Sustainable Mountain Agriculture
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Introduction

by

Joachim Voss

Over fifty percent of the world's population is directly affected by mountain ecologies, either as a source of livelihood for the 10 percent who live there, or in terms of the services provided by mountain ecologies. These services include the supply of water, energy, mineral and forest resources as well as a host of agricultural and manufactured products (IDRC 1993). Conversely, when mountain habitats become severely degraded through deforestation and improper agricultural practices, major disasters are the result. Floods in the Indo-Gangetic and Yangtze plains as well as the recent mud slides that have killed thousands of lowland villagers in the Philippines are especially dramatic examples. More insidious is the ever increasing siltation of rivers that destroys aquatic habitats and a large part of the livelihood of fisherfolk who depend upon aquatic resources. The proceedings of this workshop are the papers presented at the second global meeting of researchers working on issues of sustainable mountain agriculture in Latin America, