till system reduced runoff by 63% at 10% slope, and 79% at 15% slope. Soil erosion was negligible even on a steep slope of 15%. In the UDP area, farmers obtained 70% savings in labour and got up to three times the corn yields from the same area of land by killing the weeds with herbicide, planting hybrid seeds and applying inorganic fertilizers.

The most important need is to develop agronomic packages that produce adequate quantities of crop residue mulch. Viable systems that produce residue mulch include:

> The use of previous crop residues: the use of a grain cereal, e.g. corn, in rotation with a monggo bean crop is a workable system. The use of HYV corn plus fertilizers is an effective way of generating ample amounts of mulch.
>
> A leguminous cover crop, such as forage peanut, can help restore the soil and produce a mulch in situ. It is best to chemically (i.e. with herbicides) or mechanically suppress the cover crop without ploughing before seeding the grain crops through the mulch. Otherwise, the live mulch will compete for moisture and nutrients and smother the germinating food crop. Live mulches will be more competitive on truncated and degraded upland soils, and can be expected to out-compete the crop in drier periods, Multi-storey tree cropping provides continuous vegetative cover throughout the year protecting the soil against raindrop impact.

3. ORGANIC FARMING

3.1 FACTS/OBSERVATIONS

3.1.1 Organic fertilizers vs inorganic fertilizers

The recent increase in costs of inorganic fertilizers has led to organic farming being promoted by local governments in the belief that it is a cheaper option for resource poor farmers. However,

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[35] Cited in: Garrity, D. P., (2000).Contour Farming based on Natural Vegetative Strips: Expanding the scope for increased food crop production on sloping lands in Asia. *Environmental Development and Sustainability,* 1 (Special Issue):323-336. (in ICRAF Leaflet). www.worldagroforestry.org/sea/ph/02_pubs/papers/03_cons/cont_01.pdf

[36] Lal, R. (1995). *Sustainable management of soil resources in the humid tropics*. United Nations University Press, The United Nations University 1995. http://www.unu.edu/unupress/unupbooks/uu27se/uu27se0b.htm

organic fertilizers are low quality fertilizers (i.e. 2% Nitrogen compared with 46% N for urea) but, by improving soil structure and water-holding capacities, they make applications of inorganic fertilizer more effective, especially on sandy soils.

Preparing organic fertilizer is labour intensive and time-consuming, and not always available in sufficient quantities for spreading on fields. Scarce organic fertilizers are most effective when used to improve vegetable production around the homestead, where supplementary watering is likely.

Table 3.1 lists some advantages and disadvantages of preparing compost and organic fertilizers.

Table 3.1 Advantages and disadvantages of organic fertilizers

Advantages of organic fertilizers	Disadvantages of organic fertilizers
• Bag for bag homemade fertilizer is much cheaper than having to buy inorganic fertilizer (e.g. P 110 for a 50 kg bag of organic compared to P 1,000 for a 50 kg bag of inorganic fertilizer. • The nutrients in organic waste can be recycled. • Applications of organic fertilizer improve soil structure, increase the water-retaining capacity and improve soil fertility in the long run.	• The concentration of available nutrients in organic fertilizers is considerably lower than in inorganic fertilizers. 14 bags of 1:4:1 (NPK) organic provide the same amount of N as one 50 kg bag of 14:14:14 fertilizer. Between 12-20 tons/ha/yr need applying to be effective*. • Preparing compost, liquid manure, or bokashi is very labour intensive and time-consuming. • Applying compost and goat manure can introduce weeds and fungal diseases in the crop to be grown. In the tropics the rate of oxidation of organic matter is very rapid.

Before encouraging farmers to produce organic fertilizers, it is worthwhile determining whether farmers will be able to overcome the disadvantages by asking:[37]:

- Does the farmer have enough time and energy to spare to make organic fertilizers?
- What will s/he gain by starting to make organic fertilizers? (Compare prices of artificial fertilizer, look at the status of soil fertility, etc.)
- Is there enough organic matter available to make organic fertilizer?
- Are the farmers motivated to introduce a new method of making compost?
- Is green manuring a cheaper, easier alternative? (If the farmer plants hedgerows, will there be enough material to apply on the inter-hedgerow spaces, or will the cuttings be fed to goats or other livestock?)

3.1.2 Is organic farming in a hot, humid climate a practical option for upland farmers?

Despite the high daily temperatures throughout the year, which prevents a build up of organic matter due to high decomposition rates (see 1.2.4), an Executive order has been issued promoting organic agriculture as a farming scheme for rural farming communities that "enhances global competitiveness, environmental integrity, food security and safety, and increases productivity and

* Measurements of leaf litter fall in undisturbed tropical rain forests indicate that between 8-25 t/ha/yr are recycled. As there was no removal of any animal or plant products, these figures can be taken as the minimum needed to maintain the closed system of the rain forest. The nutrients lost by removing fruits, leaves, timber etc would have to be replaced from outside sources.

[37] Inckel, M, de Smet, P, Tersmette, T, Veldkamp, T. (2002). *The preparation and use of compost*. Agrodok series No. 8. Agromisa, The Netherlands.

alleviates poverty"[38]. There are several factors that advocates of organic farming in the UDP area appear to have neglected to take into consideration:

- The Executive Order does not differentiate between organic production in regions above 1,200 m elevation, where climate is favourable for organic farming (e.g. Baguio, La Trinidad, and Banaue), and the unfavourable hot, humid tropics below 1,000 m elevation, where fertilizers can be replaced by manures and composts in exceptional cases only (e.g. on volcanic and alluvial Inceptisols and Entisols). There are simply not enough nutrients in the available organic matter to sustain a vigorous crop vegetation [39].

  Have the ecological aspects been properly explored before imposing organic farming on resource poor upland farmers?

- Organic fertilizer contains only 2% nitrogen compared to 46% for urea. Farmers need to apply at least 80 bags of organic fertilizer for a hectare rice land, as compared to only five to six bags of urea[40]. Even at a price of P110/bag for organic fertilizer as opposed to P1,000 for urea, the farmer's cost is P8,800 for organic fertilizer, but only P5-6,000 for inorganic fertilizers. The cost of organic fertilizer rises to P12,000 when transport costs of P40/bag are factored in, and go higher still when the labour to carry the organic fertilizer to the field and apply it are included.

  Have advocates of organic agriculture assessed the costs, in terms of labour, versus the outputs (yields, etc) for range of crops to be grown on the infertile and degraded soils of the uplands? What marketable surpluses are expected? Will organic farming really increase productivity and alleviate poverty amongst upland farmers as the EO intends?

- The previous example (from Pangasinan, Luzon), indicates that producing organic food can cost twice the price of conventionally grown food. Experience from Europe finds that organically grown crops are more labour intensive to cultivate and transport because they must be protected from pests, fungi and other hazards. Overall, an organically grown crop will produce less, fruits and vegetables are often smaller than conventionally grown produce, and they require more arable land than non-organic crops[41].

  Teagasc, Ireland's agricultural research body, found that:
  - organic cereal crops yield 60-70% *less* than conventionally farmed cereal crops.
  - organic potatoes produce 75% of conventional yields, and
  - organic vegetables result in 20-50% smaller yields when compared with non-organically farmed vegetables.

  Since organic food can cost as much as twice the price of conventionally grown food to produce, are Filipino consumers able and willing to pay higher prices for organic food? Will the Project achieve its Purpose of developing models "that address the upland communities' subsistence needs and produce marketable surpluses?" From the

[38] Executive order NO. 481, December 27, 2005, *Promotion and development of organic agriculture in the Philippines.* http://www.da.gov.ph/agribiz/eo_organic.html
[39] H Ruthenberg (1983): *Farming Systems in the Tropics*. OUP
[40]Cited in *The Sun Star* Sunday, February 02, 2003. Price hike in imported fertilizers affecting farmers, by Yolanda S. Fuertes
[41] http://www.ecpa.be/commonground/downloads/articles/article01.html

above, it is doubtful whether the upland farmer's subsistence needs for food, will be achieved by growing native corn or OPV with organic fertilizers; or whether marketable surpluses will be possible.

- The EO aims to ensure the integrity of organic products through the approved organic certification procedures and organic production, handling and processing standards. According to PCCARD, the *minimum* fee of P15,000 is charged for certification, it takes 3-6 months from certification to inspection, and the validity of certification is 18 months[42].

  Would resource poor upland farmers be better off spending P10,000 a year on inorganic fertilizers, with a certainty of higher yields and increased incomes, than paying the same price for certification?

- Finally, most of the vegetable seeds available to farmers are sold pre-treated with chemical fungicide to protect the germinating seed against soil-borne diseases – which automatically disqualifies them from being certified as organic.

  Are reliable sources of untreated seeds available to upland farmers in sufficient amounts at the desired times?

The consequences for the cost of organic produce are self-evident, yet the Executive Order makes no provision for paying organic farmers premium prices for organic farm produce. Upland farmers have not been provided with a comparison of the costs between organic (or alternative farming) and conventional farming using fertilizers, so they can evaluate the options available.

There is a wealth of scientific literature specifically stressing the importance of applying artificial fertilisers and liming for sustainable agriculture on most of the upland soils in the hot, humid tropics (see Annex VI). Organic agriculture requires more labour, gives lower yields and upland farmers are not guaranteed premium prices for their produce in the markets. Soil scientists consider low-input agricultural systems alone to be obsolete, environmentally incompatible, soil degradative, and responsible for perpetuating low standards of living[43]. Surprisingly, there is reluctance in some quarters even to do trials to compare the effectiveness of inorganic fertilizers with organic ones..

3.1.3 The BSWM "Balanced Fertilisation Strategy" (BFS)

The BFS was launched by BSWM under Presidential Proclamation No. 1071 in June 1997. Its vision is to ensure the stable production of affordable supplies of basic staples as well as ensuring the sustainable productivity of high value crops. Location specific recommendation is one of guiding principles of BFS. The grades and proportion of fertilizer elements must conform with plant and soil analyses, and climatic conditions.

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[42]Philippine Organic Farming. http://www.pcarrd.dost.gov.ph/phil-organic/market%20files/certification2.htm

[43] Lal, R. (1995). *Sustainable management of soil resources in the humid tropics*. United Nations University Press, The United Nations University 1995. http://www.unu.edu/unupress/unupbooks/uu27se/uu27se0b.htm

4. HEDGEROWS, A CHEAP OPTION TO INORGANIC FERTILIZER?

4.1 FACTS/OBSERVATIONS

4.1.1 Hedgerows are not appropriate SWC measures on long, steep slopes

Woody, leguminous hedgerows have been planted in upland farms as barriers against erosion and as an alternative source of nitrogen input for acid upland soils. In many instances, the "traditional" SALT leguminous hedgerows, initially tried by the Project, have proved to be inappropriate SWC measures for the long, steep slopes found in much of the uplands. Reasons to doubt the suitability of hedgerow intercropping on steep slopes, include:

- they were designed for short, gentle slopes below 20%;
- the very close spacing required on steeper slopes, and consequent reduction in cultivable land, make hedgerows unacceptable to some farmers;
- they do not prevent a build up in volume and velocity of run-off on long slopes.

UDP experience with hedgerows on long, steep slopes supports the view of soil conservationists that hedgerow intercropping may be applicable on gentle to moderate slopes, but it has only speculative potential on steep slopes (Young 1989[44]; Hudson 1992[45] p.102).

In selecting planting materials, little attention has been given to matching the hedgerow species with their soil requirements. Ipil-ipil (*Leucaena leucocephala*) and madre de cacao (*Gliricidia sepium*) do better on Alfisols, while *Calliandra calothyrsus,* and *Flemingia macrophylla* perform well on Oxisols and Ultisols soils[46].

4.1.2 Hedgerow layouts not related to soil depth

Hedgerows were initially planted without relating the spacing to soil depth. This has resulted in the development of a soil fertility gradient caused by the redistribution of topsoil and nutrients from the upper zones of each individual alley downhill to the lower parts of the alley. This has also been observed at the ICRAF-Visayas Research and Development Site, Baybay, Leyte [47]. The crop in the rows in the upper zones are more stunted and show more obvious signs of nutrient deficiency than the rows behind the hedgerow. In extreme cases, e.g. in parts of South Corabato, the end result is a "skeleton soils" consisting of coarse sands, gravels and volcanic lahar[48]. These soils are unsuitable for any production, not even forest trees[49].

Spacing of hedgerows was based on Vertical Interval (VI). In this, one contour line is at the farmer's feet, the position of next one up the slope is in a horizontal line with his eyes. Applying VI is not appropriate for spacing cross-slope barriers such as hedgerows and NVS. The VI procedure is meant

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[44] Young, A (1989). *Agroforestry for soil conservation*. Wallingford UK, CAB International
[45] Hudson, N (1992). *Land husbandry*. London. Batsford
[46] Management of low-activity clays (LAC) soils. http://www.fao.org/Wairdocs/ILRI/x5546E/x5546e04.htm#1.7%20management%20of%20low%20activity%20clays%20(lac)%20soil
[47] Stark M and Itumay J. 2002. Natural vegetative strips in degraded calcareous soil environments: Successful stabilization of steep slopes in Leyte**.** Laguna, Phillippines. International Centre for Research in Agroforestry, SEA Regional Research Programme
[48] Proud, KRS (2005). The making of skeleton soils – a major unseen threat to upland productivity in Southern Mindanao. *EU News* Vol 3, Issue 7, June 2005. Delegation of the European Commission of the Philippines
[49] Proud. KRS (2006). **T**he effect of hedgerow layout on erosion and farm productivity. Handout prepared for DFS Quality Controllers. The Upland Development Programme in Southern Mindanao, The Philippines. Feb 27, 2006

for designing channel terraces intended to intercept and drain the run-off from the land above it.[50]. Accordingly, under STOP 1: Land Unit Farming, hedgerow spacing is based on soil depth (minimum of 100 cm)l, slope and soil texture. They are located on short lengths (30 m) of gentle slopes (12-25%) at the tops of hills and upper slopes[51].

4.2 SIGNIFICANCE

4.2.1 Alley-cropping systems can decrease crop yields

Studies have shown that alley-cropping systems can also decrease crop yields due to competition for nutrients water, and light. While the concept of recycling nitrogen produced by leguminous hedgerow species seems attractive, it needs to evaluated from an economic point of view and compared with importing N in the form of fertilizers [52].

4.2.2 Costs of pruning hedgerows for nutrients are much higher than inorganic fertilizers

10 tons of ipil-ipil cuttings are equivalent to applying 100 kg of Nitrogen. Studies in northern Mindanao found that pruning hedgerows and using the cuttings to fertilize the corn crop required 124 days of annual labor for four prunings (i.e. P9,920 in labour costs at P80 a day). Any increases in corn production could not justify the 90% increase in production costs[53]. On the other hand, 217 kg of urea (46:0:0), costing about P4,300, including transport and handling charges, would also provide 100 kg N, and save four months of labour..

ACIAR also reported increased labour requirements for pruning hedgerows and applying organic fertilisers by adoptors[54]. Hedgerows were usually abandoned after a few years. In addition, pruning hedgerows to feed small ruminants in stalls effectively “mines” the soils of residual fertility as goat manure is seldom returned to the corn plots in the hills. As Lal has warned: “nutrient recycling mechanisms can work only if there is something useful to recycle” [55].

5. REVIEW OF CONVENTIONAL Vs ALTERNATIVE (Organic) APPROACHES

The observations and studies summarized above, supported points raised in a review of the record of the 'conventional' approach, and evidence related to the 'alternative' (i.e. organic)

[50] Hudson, N (1992). *Land husbandry*. London. Batsford (page 98).
[51] Proud, KRS (2004). *LAND UNIT FARMING. Slope Treatment-Oriented Practices (STOP) 1.* Principles for developing productive upland agriculture in the humid tropics #1. Handout prepared for the Upland Development Programme in Southern Mindanao.
[52] Lal, R. (1995). *Sustainable management of soil resources in the humid tropics*. United Nations University Press, The United Nations University 1995. http://www.unu.edu/unupress/unupbooks/uu27se/uu27se0b.htm
[53] Cited in: Garrity, D. P., (2000).Contour Farming based on Natural Vegetative Strips: Expanding the scope for increased food crop production on sloping lands in Asia. *Environmental Development and Sustainability,* 1 (Special Issue):323-336. (in ICRAF Leaflet). www.worldagroforestry.org/sea/ph/02_pubs/papers/03_cons/cont_01.pdf
[54] Cramb, R A; Garcia, J N M; Gerrits, R V; and Saguiguit, G C. (2000). Adoption of soil conservation technologies in the case study sites. In: *Soil Conservation Technologies for Smallholder Farming Systems in the Philippine Uplands* pp 72-94. Autralian Centre for International Agricultural Research.
[55] Lal, R. (1995). *Sustainable management of soil resources in the humid tropics*. United Nations University Press, The United Nations University 1995. http://www.unu.edu/unupress/unupbooks/uu27se/uu27se0b.htm

approach, in the context of trends in world food production and future world food needs[56] examined a number of assertions made on the advantages of alternative agriculture.

Assertion 1
Purchased inputs are more costly than on-farm inputs, and alternative agriculture proponents advocate using resources internal to the farm to increase production in lieu of purchased inputs.

The review concluded:

- to the farmer it is not the absolute cost of inputs that counts, so much as the relative costs of inputs compared to their respective productivity.
- Alternative agriculture proponents have not addressed these tradeoffs. (Labor is a limiting input, and its opportunity costs are often crucial.
- Inputs that substitute for labour are often highly desire by smallholders. Foregoing their use may be real sacrifice.

Assertion 2
*The use of internal resources reduces the farmer's reliance on nonrenewable energy suppl*ies.

The following points are extracted from Garrity (2000)[1].

- As the bulk of the entire world economy now depends on nonrenewable energy, some would question why farmers should bear a special burden to conserve this energy when there is wasteful usage in other sectors. *As indicated above, the cost of labour required for organic farming can be more than double the cost of purchasing inputs*).

Assertion 3
The use of conventional inputs is ecologically unsustainable. This is due to the role of commercial inputs in environmental degradation.

Garrity (2000)[1] notes:

- The case for reduced use of pesticides through integrated pest management, without any cost in yield, has now been amply demonstrated. IPM can make major contributions to the maintenance of yields while reducing human health hazards.

- The challenge of increasing food production will necessarily depend on yield-enhancing mechanisms. This makes the case for minimizing the use of commercial fertilizers much less secure.

- There are compelling questions of how to provide adequate organic nutrient quantities in the broad range of agricultural systems, and of their costs relative to commercial sources.

- Increased agricultural production requires increased export of nutrients from the farm.

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[56] Crosson and Anderson (1999) cited in: Garrity, D. P., (2000).Contour Farming based on Natural Vegetative Strips: Expanding the scope for increased food crop production on sloping lands in Asia, In: *Environmental Development and Sustainability,* 1(Special Issue):323-336. (an ICRAF Leaflet). www.worldagroforestry.org/sea/ph/02_pubs/papers/03_cons/cont_01.pdf

- There are ecological limits to biological nutrient production and re-cycling of nutrients on-farm. And the relative costs to use organic inputs compared to inorganic sources often become quite high before these limits are reached.

The final words on the suitability of low-input systems for resource-poor farmers are reserved for soil scientist and agriculturalist Rattan Lal (1995)[57]:

> "Agriculture must be made a respectable, dignified, and comfortable profession devoid of drudgery and undue misery. The approach adopted should be dynamic to replace labor-intensive systems with labor efficient technologies….
>
> The scientific community must address the issue of human values and dignity. Tilling land with obsolete manually powered tools, controlling weeds with a back-breaking hoe, threshing grain by beating with a stick or trampling by human and animal is not an inspiring profession.
>
> Concern about over-dependence on nonrenewable and rapidly dwindling fossil fuels is genuine but is not a justification for condemning resource-poor farmers to sub-human operations"
>
> "With the world's highest rate of population observed in many countries of the humid tropics, <u>low-input systems alone are obsolete, environmentally incompatible, soil degradative, and responsible for perpetuating low standards of living</u>".

6. PLANNING FOR CLIMATE CHANGE

6.1 THE WAY FORWARD

6.1.1 Use learning sites in a range of climate types to test or pilot promising interventions

Loss of lowlying agricultural lands as a result of rises in sea levels from global warming, will put more pressure on marginal lands to provide food and economic security for upland farmers. Slopes increasingly farmed for cash crops cause a decline in fertility which leads to escalation in environmental degradation. This increases the costs of cultivation and narrows the profit margins of small upland farmers. Expansion onto even steeper sloping lands will damage the watersheds of remaining water sources aggravating the situation even further.

The UDP's strategy of diversifying subsistence farming into cash crops (fruits and vegetables) is producing positive results. However, this is in Climate Type 4, which does not have a distinct dry season. To identify and test measures to counter the effects of climate change, the concepts need trying in areas which already have long dry seasons. Similarly, climate change farms need setting up in those drier areas so proven packages of suitable cropping strategies will be ready for application as climate change makes itself felt.

There is an encouraging trend of farmers moving away from corn as a cash crop into bananas and fruit trees. However, their top priority of attaining food security for their families still needs

[57] Lal, R. (1995). *Sustainable management of soil resources in the humid tropics*. United Nations University Press, The United Nations University 1995. http://www.unu.edu/unupress/unupbooks/uu27se/uu27se0b.htm

to be addressed. This can be done economically and effectively on 0.1 to 0.25 ha plots of land with hybrid corn and inorganic fertilizer, returning crop residues to the soil, and applying minimum-tillage practices. Learning sites set up by UDP should be used to develop and test the appropriateness of production systems (e.g. corn patch; vegetable gardening in permanent raised beds; organic agriculture; bio-dynamics; etc) in the marginal up lands.

6.1.2 Extrapolation and promotion of promising interventions elsewhere

Those interventions that prove to be successful in pilot projects on learning sites need to be promoted elsewhere. Since soil order/soil type and slope are important, it is sound to promote them on similar sites.

Enhancing BSWM's existing LMU maps to make them of practical use to LGU staff is a simple way of extrapolating data to new areas. Instead of eight or more maps (e.g. geology, soils, slope, vegetation/land use, etc), there is only one map, the LMU map showing the distribution of the various LMUs in the region. Three-dimensional block diagrams, show the relationships between soils, slope, vegetation and other factors within each LMU, effectively combining the various maps for each of these features.

Support is needed to upgrade the LMU maps to land systems maps. This involves further subdividing the LMUs based on geology, identifying the constituent land units or facets (i.e. hill tops, plateaux, side slopes, spurs, valley bottoms, etc) and creating 3-dimension block diagrams and accompanying tabulated descriptions (see Annex XVI).

Consulting the LS map can help investors or bankers decide whether proposals to fund the establishment of agroforestry schemes, orchards, irrigation schemes or plantations, such as rubber and oil palm, are sound propositions. Knowing that appropriate mitigating measures for cultivating particular upland soils are included in the proposal can the reduce the risk of bad loans.

7. APPLY GROSS MARGIN ANALYSES (GMA) TO EXCLUDE NON-VIABLE FARMING ACTIVITIES

7.1 PROTECT FARMERS' FROM GETTING INTO DEBT

7.1.1 Cassava production

Efforts must be taken to prevent upland farmers venturing into non-viable farming activities. In a well-documented example, farmers in Isabella province took loans to grow cassava and ended up in debt. Some were reported to have lost their land and homes as a result.

Nonetheless, cassava is still being promoted as a crop with yields of 40-50 tons per hectare if the technology supplied by the purchasing company is followed. "Farmers are assured a buying price of not less than one peso per kilo, but they have to sell it to the assemblers" who dry and shred the cassava and sell it to the processor for P5.50/kg [58]. However, according to the Bureau of Agricultural Statistics, the average yield for cassava per province in the Philippines in 2003 was 7.75 MT/ha (up from 6.89 MT/ha for the period 1994-2003). The highest yields were only 16.41 MT/ha.

[58] Sarmento, B.S. (2006). Cassava making a comeback. In *Sun Star* Vol. I No. 83 Sep 4-10 2006

In their 2003 Commodity Fact Sheet for cassava, BAS calculated the average production costs for cassava as P1.61/kg[59], which means production costs for 40 t/ha would cost P64,4000. Claims that farmers can earn a *gross* income of P44,000 per hectare per cropping are clearly misleading. The *net* income should be determined for all products.

7.1.2 Gross Margin Analysis

Undertaking gross margin analyses of the costs and returns will show whether the proposed enterprise is profitable, increasing upland farmers' incomes, rather than be loss making incurring debts and hardship. Banks often require a 10% internal rate of return (IRR) to justify a project from either the financial (beneficial to the farmer) or economic (beneficial to the national economy) perspective. Farmers are more likely to be prepared to take out small loans when they have been convinced that an enterprise will improve his income at low risk.

The bank is more likely to provide a loan when they can see the expected IRR for the proposed project. GMAs for projects such as the corn patch and raised bed vegetable gardens, prepared for Panay and Negros, have shown that the costs of the enterprises are repaid with profit within the first year of application.

[59] Cassava Statistics. Bureau of Agricultural Statistics. http://www.bpre.gov.ph/phindustry/cassava.htm

8. RECOMMENDATIONS AND PROPOSED ACTIONS

The following recommendations (italicized) are taken from the *APO Study Meeting on Sustainable Farming Systems in Upland Areas*[60]. Proposed actions, based on the points raised in the foregoing sections, are suggested for each APO recommendation:

1. *Developing sustainable production systems for sloping lands requires new strategies that follow certain guiding principles which emphasise that "approaches to use sloping lands will be sustainable if they are designed to mimic the control mechanisms that occur naturally in these ecosystems".*

Proposed actions

Control mechanisms that occur naturally in upland ecosystems are: the multi-layered forest canopy, which intercepts and breaks up the velocity of raindrops; and a forest floor covered with layers of dead leaves in various stages of decay, which increases the permeability of the soil and keeps rates of soil erosion below 6 t/ha/year, even on steep slopes.

- *Promote Multi-storey Tree Cropping as part of diversifying the farming system*

  Guiding principle:

  > Imitating the multi-layered canopy of the original rain forest, by planting a mixture of trees of different heights, dissipates the energy of raindrops before they strike the ground. Dead leaves on the soil surface improve infiltration, reduces erosion, and rapidly decompose to recycle nutrients.

  - Encourage farmers to move to multi-storey tree cropping to protect the soil from erosion and increase the relative humidity in the under-storey[61].
  - The rate of mulch formation can be increased in a number of ways:
    - Plant *Acacia falcata* as a shade tree (e.g. for durian). Its fine leaves help mulch the soil. Cut the *Acacia* trees after four years and sell the stem.
    - Establish a cover of *Arachis pintoi* (forage peanut). Sprayed it with a non-systemic herbicide to form a mulch of dead leaves. Once the live cover regenerates from the roots, repeat the process.

- *Demonstrate mulch-based agriculture on cleared land*

  Guiding principle:

  > Emulating the original forest floor by covering the soil with a thick layer of mulch protects it from raindrop impact, improves infiltration of rainfall, and encourages soil micro-organisms.

  - Apply a thick layer of grass cuttings, dead leaves, etc. in a 3-meter diameter circle around seedlings and trees to reduce the need for weeding, retain soil moisture during dry spells, improve soil porosity, and to support soil micro-organisms, such as mycorrhiza, which help trees grow in soils of low fertility.
  - Mulch vegetable crops with leaves from hedgerows or compost, to reduce the need for weeding, keep the soil cool, and provide nutrients for earthworms.

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[60] *Report of the APO Study Meeting on sustainable farming systems in upland areas*. Held in New Delhi, India, 15-19 Jan 2001. (ed. Dr Tej Partap). Pub. Asian Productivity Organisation.
www.apo-tokyo.org/00e-books/AG-02_Sust**Farming**/00CoverTOCFore_Sust**Farming**.pd

[61] Proud, KRS (2004). *MULTI-STOREY TREE CROPPING. Slope Treatment-Oriented Practices (STOP) 2.* Principles for developing productive upland agriculture in the humid tropics #2. Handout prepared for the Upland Development Programme in Southern Mindanao, The Philippines. 2004

- *Show upland farmers how zero- or minimum-tillage(ZT) can save time and money*
  ZT uses herbicides to control weeds, instead of burying them by ploughing. The soil is protected by a mulch of dead grasses into which annual crops are planted without loosening or exposing the soil wind and water erosion. Mulching is a major contributor to soil moisture conservation. This approach saves farmers a lot of labour in land preparation and enables them to reclaim land infested with the cogon (*Imperata cylindrica*) for *Agroforestry* uses. Zero- or minimum- tillage is expected to be useful on soils prone to drought due to low plant available water reserves and shallow effective rooting depth as a result of erosion, or subject to supra-optimal soil temperatures at planting time[62].

  Guiding principle:

  > Boost organic matter production with an HYV seed-inorganic fertilizer package to produce large amounts of crop residues; kill weeds by spraying with herbicide; keep the soil covered with a layer of mulch; plant short-term crops through a crop residue mulch without turning the soil; diversify crop production; apply fertilizer on top of the mulch.

  - Train local government technicians how to apply herbicides properly, to suppress live mulches of cover crops, or to kill existing weeds and cogon.
  - Adapt zero- or minimum tillage systems to site-specific conditions. For example, introduce the chisel plough* where farmers find it difficult to make the holes for planting seeds by hand in compacted sub-soils of ultisols, oxisols, and alfisols.

  (* Chisel plough: A single chisel-like tine that cuts a narrow 1-2 cm wide slot to loosen the compacted soil without inverting it or burying the surface mulch. Seeds and fertilizers are dropped down the slot).

2. *Technologies for increasing the productivity of steep lands include biological and physical or mechanical measures. The choice of appropriate land modification technologies must be determined by soil and climate conditions and socio-economic constraints of the site in question. At any rate, maintaining an effective surface cover (live or dead) during the onset of the rainy season is of paramount importance for controlling runoff and erosion* (see Proposed Actions in Recommendation 1, above).

Proposed actions

70% of the word *T<u>EC</u>HN<u>OLOGY</u>* is *ECOLOGY*. Current technologies must be changed, modified or adapted to suit the changing ecology of a site resulting from a change in soil conditions due to land degradation and changes in climate. For land modification technologies:

- *Match hedgerow species to soils and slopes*
  Leguminous hedgerows were originally designed for short lengths of 18% slopes where run-off velocities were low (see STOP 1 in Recommendation 5).
  - Avoid planting hedgerows on long, very steep slopes, as they are unable to prevent a build up in the velocity and volume of run-off, and may be responsible for increasing erosion, and lowering the productivity of the land. The maximum slope should be 18-25% on slope lengths not more than 30 m on hill tops.
  - Match leguminous species to soil types. Planting Ipil-ipil (*Leucaena leucocephala*) and madre de cacao (*Gliricidia sepium*) hedgerows on gently sloping hill tops on the more

[62] Lal, R. (1985). No-till in the lowland humid tropics. Proceedings of the 8th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. 16-17 July, 1985,

productive non-acid or slightly acid Alfisols will give higher growth and biomass production. If necessary, add nutrients to improve hedgerow growth.
- On short lengths of slopes >25% of the less productive Oxisols and Ultisols, plant hedgerows of *Flemingia macrophylla* and *Calliandra calothyrsus,* as they perform well on the low pH soils[63].

- *Introduce appropriate soil conservation measures for sloping lands in the humid tropics*
  According to FAO, outward-sloping terraces, such as formed by contour cultivation between hedgerows, are *not* appropriate soil conservation measures for sloping lands in the humid tropics. Being porous barriers they cannot prevent the progressive build up in volume and velocity of run-off in heavy storms on long slopes.
  - Set up demonstrations of intermittent *reverse-sloped* bench terraces (see Annex VIII) which are built every 11-14 m down slopes <58% with small catchment areas of 0.5 to 1.0 ha. Grass waterways of <20%, are needed to dispose of run-off intercepted and diverted from the terraces. These can be constructed diagonally across the slope to achieve the required gentle gradient.

- *Demonstrate moisture-stress avoidance strategies*
  As perennial crops need moisture in their root zones throughout the year, the longer dry seasons expected with climate change, will increase the possibility of yield-reducing moisture stress affecting tree crops. Trees in soils made shallow by erosion, are at increased risk.

  - The following d*rought management* practices can minimize the risk of moisture stress affecting coconuts[64]:
    - Increase the supply of moisture to the root zone by burying fresh or dried coconut husk in trenches 2.5 m uphill from the palm to intercept and absorb run-off.
    - Conserve stored soil moisture by applying mulch around the trees to reduce evaporation of moisture from the soil surface.
    - Reduce the demand for soil moisture by cutting down the leaf area available for transpiration by pruning the bottom five green leaves.
  - Minimise the chances of corn crop failure by lopping off the bottom four green leaves to reduce transpiration rates.
  - Gradually replace existing over-mature coconut palms with high-yielding, drought-resistant varieties planted in an East-West direction to facilitate intercropping. Sell the wood of felled coconuts to pay for new seedlings.

- *Establish fruit trees by direct seeding*
  Direct seeding is a cheap, low risk strategy for farmers to establish a fruit orchard. Risks of failure tend to be lower as seeds usually only germinate when the soil is sufficiently moist. The tap root growing from the planted seed is able to penetrate fissures or cracks in the rock strata underlying the shallow soil to obtain deeply stored moisture and nutrients. This enables the seedling to resist drought longer. Nursery-raised grafted seedlings tend to lose their tap roots in the potting bag. The fibrous root systems of nursery seedlings stay near the surface of the soil and are more prone to die during drought as the soil dries out.

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[63] Management of low-activity clays (LAC) soils. http://www.fao.org/Wairdocs/ILRI/x5546E/x5546e04.htm#1.7%20management%20of%20low%20activity%20clays%20(lac)%20soil

[64] Proud, KRS (2005), *Strategies to offset the effects of drought and control land degradation under coconut plantations in Southern Mindanao*. Report for the Upland Development Programme in Southern Mindanao, The Philippines. 8 April 2005

- Plant seeds directly into weeded and mulched planting sites in the field, followed by field-grafting of scions of certified varieties of fruit tree.

- *Introduce and test crops adapted to sub-humid and semi-arid climates*
  - Undertake trials, with the aim to develop farming systems for lower rainfalls, with sorghum, millet, mung bean (monggo), pigeon peas, cashew and guava. Monggo, planted at the end of the rains as a "catch crop" (i.e. to catch the last rain storms) can extend the growing season well into the dry season.
  - Grow sorghum to provide grain as feed for poultry and fodder for livestock. Sorghum has lower moisture requirements than corn, and can survive seven days without any soil moisture. Its ability to ratoon provides nutritious green fodder into the dry season.
  - Set up nurseries for producing the drought-tolerant Vetiver grass for planting as cross-slope barriers to keep soil in place, as other hedgerow species are likely to die off if soil depths are too shallow to store sufficient soil moisture.

3. *Sustainable management of sloping lands for agricultural production cannot be achieved by onsite technological improvements alone. It must be supported by governmental and private institutions capable of implementing conservation policies, providing technical and financial assistance to steep land communities, and generating public awareness of the effects of upstream (onsite) land degradation (deforestation, soil erosion) on short term economic benefits and long-term ecological and environmental consequences downstream (offsite).*

Proposed actions

- *Implement UDP's Upland Agricultural Extension Delivery*

The UDP's Sustainable Upland Development Model (SUD)[65] applies most of the above points to ensure sustainable management of the upland resource base. The objective is to improve the living standards of communities who derive most of their income from upland farming. However, funding for the project's activities will soon end. With regard to identifying, testing and disseminating new interventions to offset the effect of climate change and land degradation on food production, funding for the following SUD strategies needs to continued:

  - Environmental Awareness Campaigns (EACs);
  - Model farms/Learning sites, but in a range of different climate types;
  - LGU/Community capacity building for quality extension;
  - Access to financial services;

4. *Traditional farming is unable to meet the food and livelihood needs of the upland farming families. The need is for alternative production systems leading to diversification*.

Proposed actions

Proven technologies and development pathways for permanent upland cultivation in hot, humid climates include dualistic cropping, multi-storey tree cropping, zero-tillage, mulching, and vegetable gardening.

- *Dualistic farming system model*: the area under a diversified range of cash-generating perennial crops is increased, while the cultivation of annual crops is reduced to small areas with flat to gentle slopes (see Annex IX). The model involves:

[65] UDP (2006). Sustainable Upland Development Model. Upland Agricultural Extension Delivery. http://www.saveuplands.org/

- *Multi-storey tree cropping* - Mixtures of bananas and fruit trees of different heights replace annual crops on slopes too steep or too long for cross-slope barriers (see Annex X and Recommendation 1 above).
- *Mulching and Zero Tillage* - Seeds are planted directly through mulch without exposing the soil by ploughing (see Annex XI and Recommendation 1 above).
- *Intensive production of annual crops on small, level plots* – The Corn Patch can achieve food security by reducing the area normally required to produce corn for home consumption by 80-90% (see Annex XII). This frees land and up 3-4 months of labour for more productive activities such as intensive vegetable gardening in *permanent raised beds*, planting fruit trees, etc. (see Annex XIII).

5. *Marginal lands will have to play an important role in ensuring the food and economic security of upland farmers. However, R&D investment for developing appropriate production systems on such marginal lands are still hopelessly inadequate. Appropriate policy support to promote R&D into marginal niches-based farming systems, products, market opportunities and intellectual property rights to upland communities over their indigenous knowledge and plant material is needed.*

Proposed actions

- Adopt a land capability classification approach land allocation for agriculture
  - *Land Unit Mapping and Farming:* a farm-level land capability classification based on three simple field measurements: slope, soil depth and soil texture. It aims to achieve a better match of *land use* to *land capability* by ensuring crops are planted on the appropriate slopes and soil textures. Sustainability of cropping is promoted by restricting annual crops to flat to gentle hill top slopes and valley bottoms, and using cross-slope barriers and contour ploughing to promote terracing (see Annex XIV).

  - Set up appropriately chosen and located learning sites (see Annex XV) to demonstrate the differences in yields and costs (including labour) between and traditional and alternative production systems. E.g. Show how the labour and land freed from food production, using the Corn Patch approach, can be more productively used to grow vegetables, bananas, and tree crops to earn cash.

6. *Subsistence farming is diversifying to farming of cash crops (fruits and vegetables). Landscapes that are increasingly farmed for cash crops causing a decline in fertility leading to escalation in environmental degradation, increase in costs of cultivation and narrowing profit margins of small upland farmers. Expansion onto sloping lands is further aggravating the situation. Besides developing appropriate farming systems adequate extension services are required to create an awareness of the situation among stakeholders.*

Proposed actions

A strategy is needed to replicate or extrapolate successful interventions and lessons learned from the learning sites to other locations in the country where the terrain has similar soils, slopes and dissection, and the climate types are the same. *Land systems mapping* performs this important function ((Annex XVI).

Produce soil order maps based on land forms/land management units (LMU). This will allow generalized recommendations to be made for given land forms. This can be done through applying a land form or landscape approach. The detailed BSWM soil maps can then be extrapolated into new areas where the same land forms/landscapes occur.

7. *Non-viable farming in the uplands increases family food insecurity and poverty*.

Proposed actions

- *Undertake gross margin analysis (GMA) of a number of cropping systems currently used or being advocated to determine whether they are sustainable and environmentally appropriate, and economically sound.*
  - Analyse the financial and economic viability of the current and proposed agro-forestry and upland agriculture measures. Prepare tree farm, agro-forestry farm and upland agriculture farm budgets for typical farms and financial cash flow models of smallholder farms to demonstrate the financial viability and sustainability of activities proposed at smallholder level and their impact on returns on family labour.
  - Prepare detailed sensitivity analysis of the components, complemented by quantifying the economic benefits based on "with" and "without" intervention scenarios
  - Assess the long-term and short-term benefits to the project participants after the initial investment phase of the project
  - Apply the results of GMAs to encourage cropping systems that ensure farmers' achieve food security (usually their top priority) as efficiently and effectively (in terms of labour and cash outlay) as possible.

ANNEX I

IMPACT ON CROP PRODUCTIVITY OF STRESSES RESULTING FROM CLIMATIC VARIABILITY

Source: Arifin bin Tawang , Tengku Ariff bin Tengku, and Mohd. Yusuf bin Abdullah (2001). Stabilisation of upland agriculture in El Nino vulnerable countries: Country Report of Malaysia. *Palawija News* Vol. 18, Number 3. CGPRT Centre Newsletter.

Weather plays a major role in determining year to year variability in crop yields, and the spatial patterns of global agriculture. The impact of climatic stresses such as drought, high temperature and air pollution, on crop productivity, indicates that climate variability can pose a threat to national food security and the economic contribution from the agricultural sector..

Any change in the following environmental variables would have a significant impact on crop growth and productivity and land use patterns:

- rainfall,
- temperature,
- solar radiation and
- atmospheric gases, particularly carbon dioxide and oxygen.

Water stress and high temperature stress are the main stresses commonly encountered under rainfed conditions.

Rainfall
Most crops grow well with a mean annual precipitation > 2000 mm and a minimum monthly rainfall of about 150 mm. Crop productivity decreases linearly with a decrease in rainfall and is severely affected when mean annual precipitation falls below 1000 mm. This precipitation requirement is true for plantation crops such as oil palm, rubber, cocoa, and other annuals such as rice and vegetables.

The influence of lack of water on crop growth depends on the severity, duration, and time of stress in relation to the phonological stages of growth.

Periods when most annuals, particularly vegetable crops, are sensitive to drought:

- flowering, and
- fruit development (tuber formation or head formation).

Depending on the vegetable type, this period may extend from 3 to 10 weeks.

In perennials, such as oil palm, monthly yield depends on climatic conditions 2 to 2.5 years before harvest and the effect of drought on fruit trees can result in reduced yields for several years. On the other hand, some perennials, e.g. mango, durian and mangosteen, will not flower properly unless they have been through a period of water stress.

High temperature
The effects of high temperature stress can be confused with those of water stress. Drought is usually accompanied by high temperature, which increases the rate of transpiration and hastens the occurrence of injurious dehydration.

Solar radiation
Solar radiation is also an important factor in agricultural production as it controls photosynthesis and has a strong effect on many other biological processes.

Photosynthesis and transpiration are two physiological processes that increase almost in proportion to the intensity of solar energy. In general, most tropical crops require the optimum amount of sunshine of about 3-4 hours and yield is not usually affected if the intercepted radiation is more than one-third of the full solar energy.

Relatively high solar radiation during the reproductive stage has remarkable effects on increasing yield in rice, oil palm and fruit trees. However, a reduction of 40 to 70% in intercepted radiation as the result of air pollutants or with the occurrence of haze may to a certain extent affect crop productivity. The reduction in fresh fruit bunch yield and lower extraction rate for oil palm are presumably due to haze that occurred within the previous three months.

ANNEX II

STRATEGIES FOR OFF-SETTING A RISE IN SEA-LEVELS

Source: Parry, M. L., A. R. Magalhaes, and N. H. Nih. (1992). The potential socio-economic effects of climate change: A summary of three regional assessments. Nairobi, Kenya: United Nations Environment Programme (UNEP). http://www.ciesin.columbia.edu/docs/004-149/004-149.html

It is possible that the rise in groundwater will be accompanied by the upward movement of subterranean salt, resulting in saline damage to rice fields and farmland soils. It may be tempting in such conditions to convert these areas into brackish-water, fish and prawn ponds to replace those threatened or lost in the mangrove areas.

It will be evident that some environmental changes are already in progress on the coasts of South-East Asia, and that substantial modifications, both natural and man-made, would have occurred on these coasts during the coming century even if there were no global warming and sea-level rise. Coastal erosion is already extensive and likely to continue, and coastal environments will be changed by further urban and industrial development.

The combination of such pressures, together with possible future sea-level rise due to global warming suggests a number of possible strategies:

- Adapt and evacuate: Under this strategy land lost to submergence and erosion would include large areas of currently productive coastal land, especially fish and prawn ponds. It would not be difficult to convert rice fields into fish and prawn ponds as sea-level rises, but who would bear the cost of resettlement and land transformation for rice farmers?

- Hold the coastline: It has been estimated that the raising and elaboration of coastal defences to counter a sea-level rise of 20 cm along approximately 250km of coastline would cost US$1 billion; for a 1m sea rise the cost would be US$10 million per kilometre. In these terms the cost of preventing sea incursion on 5000 km of low lying coastline in Thailand, Malavsia and Indonesia would total about US$50 billion.

- Counter attack: The cost of building sea walls and putting in drainage and pumping systems to manage the land margin as sea-level rises would be great, and it is difficult to envisage South-East Asian countries achieving this on a large scale without substantial international assistance. An alternative solution may be to construct sea walls offshore and reclaim the enclosed shallow areas for productive use. Where this is possible, the economic returns from the land gained could offset at least part of the cost of building sea walls and associated structures. The disadvantage of building sea walls along the coast or offshore is the associated reduction in the extent of mangrove swamps and tidal mudflats, with consequent losses in the productivity of fish and shellfish resources

In the short term, i.e. the next few decades, the wisest response to the predicted sea-level rise is likely to be a reorganization of coastal land use planning in low lying coastal areas, delimiting these areas in relation to predicted submergence and erosion. For example, it is unwise to develop new resorts within 200m of the present high tide line on beach-rich terrain unless plans allow for abandonment or relocation during the coming century.

Aquaculture could be restructured towards intensive production from relatively small and concentrated areas which can be protected from submergence and erosion as sea-level rises and can be adapted to new tidal levels

Policy Implications

Funding should be sought for workshops to consider the policy implications of the climate change. The workshops should be designed:

- to inform policy makers about the magnitude and characteristics of potential future climate change;
- to consider the range of possible response strategies to mitigate adverse impacts; and
- to outline the need for future research.

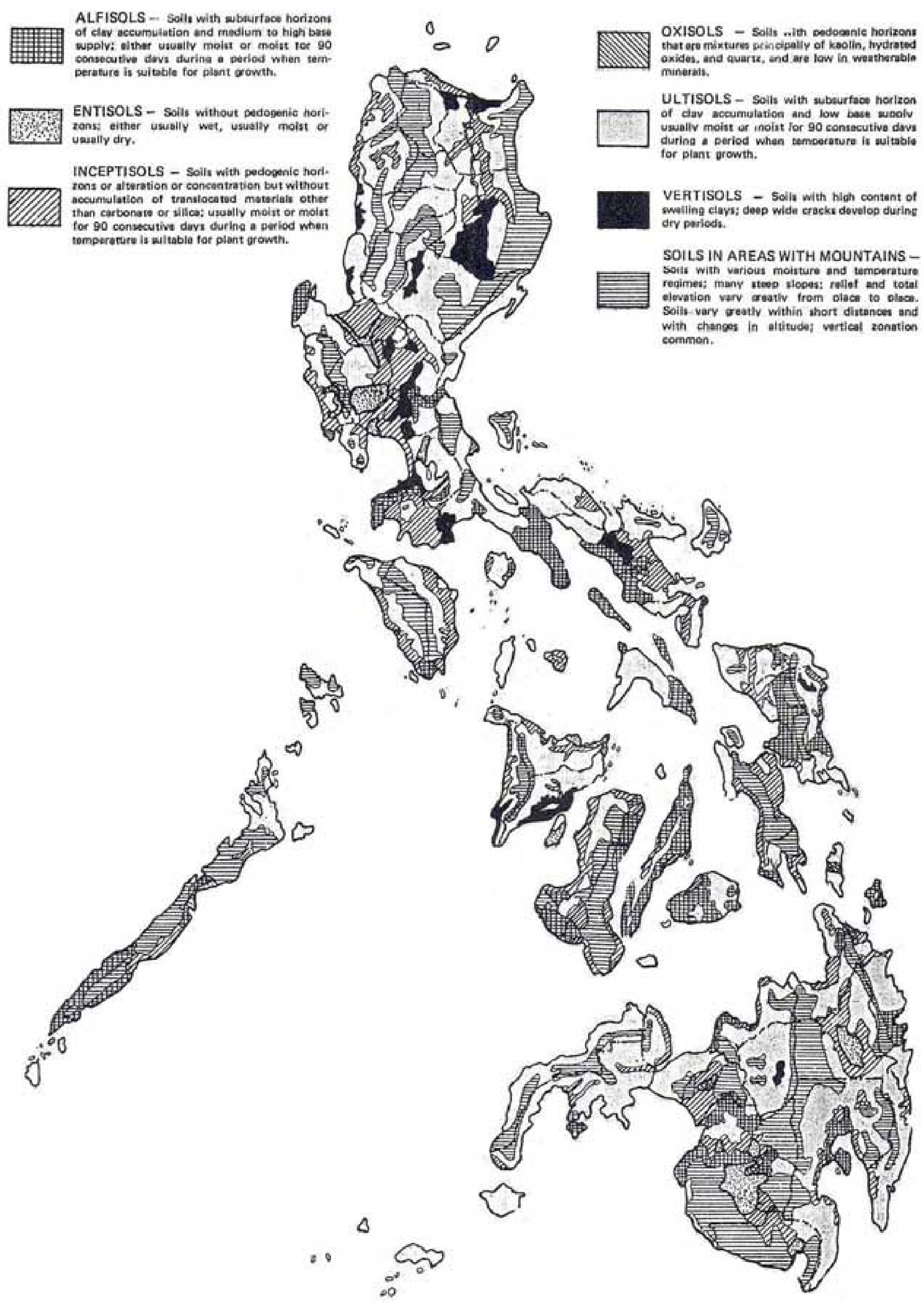
Similar workshops in Malaysia and Indonesia were conducted as policy exercises, bringing together policymakers and their scientific advisors at the national government level and scientists who had worked on studying climate change to generate the impact assessments.

Five major types of policy response were considered at these exercises:

- economic (changes in existing tax structure, subsidies, pricing systems, etc.);
- technological (breeding new varieties, constructing dams and coastal protection structures);
- institutional (enhanced or distorted market mechanisms, formal government regulations, legal instruments);
- research needs (information required for formulating adequate response strategies); and
- monitoring (characteristic signs of change, both biological and socio-economic, that could provide the necessary early warning to ensure timely action).

ANNEX III

FAO SOIL ORDER MAP OF THE PHILIPPINES



Source: http://www.fao.org/ag/aGp/agpc/doc/Counprof/Philippines/phfig4.htm

ANNEX 1V

CHARACTERISTICS OF THE MAIN SOIL ORDERS IN THE UDP AREA

Soil Order	Description	Inherent fertility	Occurrence	Comments
Oxisols	Old, intensely weathered, permeable, and well-drained soils	Low	Regions without a marked dry season	Most nutrients in Oxisol ecosystems are contained in the standing vegetation and decomposing plant material. Despite low fertility, Oxisols can be quite productive with inputs of lime and fertilizers.
Ultisols	Strongly leached soils with a subsurface zone of clay accumulation and <35% base saturation. Similar to Oxisols but relatively less weathered.	Relatively higher nutrient reserves and effective CEC* than Oxisols	Warm humid climates with 1500- 2000 mm annual rainfall and a marked seasonal deficit of rainfall	The high acidity and relatively low quantities of plant-available Ca, Mg, and K associated with most Ultisols make them poorly suited for continuous agriculture without the use of fertilizer and lime. With these inputs, however, Ultisols can be very productive.
Alfisols	Moderately leached soils with a subsurface zone of clay accumulation and <35% base saturation. Less weathered than Oxisols and Ultisols but more strongly weathered than Inceptisols	Of intermediate fertility. Generally productive soils	Occur in the semi-humid and sub-humid tropics in cool to hot humid areas with a prolonged dry season	Very productive soils for both agricultural and silvicultural use.
Entisols	Young, generally featureless, soils formed on relatively inert parent material: *Psamments*: coarse textured soils with high permeability, low water-holding capacity, and low nutrient reserves. *Fluvents*: recent alluvial deposits formed along flood plains *Lithic soils*: shallow and rocky soils marginal for agricultural production	Of intermediate fertility	Many Entisols are found in steep, rocky settings as well as in large large river valleys and associated shore deposits	Entisols of large river valleys and associated shore deposits provide cropland and habitat for millions of people worldwide.
Inceptisols	Young, very fertile soils with weakly developed subsurface horizons: *Aquepts*: alluvial soils formed along the flood plains. *Andepts*: soils of volcanic origin, and extremely fertile. *Tropepts*: soils containing relatively high amounts of soil organic carbon.	Good fertility and high productivity	Flood plains. Often found on fairly steep slopes in mountainous areas, young geomorphic surfaces, and on resistant parent materials	.
Mountain soils				

* Cation Exchange Capacity

ANNEX V

ACIDIFYING FERTILIZERS AND RATES OF LIME APPLICATION

(Source: http://www.ipm.iastate.edu/ipm/hortnews/1994/4-6-1994/ph.html)

a) ACIDIFYING FERTILIZERS

Some types of fertilizers can help to acidify the soil and most of them are safe to apply:

- Acidifying fertilizers include:
- ammonium sulfate,
- diammonium phosphate,
- monoammonium phosphate,
- urea, and
- ammonium nitrate.

Read the label on the fertilizer bag to determine if it is an acidifying fertilizer

b) RATES OF LIME APPLICATION

The pH of highly acidic soils can be raised by incorporating limestone into the soil. Hydrated lime works quicker, but over-liming is more likely. Table 1 shows the kilograms of ground limestone needed per 100 square metres to raise the pH to 6.5 in the top 15 cm of soil.

Modifying a soil's pH is usually a slow process and may require repeat treatments. It is often most effective to use a combination of treatments. However, don't expect a quick fix or a miracle cure.

Table 1. Kg limestone per 100 sq m to raise pH to 6.5 in top 15 cm of soil

Existing Soil pH	Sandy loam	Loam	Clay loam
5	39.09	48.87	73.30
5.5	29.32	39.09	48.87
6	14.66	19.55	29.32

Adapted from: How To Change Your Soil's pH. *Horticulture, Home Pest News* April 6, 1994 issue, pp. 1994 issue, pp. 42-43. http://www.ipm.iastate.edu/ipm/hortnews/1994/4-6-1994/ph.html

ANNEX VI

CAUSES OF SOIL ACIDITY

The use of fertilizers, especially those supplying nitrogen, has been blamed as a cause of soil acidity. Although acidity is produced when ammonium-containing materials are transformed to nitrates in the soil, this is countered by other reactions and the final crop removal of nitrogen in a form similar to that in the fertilizer. The effect of other fertilizers is increasing soil acidity has been through ncreasing yields and thus increasing the removal of bases in the crop residues.

Harvesting of crops has its effect on soil acidity development because crops absorb the lime-like elements, as cations, for their nutrition. When these crops are harvested and the yield is removed from the field, then some of Ca and Mg cations responsible for counteracting the acidity developed by other processes are lost, and the net effect is increased soil acidity[66].

Increasing crop yields will cause greater amounts of basic material to be removed. Grain contains less basic material than leaves or stems. For this reason, soil acidity will develop faster, for example, under continuous wheat pasture than when only grain is harvested. High yielding forages, such as Bermuda grass or alfalfa, can cause soil acidity to develop faster than with other crops.

The strategy to offset the increase in acidity is to leave the crop residues (stalks and leaves) as a surface mulch.

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[66] Johnson, G.V. & Zhang, Haitin (2004). Causes and Effects of Soil Acidity. *Oklahoma Cooperative Fact Sheet F-2239*. Division of Agricultural Sciences and natural Resources, Oklahoma State University http://www.osuextra.com

ANNEX VII

THE CASE FOR APPLYING FERTILIZERS TO SOILS OF THE HOT, HUMID TROPICS

Quotation	Reference
1. High-intensity cropping systems involving: several short- and medium term crops that cover the land for most of the year; bananas; a cover of tree crops; and small animals such as goats, tend towards zero tillage on the upland. These would have to be maintained by mineral fertiliser and mulching, with the functions of tillage taken over by herbicides (weed control) and pesticides (insect control)…. 2. …hardly anything is as destructive in terms of maintaining a balanced environment as the expansion of impoverished smallholder farming producing unfertilised arable crops on depleted soils in a tropical setting. 3. Land-use intensification under tropical conditions seems to be even more dependent on chemical inputs than in temperate climates…… 4. Fertilisers can be replaced by manures and composts in exceptional cases only. There are simply not enough nutrients in the available organic matter to sustain a vigorous crop vegetation. 5. High output modes of production (in the humid tropics) are almost without exception tied to high chemical inputs, in particular of fertilisers. 6. The more humid and the warmer the climate, the more do chemicals encourage the trend towards a spatial concentration of production, and the more opportunity there is for untouched areas that preserve the environment	H Ruthenberg (1983): *Farming Systems in the Tropics*. OUP (p. 174) p. 363
7. Most NGOs lack the technical skills or resources to provide the kind of adaptive research and extension services needed in the uplands, and resort to the same SALT package as the government agencies, regardless of the circumstances of the farmers they are serving. Some are also hampered by an ideological commitment to 'organic' farming when one of the main short-term benefits of adopting conservation techniques is the increased effectiveness of chemical fertiliser use.	Cramb, R A; Garcia, J N M; Gerrits, R V; and Saguiguit, G C. (2000). Adoption of soil conservation technologies in the case study sites. In: *Soil Conservation Technologies for Smallholder Farming Systems in the Philippine Uplands* pp 72-94. Autralian Centre for International Agricultural Research
8. …..in many countries of the humid tropics, low-input systems alone are obsolete, environmentally incompatible, soil degradative, and responsible for perpetuating low standards of living 9. The use of chemical fertilizers is essential for obtaining high yields in the highly weathered soils of the humid tropics ….. Most soils in the humid tropics are so deficient in primary nutrients that it is imperative that strategies be developed for adding them from outside the ecosystem. Otherwise, sustainable cropping systems cannot be developed. 10. The use of synthetic fertilizers being inevitable, the strategy is to decrease their rate of application through better systems of soil and crop management. Hoping to increase and sustain agricultural production by adding chemicals alone, without improved and efficient systems of soil and crop management, is bound to cause frustrations and disappointments.	Lal, R. (1995). *Sustainable management of soil resources in the humid tropics*. United Nations University Press, The United Nations University 1995 http://www.unu.edu/unupress/unupbooks/uu27se/uu27se0b.htm

Annex VII cont'd

Quotation	Reference
11. some purchased inputs are used in semi-commercial farming systems. It is common to use chemical fertilizers on tree crops. Most management inputs are directed to cash crops rather than food crops. In addition to chemical fertilizers soil fertility is also maintained through application of organic manners involving compost, … and crop residue mulches. 12. A low-output subsistence system….is unsustainable because of low productivity. The energy efficiency of a high-input system can, however, be improved by: reducing nutrient losses by effectively containing leaching and erosion, and enhancing nutrient capital through judicious inputs of chemical fertilizers and organic amendments. 13. Nitrogen deficiency is a major constraint in most soils of the tropics….Locale-specific research is needed to ensure an adequate supply of nitrogen for the desired level of high yields through the input of synthetic chemical fertilizers *supplemented by* alternate sources of nitrogen (e.g., symbiotic nitrogen fixation through legume-based rotations and agroforestry systems, organic manures and composts, azolla) 14. The productivity of soils notably deficient in available P can be enhanced only through substantial and regular additions of phosphatic fertilizers. 15. Concern about over-dependence on nonrenewable and rapidly dwindling fossil fuels is genuine but is not a justification for condemning resource-poor farmers to sub-human operations. 16. Nutrient management is crucial to sustained production. Highly weathered Oxisols/Ultisols and Alfisols, being inherently low in nutrient reserves, must have a regular and supplemental nutrient supply to facilitate intensive cultivation for increased food production. 17. Intensive land use and high yields on soils of low inherent fertility can be achieved only by raising the nutrient levels through the use of inorganic fertilizers, organic amendments, and nutrient recycling. Nutrient enhancement for these soils is indispensable.	Lal, R. (1995). *Sustainable management of soil resources in the humid tropics*. United Nations University Press, The United Nations University 1995 http://www.unu.edu/unupress/unupbooks/uu27se/uu27se0b.htm
18. Results of long-term field experiments carried out on Alfisols have also shown that with judicious fertilizer use and crop rotation, high and sustained crop yields can be obtained	Kang, B.T. and Juo, A.S.R. 1986. Effect of forest clearing on soil chemical properties and crop performance. pp. 383-394. In: Lal, R. Sanchez, P.A., Cummings, R.W. (eds.). *Land clearing and development in the tropics*., Rotterdam, Netherlands: A.A. Balkema
19. Similar principles also apply for managing the Ultisols/Oxisols. For sustained crop production, the Ultisols and Oxisols additionally require judicious liming	International Institute of Tropical Agriculture (IITA). 1984. Farming system program research highlights 1981-1984.
20. Under continuous cropping, recycling and reusing nutrients from organic sources may not be sufficient to sustain crop yields. Nutrients exported from the soil through harvested biomass or lost from soil by gaseous loss, leaching, or erosion must be replaced with nutrients from external sources. The judicious use of chemical fertilizer is essential to maintain soil fertility	Moorman and Greenland 1980, Tandon 1993, Ofori 1995, Hossner and Dibb 1995, cited in Lal, R, (1995) above..

Annex VII cont'd

Quotation	Reference
21. While fertilizer is needed to maintain soil productivity, it must always be used in conjunction with management practices that help maintain soil organic matter, such as return of residues or other organic materials to the soil, and minimum tillage 22. For the cultivation of crops such as maize and beans (on Ultisols and Oxisols), liming is needed not only to correct Al and/or Mn toxicity, but also to supply Ca and Mg as plant nutrients.	Integrated nutrient management in the tropics http://www.agnet.org/library/article/eb471.html
23. regardless of the tllage methods, maize does not grow well on unlimed Ultisols.	Lal, R. (1985). No-till in the lowland humid tropics. Proceedings of the 8th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. 16-17 July, 1985, Griffin, Georgia
24. …alternative agriculture proponents assert that purchased inputs are more costly than on-farm inputs…. to the farmer it is not the absolute cost of inputs that counts, so much as the relative costs of inputs compared to their respective productivity…..alternative agriculture proponents have not addressed these tradeoffs. Labor is a limiting input, and its opportunity costs are often crucial. Thus, inputs that substitute for labor are often highly desired by smallholders. Foregoing their use may be a real sacrifice…… the challenge of increasing food production will necessarily depend on yield-enhancing mechanisms. This makes the case for minimizing the use of commercial fertilizers much less secure. 25. There are compelling questions of how to provide adequate organic nutrient quantities in the broad range of agricultural systems, and of their costs relative to commercial sources. 26. Increased agricultural production requires increased export of nutrients from the farm. There are ecological limits to biological nutrient production and re-cycling of nutrients on-farm. And the relative costs to use organic inputs compared to inorganic sources often become quite high before these limits are reached. 27. Farming systems in many parts of the tropics are increasing in productivity through the use of commercial fertilizers. And the external nutrients that are applied increase the amount of organic matter available for cycling to following crops. 28. …..an accelerated shift toward smallholder timber and fruit tree production systems…. was a market-driven phenomenon facilitated by strong productivity increases in maize and other annual crops, enabling large parts of many farms to be released from food production to more profitable, and environmentally sustainable tree-based systems. 29. …maize yields in Claveria … ranged between 1 to 2 tons/ha in 1984, and … increased to between 2 and 3 ton/ha currently. This increase resulted from a number of interacting changes in crop and land management. Particularly noteworthy are the shift to hybrid maize from local cultivars, and the increasing use of lime and nitrogen and phosphorus fertilizers. 30. with yield-conserving practices (contour buffer strips and reduced tillage) and yield-enhancing practices (fertilizers and new varieties) continuous intensified production is possible…. on sloping soils…The gains also provide the opportunity to release land for other more profitable and environmentally suitable enterprises. Alternatives include vegetable production systems, perennial horticultural trees, timber production, and livestock systems, all of which tend to have relative comparative advantage on sloping uplands.	Garrity, D. P., (2000).Contour Farming based on Natural Vegetative Strips: Expanding the scope for increased food crop production on sloping lands in Asia, In: *Environmental Development and Sustainability,* 1(Special Issue):323-336. (an ICRAF Leaflet). www.worldagroforestry.org/sea/ph/02_pubs/papers/03_cons/cont_01.pdf

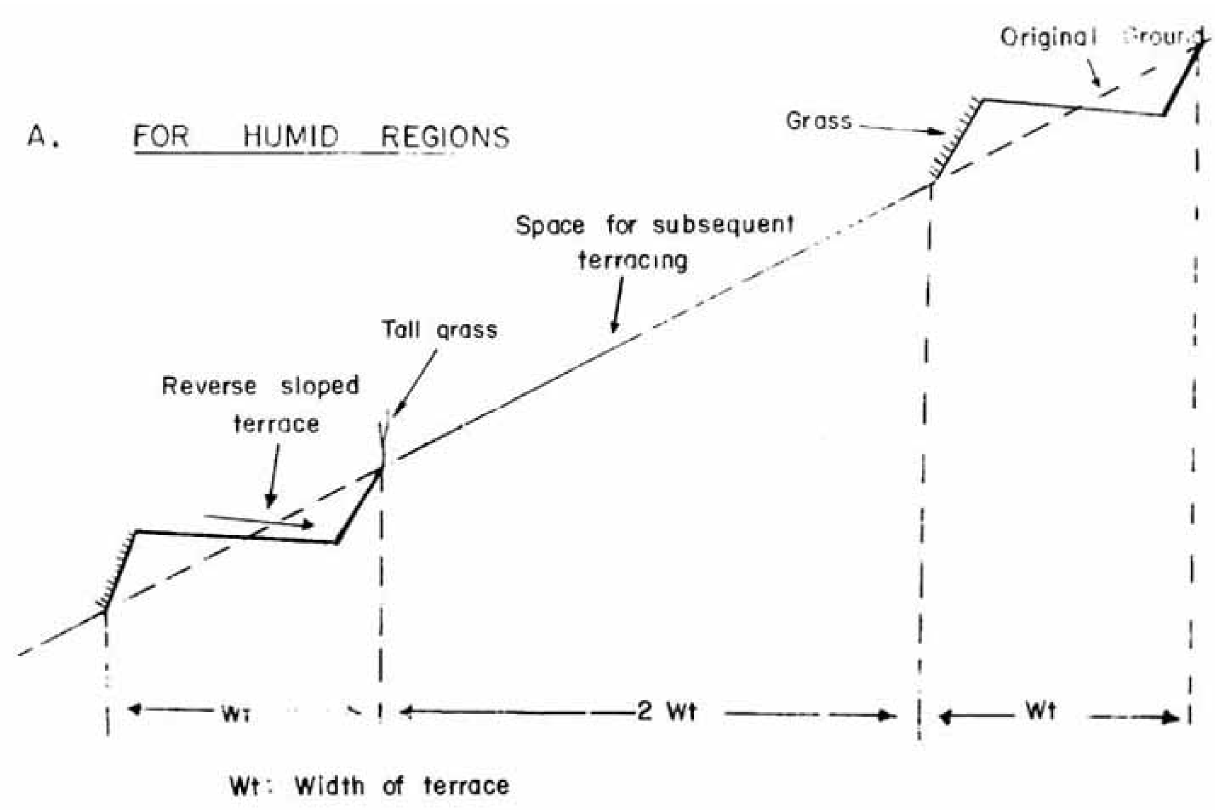
ANNEX VIII
INTERMITTENT REVERSE SLOPED BENCH TERRACES [67]

In humid tropical regions with heavy rainfalls, reverse-sloped benches intercept run-off from short lengths of slopes (range 12-49°) and divert it horizontally across the slope into a protected disposal outlet. They therefore prevent run-off from progressively building up in velocity and volume down the slope. Run-off does not flow over the edge of the terrace, as with outwardly sloping terraces formed by hedgerows.

Design specifications can be obtained from the FAO website:
hhttp://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/AD083E/AD083e09.htm

Fig. 1 shows the cross-section of reverse-sloped terraces.

Fig. 1. Cross-sectional view of reverse-sloped terraces for use in humid regions



[67] FAO (1986). *Watershed management field manual Slope treatment measures and practices.* FAO Conservation Guide 13/3 (1988). http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/AD083E/AD083e09.htm

ANNEX IX

DUALISTIC CROPPING TO MINIMIZE UPLAND DEGRADATION

Dualistic cropping expands cash-generating perennial crops onto forest-type land (i.e. steep slopes) while the area for annual food crop production is greatly reduced and moved to gentler upper slopes or minor valley bottoms. Annual crops are limited to producing the household's corn or rice requirements, and a surplus of vegetables for market. It is typical of smallholder cropping practices in many parts of the hot, humid tropics and is an obvious model to reduce the widespread land degradation caused by intercropping annual and perennial crops on sloping lands.

Because of the very steep slopes, and factors such a fluctuating market prices, a *diversified farming system* (DFS) approach is advocated, rather than mono-cropping. This involves planting a range of perennial trees on the slopes, with high value vegetables grown on small intensively cultivated plots on flat to gentle slopes. (See *Multi-storey Tree Cropping*, and *Vegetable gardening in Permanent Raised Beds*).

Objective:	**To combat upland degradation by restricting the cultivation of annual crops to flat or gently sloping land protected with soil conservation measures and growing a mixture of perennial crops on sloping land.**

Strategic directions and action

• **Short-term:**	Train LGU extension workers in land unit farming. Advise MAOs on setting up corn patch and raised bed vegetable gardening demonstrations. Plant banana suckers and fruit tree seeds followed by field grafting of scions.
• **Long-term:**	Teach farmers tree management techniques (weeding, mulching, pruning, fertilizing, pest control, fruit handling and packaging, etc)

Expected Results

- Better farm planning matching crops to soils and slopes with SWC measures. Land and labour released for more productive uses such as fruit and vegetable production.
- Increased yields from perennial crops due to reduction in damage to lateral tree roots from inter-cropping with annual crops.
- Substantial increases in income. 1.0 ha of land unit-based diversified farming system (e.g. a 100-200 m^2 vegetable garden and the rest dominated by fruit trees and bananas) generating over P110,000/ha/yr, after 12 years.

Impact

- Soil erosion losses substantially reduced once a good tree cover has developed and the soil is protected by a mulch of dead leaves falling from the trees.
- Sustainable arable agriculture in *parts* of the uplands becomes feasible on gentle slopes.
- Significant increase in efficiency of food production for home consumption and food security making farmer more receptive to sustainable agriculture interventions.
- Easier application of yield-increasing innovations, e.g. optimum spacing, fertilizers, mulching, and plant protection, produces marketable surpluses boosting upland incomes
- Farmers likely to invest more time to tending their tree crops and preventing soil erosion to maintain their higher incomes.

ANNEX X

MULTI-STOREY TREE CROPPING

Multi-storey tree cropping involves planting slopes with a mixture of trees and shrubs as cash crops to imitate the protective multi-storey canopy and leaf-litter mulched soil of the original rain forest. It gives higher incomes per hectare than monocultures of coconuts, and enables farmers to buy their household staples, and frees time to earn off-farm income.

Greatly reducing the area for cultivating annual field crops by expanding the area planted with perennial crops (i.e. *dualistic cropping*) is one of the proven development pathways for achieving a balanced system of high productivity in the humid tropics.

As self-sufficiency in food is often a more important consideration to many upland farmers than the higher income provided by cash crops, adoption of the *Corn Patch* intervention will achieve food security and release the labour and land for multi-storey cropping..

Planting banana suckers and direct seeding of fruit trees, followed by field-grafting of scions, are low cost, are low risk strategies that enable upland farmers to replace extensive areas of corn on sloping land with permanent crops at low cost.

Objective: **To reduce land degradation on sloping land and buffer farmers against fluctuations in the prices of farm produce by planting mixtures of different tree and shrub crops.**

Strategic directions and action

- **Short-term:** Expand the farmers' time scales for planning by promoting the planting of perennial crops as "pension funds" for the time when they are too feeble to do heavy farm work. Encourage the switch from corn to bananas by providing good quality disease-free sword suckers through "plant now, pay later" scheme. Early desuckering of banana hills.
- **Long-term:** Plant fruit trees from seeds, not seedlings, followed by field-grafting of scions. Give loans to replace old low-yielding coconut trees with high-yielding dwarf varieties. Facilitate training in improved crop husbandry (e.g. pruning, etc). Sustainability depends on expanding markets and maintaining roads to encourage traders into the uplands

Expected Results

- Reduced area of bare soil on slopes as tree cover replaces corn, cassava, etc.
- Incomes and welfare start to improve after 12-18 months when bananas start bearing fruits. After 12 years incomes are expected to exceed P100,000 per hectare.
- Increased income from the sale of copra, bananas and fruits used to buy food staples

Impact

- Environmental degradation slowed down as the multi-layered canopy and mulch of dead leaves develop and protect the soil against erosion.
- Improved family welfare (better permanent housing, education, clothing, diet, etc).
- Possible decline in upland population growth as the educated children seek work elsewhere rather than returning to the uplands.

Developing a fruit tree farm with a P600 investment

The following example illustrates how a 3.0 ha farm can be diversified from an investment of P600 by buying banana suckers. By using part of the proceeds of the subsequent banana harvests to purchase more suckers and also to buy fruit tree seedlings the farm income can be dramatically increased. In this projection, Farmer B only buys durian seedlings for comparison with Farmer A. He would normally be expected to buy a range of fruit trees.

FARMER A	FARMER B
Farmer A opts to take P600 worth of durian seedlings. After 6 years he gets his first income. After 12 years he has 18 durian trees which have earned a total of P 75,600 and currently give an annual income of P21,600 (@ P20/kg)	Farmer B buys P600 worth of banana suckers. Every 1.5 yrs he sells bananas and buys 18 durian seedlings and 120 banana suckers and still has cash in hand. The farm produces its own suckers after 4.5 years. After 12 years Farmer B has 1,080 banana hills, 72 durian trees producing fruits and 72 other fruit trees yet to bear fruit. His total net earnings are P307,800 and his current annual income is P103,800. Buying different fruit tree seedlings diversified the farm

Item	No.	Cost	Total
Banana suckers	120	P5 ea	P600
Durian seedlings	18	3 for P100	P600

Item	Yield/hill	Price/kg	Total
Bananas	10 kg	P3	P30/hill
Durian fruit	See table below	P20	See Table below

Years	Total fruit trees (pcs)	Yield Kg/tree	Net Income (P)	Total fruit trees (pcs)	Income (P)	Banana (hills)	Gross Income (P)	Net Income (P)
0	18*	0	0	0	0	120	3,600	2,400
1.5	18*	0	0	18*	0	240	7,200	6,000
3	18*	0	0	36*	0	360	10,800	9,600
4.5	18*	0	0	54*	0	480	14,400	13,800
6	18	20	7,200	72*	0	600	18,000	17,400
7.5	18*	35	12,600	90	7,200	720	21,600	28,200
9	18*	45	16,200	108	25,200	840	25,200	49,800
10.5	18*	50	18,000	126	48,600	960	28,800	76,800
12	18*	60	21,600	144	72,000	1080	32,400	103,800
TOTAL INCOME AFTER 12 yrs			**75,600**					**307,800**

* Durian trees

ANNEX XI

ZERO TILLAGE AND MULCHING

Zero tillage (ZT) does not loosen or expose the soil to wind and water erosion. Weeds are killed by spraying them with herbicides, instead of burying them by ploughing. A pointed stick is used to plant (or dibble) the seeds through the mulch formed by the layer of dead grasses and weeds. ZT enhances biological activity under the mulch, and higher infiltration rates result by reducing soil compaction. Concerns that herbicides are harmful to soil micro-organisms can be allayed as research has shown that a mixture of two widely used herbicides actually *stimulates* microbial activity[68].

ZT is a relevant intervention for permanent upland cultivation in the humid tropics. Improved permanent upland cultivation in a hot humid environment depends on purchased inputs: with herbicides replacing the function of tillage for weed control, and inorganic fertilizers and mulching maintaining the fertility of the soil, a function previously done by fallow vegetation. The use of inorganic fertiliser is essential if upland farmers are to move away from low-level production[69].

Without the use of systemic herbicides to kill the subterranean rhizomes of the pernicious weed cogon, (*Imperata cylindrica*), the reclamation of cogon-infested lands for planting perennial crops would be time-consuming. The traditional way of clearing cogon by hand is to chip out the top layer of soil that contains the subterranean rhizomes exposing the resulting bare soil to severe erosion on sloping land.

Mulching crops restricts weed growth and conserves the limited amounts of soil moisture that can be stored in the soil profile. This may be critical for crop survival during the extended dry seasons common in areas with the Type 1 climate and eroded soils.

Objective:	To replace ploughing and hand-weeding with an efficient and effective way of killing and controlling weeds, particularly cogon, without exposing bare soil to erosion.

Strategic directions and action

• **Short-term:**	Set up demonstrations to show that buying and applying herbicides can save farmers considerable amounts of labour and cash. LGUs to train agricultural technicians in the precautions to take when handling herbicides. Encourage farmers to hire their services.
• **Long-term:**	The use of herbicides is seen as a short-term measure as mulching and the shade from the established trees and mulching will suppress the cogon.

Expected Results

- Investment in planting perennial crops is safeguarded as the risk of the seedlings getting choked by cogon is reduced.

Impact

- Areas of abandoned cogon-infested land reclaimed and planted with tree crops, reducing pressure to encroach into remnant stands of forest.
- Adverse environmental impacts are insignificant as miniscule volumes of herbicide are sprayed onto the green leaves of cogon over small localized areas away from streams.
- Significant savings to farmers in the time and labour used in land preparation.

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[68] Krutz, L.J., Senseman, S.A., Haney, R.L. 2003. Effect of Roundup Ultra on atrazine degradation in soil. Biology and Fertility of Soils. 38:115-118.
[69] Ruthenberg, H (1983). *Farming Systems in the Tropics*. Third edition. Oxford University Press

1, Examples of the effectiveness of applying herbicides

a) Inputs for establishing 100 trees in cogon grassland

The costs of inputs for establishing 100 fruit trees on cogon grassland are not excessive, requiring an initial expenditure of about P605 for herbicides and inorganic fertilizer:

- P85 for herbicide to clear the 700 m^2 of cogon covered land ((at 7 m^2 per tree) required for planting 100 fruit trees.
- Applying 100 g of inorganic fertilizer every three months to a young tree after its first year amounts to 40 kg for 100 trees (i.e. a total of P520 for fertiliser).

In the second year after planting the amount of fertilizer is 200 g per tree (total of P288).

Chemical suppression of aggressive weeds such as cogon, eliminates competition for moisture at the critical seedling development stage, and provides a layer of organic mulch to feed the young plant.

Environmental concerns
The amount of herbicide applied for 700 m^2 is very small. 18 tablespoons of herbicide (just less than one sardine can) in 16 litres of water is equivalent to one table spoonful of herbicide on 39 m^2. (By comparison 50 litres of water applied to the 25 m^2 root zone around a coconut tree amounts to a depth of 2.0 mm).

b) Examples from the EC-funded Upland Development Programme, Mindanao

- Two hectares of dense cogon grass were cleared for planting corn with P2,000 worth of systemic herbicide and 2-3 mandays of labour. Usually it took the farmer 20 man-days of labour @ P100/day to clear the area by hand, but the cogon needed several more cuttings to eliminate it for two seasons. The land was eventually planted with fruit trees.

- A ridge top usually took40 days to clear for planting corn using four ploughings with a carabao at a cost of PhP 12,000. Spraying with herbicide took 2 to 3 days and reduced the cost of land preparation to PhP 2,720. Being able to plant corn five weeks earlier enabled the farmer to plant a crop of beans giving extra income.

c) A comparison of organic and inorganic fertilizers

- Inorganic fertilisers cost about P 1,000 per 50 kg sack, compared to P 110 for organic fertilizer. Organic fertilizer is being promoted by LGUs and NGOs as it is cheaper than inorganic fertilizer. This is false economy. Organic fertilizer contains only 2% nitrogen while urea has 46% N. Farmers need at least 80 bags of organic fertilizer for a hectare of rice land (costing P8,800 or P12,000 including transport charges) instead of five to six bags of urea (costing P6,240)). As a result, "farmers still prefer to use chemical fertilizers because of the "slow effects" of organic fertilizers, aside from using more bags to fertilize a hectare"[70].

[70] *Sun Star* Sunday, Feb 02, 2003. Price hike in imported fertilizers affecting farmers. *By Yolanda S. Fuertes*

ANNEX XII

THE CORN PATCH: ACHIEVING FOOD SECURITY MORE EFFICIENTLY

Upland farmers dedicate as much as 3-4 man-months labour a year cultivating 1-2 ha of land to obtain corn to feed the family, without generating any income. The low yields from growing unfertilized native corn on depleted soils require the farmer to work another 45-60 days off-farm to earn the P3,600-P6,300 to buy the shortfall of corn grits. Corn is *not* a cash crop for the uplands. The costs of producing the crop usually exceed its sale value. This inefficient use of manpower may explain why there is widespread poverty in the uplands.

One ploughing loosens and turns over about 2,000 tons of soil per hectare, of which 360 to 1,000 t/ha can be washed down hill annually, reducing soil depths by 3-10 cm every year. Declining corn yields result in encroachment of forested slopes in search of fertile soil, and damages the potential of the land to support tree crops. This vicious cycle must be broken.

By showing the upland farmer how to grow the family's food more efficiently, the off-farm income can be used to improve the family welfare, and the labour freed to plant income-generating perennial crops. Locally available HYV corn seeds yield 5-7 tons of shelled corn/ha, compared with 400-700 kg/ha from native varieties. Two harvests a year from a 1,000 to 2,000 m^2 corn patch using HYV seeds and two dressings of inorganic fertilizers can provide the farmer with his annual corn needs. Unfortunately, there is a widespread belief that upland farmers cannot afford inputs.

The cost of the HYV seeds and fertilizers needed to grow all the year's corn amounts to 25-45% of the off-farm income earned just to make up the shortfall in supply! By purchasing inputs the farmer actually *saves* money. He needs to be made aware of this.

Objective:	To release land and labour for more productive, less erosive farming activities by reducing the area needed to achieve food security to 1,000-2,000 m^2 corn patches on flat to gently sloping land.

Strategic directions and action

• **Short-term:**	Set up corn patch demonstrations to show how a modest investment in HYV seeds, fertilizers and labour can secure the household's annual subsistence food requirements. Monitor their socio-economic impact.
• **Long-term:**	Encourage the adoption of corn patches by ensure HYV seed-fertiliser packages contain viable seeds and unadulterated fertilizers.

Expected Results

- 80-90% reduction in area of bare soil on slopes as tree cover replaces corn, cassava, etc.
- Increased food security with better returns per unit of inputs (seed, fertilizer, labour).
- More productive use made of land and labour released by adopting corn patch

Impact

- Encroachment of corn cropping into forest lands reduced, with a dramatic reduction in soil erosion from sloping land.
- Larger area of sloping land planted with perennial crops.
- Improvement in quality of life by removing the drudgery of extensive corn production. Off-farm income used to improve family welfare and to develop the farm.

Comparing traditional corn production with the Corn Patch

Table 1 shows that using the high-input, low labour HYV seed/fertilizer package is much cheaper than the low-input, high-labour traditional method. The traditional methods requires the farmer to work 63 days off-farm to earn cash to make up the 350 kg shortfall in requirements for corn grits. The seed/fertiliser package requires 49 days of off-farm labour to purchase the inputs to provide the household's full annual requirements for corn.

The overall savings of 105 days, in this particular case, can be used to earn up to P10,500 off-farm income for investing in the farm or improving the family's quality of life, or for planting and managing bananas and fruit trees. By using less than 2,000 m^2 for growing corn, more 8,000 m^2 of land previously needed for growing corn is freed for growing more valuable bananas and fruit trees.

Table 1 Comparison of inputs and labour to produce year's supply of corn for home consumption

Inputs	Traditional method (1.0 ha)			Improved method (0.18 ha)		
	No. of Units	**Cost/Unit (P)**	**Total (P)**	**No. of Units**	**Cost/Unit (P)**	**Total (P)**
Corn Seeds		0	0	3.24 kg	100	324
Fertilisers						
Complete	0	0		38 kg	15	570
Urea	0	0		38 kg	14	532
Labour	37 md	P100	3,700	10 md	100	1,000
Sub Total			**3,700**			**2,426**
Harvests/yr	3	3,700	11,100	2	2,426	4,852
Labour used	111 md			20 md		
Off-farm work	63 md [a)]	100	6,300	49 md [b)]	100	4,900
TOTAL	174 md		**17,400**	**69 md**		**9,752**
Labour saved	0 md	100	**0**	**105** md	100	**10,500**
Balance			**-17,400**			**+748**

a) income from labour used to buy corn to make up shortfall in food requirements
b) income from labour used to buy inputs to buy whole year's corn requirements

ANNEX XIV

LAND UNIT MAPPING AND FARMING AND LAND CAPABILITY CLASSIFICATION

Land Unit Mapping is a land capability classification to aid the *micro-level* planning of upland farms, one to seven hectares in area[71]. Three simple measurements (slope, soil depth and texture) are used to assess the suitability of the different slope classes for a range of crops. The soil conservation measures best suited to the recommended cropping pattern are outlined (see Manual[72]).

The cultivation of annual crops is restricted to minor valleys and flat to gently sloping hill tops protected by properly designed and laid out cross-slope barriers/hedgerows. Tree crops replace annual crops on slopes between 25-55%. Multi-storey mixtures of bananas, fruit trees and shrub crops planted under coconut trees replace mono-cropping. High value vegetable production is advocated in the minor valleys.

The output of Land Unit Mapping is a map showing the different land units (i.e. areas of different slope classes) on the farm, and a prescription for each one detailing the best land use and the SWC measures to be applied appropriate to the crops to be grown. The object is to keep the land healthy so options for change are available in the future. Land unsuitable (and unsafe) to be brought into cultivation, should be referred to the Secretary of DENR who can exercise his power to cancel permits, etc and relocate people, if it is in the public interest.

Objective of Land Unit Mapping:	**To provide land unit maps and prescriptions which match crops to slopes and soils, showing how to zone upland farms for dualistic cropping with the appropriate SWC measures.**

Strategic directions and action

- **Short-term:** Develop a menu of appropriate site-specific, environmentally-sound land care and land management strategies for each climate type.
  Train extension staff in land unit mapping and dualistic cropping.
  Set up demonstration farms as part of LGU training programme
- **Long-term:** Produce land capability classifications for the Region's climate types.

Expected Results

- Land units grouped according to their fitness for specific kinds of land use with crops matched to slopes and soil types and appropriate SWC measures applied.
- The simple farm mapping system allows slope treatment prescriptions to be prepared for areas as small as a few hundred square metres, providing the farmer with a long term development plan for his whole farm, projecting incomes for each land unit.
- Field technicians able to assess the suitability of a site for annual or perennial crops.
- Land titles and loans only issued for upland farms on submission of land unit maps and prescriptions, certified by MAOs, showing the slopes and soil depths are suitable for agriculture and have been appropriately protected with SWC measures

Impact

- Farmers more willing to obtain small loans to purchase inputs as they can see long-term income potentia.
- Decline in the rate of soil erosion as perennial crops replace corn on long slopes.
- Properly designed and laid out hedgerows, appropriately restricted to short lengths of gentle slopes, help maintain the productivity of the land.

[71] The 1:25,000 scale maps produced by BSWM in its soil and land resources evaluation reports for municipalities cover a minimum area of 10 ha. These have insufficient detail to plan small upland farms.

[72] Proud, KRS (2004). *LAND UNIT FARMING. Slope Treatment-Oriented Practices (STOP) 1.* Principles for developing productive upland agriculture in the humid tropics #1. Handout prepared for the Upland Development Programme in Southern Mindanao,

ANNEX XV

RECOMMENDED PROCEDURE FOR SETTING UP LEARNING SITES TO DEMONSTRATE UPLAND INTERVENTIONS AND DIVERSIFIED FARMING

1. Rationale for setting up show case farms to highlight STOP innovations and DFS

Resource-poor upland farmers say they are unlikely to purchase additional fruit tree seedlings, due to the high costs. **R**apid and strikingly visible results in terms of improved incomes and reduced environmental degradation can be achieved with interventions, such as switching to bananas, and growing corn for home consumption on small plots. However, upland farmers cannot be expected to suddenly switch their production systems. Being risk-adverse, they need to be able to evaluate for themselves the potential savings in labour and inputs and resulting yields and incomes from the interventions. Setting up demonstrations is a proven way to stimulate farmers' interest in undertaking small low cost trials on their own farms with a view to full adoption later on.

Examples of technological packages for a range of slope zones, in pack sizes affordable to upland farmers, that continually increase the area devoted to perennial plants, while decreasing the area devoted to annual plants, are given in Annexes X to XIII. These aim to increase the productive efficiency per unit area of annual crops, releasing land and labour to earn income from activities such as fruit orchards on-farm, or paid labour off-farm. Despite upland farmers devoting excessive amounts of time to attain food security for their families, they often have a shortfall in production. The low cost technological packages, e.g. the corn patch and zero tillage, result in considerable savings in labour and inputs to upland farmers. Demonstration of these need setting up in several locations.

2. Strategies to encourage adoption of interventions

A better match of *land use* to *land capability* can be achieved by applying Land Unit Farming. This ensures that crops are planted on the appropriate slopes and soil textures**.**

Procedure

Train LGU agricultural technicians (ATs) in setting up the pilot and promotion projects show casing the corn patch, vegetable production in permanent raised beds, and agroforestry models. Give each technician the responsibility for setting up at least two farms under close supervision, with the assistance of other technicians in the areas.

The farms should have a representative range of land units occurring in the area and be beside and visible from the road.

3. Phases in the process of adoption of innovations

There is a saying that *to hear is to know, to see is to believe, but to do is to understand*. Based on this philosophy, the five main phases in the process of adoption are: *awareness*, *interest*, *evaluation*, and *trials* followed by *full adoption***.**

Awareness

Situating show case farms in visible locations beside roads raises the awareness of upland farmers who will see properly located and laid out hedgerows, multi-storey tree cropping, productive corn patches and raised bed vegetable gardens. This also applies to LGUs who may want to demonstrate the technologies in other municipalities

Interest
Because they pass the farms on a regular basis (daily or weekly) over a period of months or years, farmers living along the same road will see the changes land use, and are likely to be interested in applying STOP innovations and DFS.

Evaluation
Sign boards, highlighting the cost of inputs (both labour and purchased items) as well as the yields expected compared to their current practices, will enable farmers to evaluate the systems to decide if they fit in with their own objectives, interests and constraints.

Trials
Farmers who want to test the technologies can undertake small-scale trials on similar land units on their own farm.

Full adoption
Adoption rates become high as costs are relatively low; the innovations are easy to apply and can be used on small areas; and returns are high.

4. Activities

4.1 Selecting farmers for the pilot and promotion projects

To be effective and efficient, extension workers need to focus their attention on contact farmers who are typical of the farming population in the area and who can be trusted to pass on their knowledge. The proven way of choosing suitable contact workers is to leave the selection process to the farmers themselves[73] as they are likely to choose someone they trust not to monopolise all the benefits, and so avoid the problem of jealousy which arises when outsiders select someone to receive the inputs. Extension experience elsewhere in the developing world learned that when progressive farmers are chosen as contact farmers the innovations often failed to reach the mass of small farmers all together. The following procedure to select farmers for the pilot and promo projects is recommended:

- Gather a group of farmers living along the same road and discuss their problems with agricultural production and land degradation. Determine the costs in labour and the yields from growing corn for home consumption or as a cash crop, and compare with the income if bananas are grown[74].

- Explain to the group the plan and reasons for setting up show case farms.

- Point out that limited funds restrict inputs to one farm (though they can sometimes be shared by two adjacent farms to make use of different soils and slopes).

- Ask the farmers to choose a member of the group, whose financial status is the similar to the rest, to be the contact farmer. They should make the selection with the understanding that the contact farmer will receive inputs to develop his/her farm in a way that achieves the objectives of the farmer as well as

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[73] Adams, M E (1987). *Agricultural extension in developing countries*. Intermediate Tropical Agricultural Series. Longman Scientific and Technical.
[74] Use the UDP Form: *Comparing inputs and outputs of Corn and Bananas*

those of the Project. They should trust the person to teach them the technologies and share seeds, cuttings, etc in due course.

- The contact farmer's land should cover a range of land units representative of those making up other farms in the area.

- The other farmers should be invited to assist in developing the contact farm as part of their training.

4.2 Mapping the farm and preparing land unit prescriptions

- ATs, BEWs, FTGs and interested LGU staff should map the entire farm and delineate the land unit boundaries (see STOP manual).
- Ask the contact farmer to dig soil pits in each land unit so he can be aware of any problems due to soil erosion, such as truncated or shallow soils.
- Prepare land use prescriptions for each land unit, and estimate the predicted yields and incomes.
- If the farmer eats corn grits then determine his family's annual needs for shelled corn (see STOP 4). Also estimate the annual yields and/or income the farmer currently earns from the farm.

4.3 Establishing STOP innovation demos

Proven technologies and development pathways for permanent upland cultivation in hot, humid climates include dualistic cropping, multi-storey cropping, zero tillage and mulching, a reduction in the area of annual crops to meet the family's food needs, and intensive cultivation of vegetables in gardens.

Fruit tree inputs
For some years the project has been providing beneficiary farmers with 20-30 fruit tree seedlings purchased from nurseries. Most of the farmers the Upland Farming/ SWC Consultant spoke with have said they will *not* buy more seedlings to increase the area under tree crops as the cost is too high. In addition, the fruit trees provided to farmers only start producing fruits for sale after six years. Clearly, as this type of input is not affordable to upland farmers it is not or sustainable. A more appropriate, very cheap alternative is to directly plant seeds of fruit trees in the field, followed by field-grafting of scions when the stem of the seedling is as thick as a pencil.

4.4 Benefits expected from diversifying the farming system and applying STOP

Erect signboards to explain the purpose of each demonstration. For example:

- Switching from corn-based mixed farming on steep slopes to bananas or other perennial crops, or multi-storey cropping. The labour and income from growing corn as a cash crop is compared with reduced labour and increased potential income from growing fruit – initially from planting bananas. The farmers' own data is to be used.

- Reducing the area used to grow corn for home consumption to a corn patch of 1,000-2,000 m^2 by planting HYV corn (preferably yielding 5-7 tons/ha) and applying the recommended applications of fertilisers. Savings in labour and income to be highlighted as well as potential income by freeing corn lands for planting bananas and optional uses of off-farm income currently earned to buy the shortfall in corn grits.

- Fruit trees are to be planted on unproductive cogon grassland. Low cost of controlling cogon around planting sites and price of fertiliser compared with future income.

- Relocating the production of highly erosive crops (e.g. peanuts) to the limited areas of hill tops and upper slopes protected with soil and water conservation measures such as strips of Napier backed up by 2-m wide NVS. Demonstrate the terracing of short slopes below 45%, with clay loam to clay soils over 100 cm deep, through a combination of contour hedgerows, no-till grass strips and contour ploughing. Explain how terracing prevents inputs such as fertilisers from being washed away.

- Intensify vegetable production in permanent raised beds, starting with backyard systems and sloping land behind hedgerows. Indicate that incomes of P100/m2 or more can be obtained from the small amount of work involved in setting up the relatively erosion-resistant raised beds.
- Show the overall income possible from diversification of the farm and the application of STOP interventions.

- A signboard at the roadside showing the progressive changes in yields and incomes will enable neighbouring farmers to evaluate the results beyond the end of the project, so they can decide to try them out themselves.

ANNEX XVI

LAND SYSTEMS/LANDMANAGEMENT UNIT MAPPING

The natural features of a landscape of significance to land use are: *landform*, soils, vegetation, drainage and climate. Dividing a region into landforms (or terrain types), e.g. beaches, alluvial plains, meander belts, alluvial valleys, hills, mountains, etc., and sub-dividing the landforms into *land systems* (river terraces, limestone hills, volcanic hills, etc) is an effective way to present land resources data and simplify the procedures for land use planning and conservation. It is based on the ecologically-sound assumption that associations of rock types, hydro-climatology, landforms, soils and organisms are interdependent.

BSWM's land management units (LMU) are essentially landscapes. However, the LMU is not sub-divided into *land units*[3] (or *land facets*) each with its own distinctive combination of topography, soils and vegetation[75]. For example, the *land units* making up a mountain *land system* include hill tops, ridges, side slopes, and minor valleys.

Although covering only a few hundred square metres, these land units may be important in determining the way an extensive area of steeply sloping land can be used to support sustainable upland agriculture. Identifying the suitability of these for agriculture can help promote sustainable agricultural practices – if only in a limited area of the uplands.

Differentiating the range of land systems in a region is the simplest basis for zoning a watershed using biophysical criteria. Their significance from the planning point of view is that they are blocks of land with similar physical characteristics and where environmental conditions tend to be uniform. The problems or potential for agriculture, or other land uses, can therefore be expected to be the same. Land systems or land units with little potential for agriculture, or where problems have been found to be insurmountable elsewhere in the region, can be excluded from further consideration, and the areas designated as protection forests.

By illustrating each land system with a three-dimensional block diagram the presence of land units covering very small areas is made known for planning purposes (see Fig 1). A table accompanying each block diagram provides on formation such as the slope range, underlying geology, soil type (and depth), vegetation cover and present land use, *for each land unit*. These give the land system its distinctive appearance. Some land systems have several land units.

3-D block diagrams are drawn from obliquely-taken aerial photographs, although it may now be possible to produce these from satellite images. If LMU maps have not been produced for the project areas then satellite imagery will be needed to map the landforms.

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[75] In undisturbed conditions, different land systems indicate the presence of different vegetation types.

Fig. 1. 3-dimensional block diagram of a mountain land system from Zambia

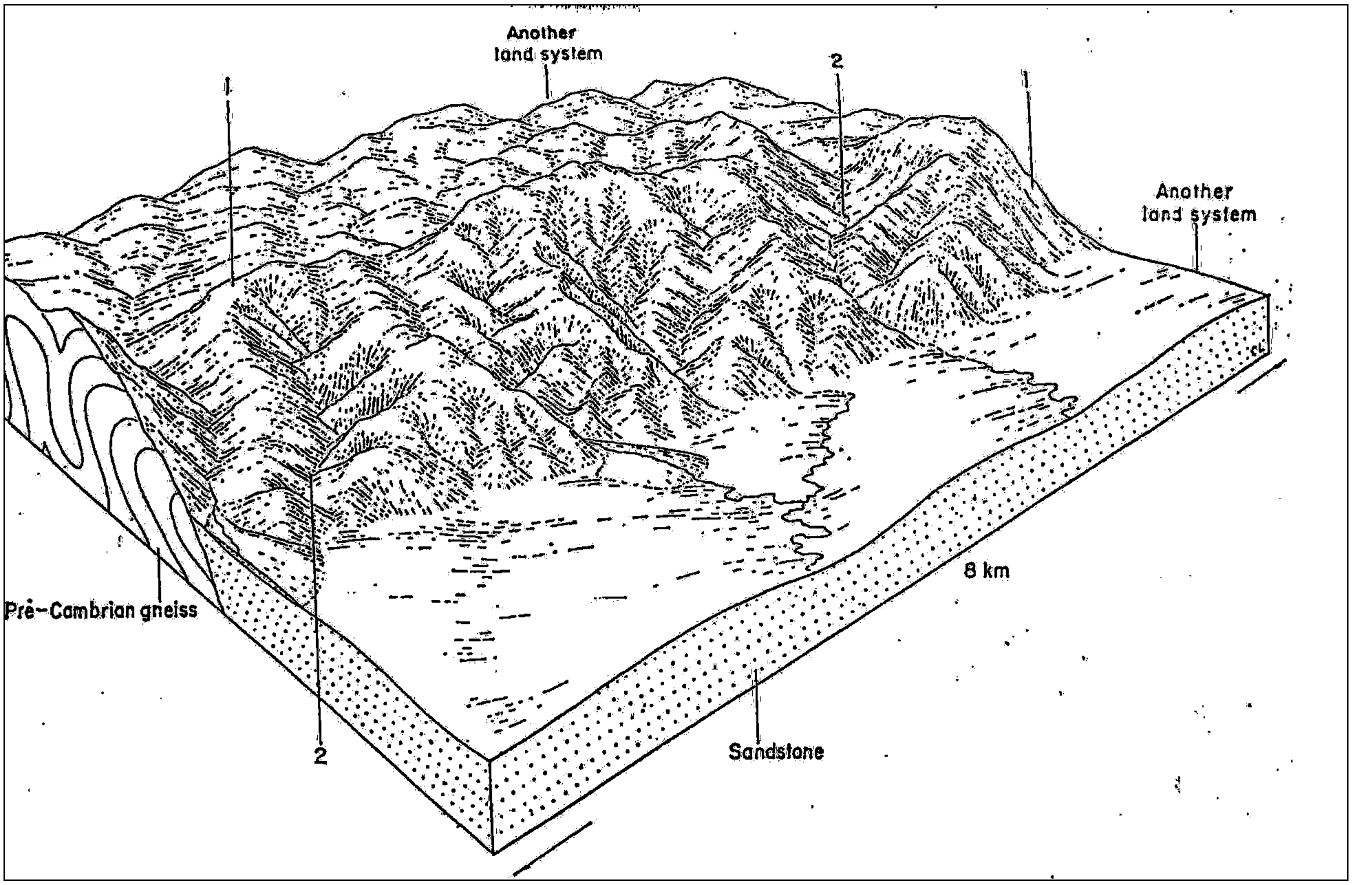

Table 1. Tabular description of a mountain land system from Zambia

Land unit	Form	Soils, materials and hydrology	Vegetation/Land use
1	SLOPES AND RIDGES. Steep and very steep (36-60%) straight slopes meeting in angular or rounded moderately sloping (c. 25%) ridge crests; slopes boulder strewn with occasional precipitous rock faces	Shallow (< 1m) of medium-textured brown or reddish-brown soil with numerous fragments of weathered rock. Large outcrops and many boulders of Pre-Cambrian crystalline igneous and metamorphic rocks.	Sparse woodland, c. 12 m high of *Julbernardia globiflora*, *Brachystegia allenii*, *B. boehmii*, *Diplorhynchus condylocarpor*, with short grass cover of *Bevesia biflora*, *Pipiostachya tramoena*, *Pogorarthria squarrosa*.
2	VALLEY BOTTOM. Narrow (up to 50 m wide), with moderately sloping (10%) longitudinal profile; includes: (a) *Stream bed*: up to 10 m wide and with occasional vertical falls (waterfalls). (b) *Riparian strip*: a few metres up to 50 m wide	 Rock bed; perennial water flow Alluvial sands and gravels; permanently moist	 Riparian forest sometimes with bamboo ((*Oxytemanthera abyssinica*) on lower slopes.

Support for enhancing the Land Management Unit maps into Land Systems format

Enhancing the existing LMU maps will make them of practical use to LGU staff. Instead of eight or more maps (e.g. geology, soils, slope, vegetation/land use, etc), there is only one map, the LMU map showing the distribution of the various LMUs in the provinces or region. The block diagrams, by showing the relationships between soils, slope, vegetation and other factors within each land system, effectively combine the various maps for each of these features.

It is recommended that the project provide support to upgrading the LMU maps to land systems maps. This involves further subdividing the LMUs based on geology, identifying the constituent land units or facets (i.e. hill tops, plateaux, side slopes, spurs, valley bottoms, etc) and creating 3-dimension block diagrams and accompanying tabulated descriptions.

The estimated cost is P1,519,000 (€23,370) per province. See budget below. Restricting the mapping to LMUs and describing the soil orders, soil depths and slopes on each land unit, and extrapolating to similar LMUs elsewhere is cheaper than having a detailed Land Resources Evaluation Survey undertaken for a Municipality (see budget below).

BUDGET FOR ENHANCING LAND MANAGEMENT UNIT MAPS

Activity: Production of detailed descriptions of LMUs and 3-dimensional block diagrams and explanatory tables

Provisional budget for one province

Item	Number	Unit Cost (P)	Price (P)
Satellite image (Conus 1 m resolution) Digital	1	936,000	936,000.00
Arcview extension software programme for generating 3-D images	1	300,000	300,000.00
Geology maps (NAMRIA) 1:50,000	28	600	16,800.00
Materials (Note books/pens/stationery etc) Lump sum	1	10,000	10,000.00
Consultant for 1 month + per diems (P3000/day)	1	90,000.00	90,000.00
Consultant airfare MLA – Iloilo ret. (plus taxes)	1	8,600.00	8,600.00
Field trips 3 PEMO pax x 45 days ea (@P900/day)	3 x 45	900.00	121,500
Field assistants (locally recruited from sitios)	3 x 45	120.00	16,200.00
Transportation (lump sum - to be paid on receipts)	1	20,000	20,000.00
GRAND TOTAL		**P**	**1,519,100.00**
		€	**23,370.77**

Land Resources Evaluation of the Five (5) municipalities of Sarangani Province

Proponent: **Bureau of Soils and Water Management**

Project Background:

A comprehensive relevant information is a necessity for a sound land use plan, not only qualitative and quantitative but the participation of stakeholders and the incorporation of a sustainable use of the resources as well. However, success of such plans depends on the reliability and credibility of information gathered.

The Bureau of Soils and Water Management has the pool of technical experts capable of collecting resource-based information collectively summarized into a technical report and transformed into spatial data or maps.. The information being gathered are soils, present land use, climate, water resources and agro-economics. From these data set, a suitability classification is derived for preferred crops and alternative crops. The soils discipline being the physical integrator of the resource-based study considers different major characteristics of the land. To summarize;

Soils
- Land Management Unit
- Soil Classification (Series level)
- Slope
- Elevation
- Soil Erosion
- Soil suitability
  *major crops
  *other suitable crops (alternative crops)

Lands Use
- Present Land Use and Vegetation and their extent (major and associated crops)

Climate
- Rainfall
- Temperature
- Cloudiness
- Evaporation/Evapo-transpiration
- Water balance/cropping calendar

Water Resources
- River Systems and their discharges/Drainage ways
- Peak flows/Volume
- Hydrological Characteristics

Agro-economics
- Cropping system
- Production
- Farming practices
- Benefit-cost Analysis
- Projected supply and demand for major commodities such as rice and corn
- Infrastructure support services

Phases of the Project:

Pre-field work phase – temporary delineations and determination of sampling
Points; orientation and reconnaissance survey
Field work phase – ground truthing and actual survey
Map finalization/ Reproduction – maps are finalized into a reproducible film
At 1:50,000 scale or maybe digitized
Report writing/editing/critiquing

Manpower Requirement

4 technical men (2x to travel)
1 technical support staff/writer/editor (2x to travel)
3 quality control supervisors (2 periodic visits in the field)
2 consultants (one visit only)
4 encoders/interviewers, locally recruited
3 laborers, locally recruited
2 drivers, locally recruited

Notations:

1. Laboratory Analysis is not included in the budget proposal. If needed, forge a Memorandum of Agreement with the nearest soil laboratory. However, soil samples maybe gathered. If not, field ph applies.

2. The proposal is for the five (5) municipalities of Sarangani Province namely: Maasim, Maitum, Malapatan, Kiamba and Glan. Alabel, Malungon and General Santos City have been surveyed in 2005 and 2006 by the BSWM, hence maps are and technical reports are already available.

BUDGETARY REQUIREMENTS

Particulars	Cost (Php)
Plane Fare (P 10,000/pax)	
5 Technical men (2x to travel)	100,000.00
1 Technical support/writer (2x to travel)	20,000.00
2 Consultants (one visit only)	20,000.00
3 Supervisors (2x to travel)	60,000.00
SUB TOTAL	**200,000.00**
Travelling Allowance (180 days)	
5 Technical Men	900,000.00
1 Technical Support/writer	180,000.00
2 Consultants	10,000.00
3 Supervisors	30,000.00
SUB TOTAL	**1,120,000.00**
Hotel Accommodation for:	
2 Consultants	12,000.00
3 Supervisors	36,000.00
SUB TOTAL	**48,000.00**
WAGES	
7 Contractuals at 300/day x 180 days	**378,000.00**
SUPPLIES	
Office Supplies	50,000.00
Cartographic Supplies	75,000.00
Gasoline & Oil	120,000.00
Report Reproduction	37,500.00
SUB TOTAL	**282,500.00**
TOTAL	2,028,500.00
INCENTIVES	70,000.00
GRAND TOTAL	**2,098,500.00**

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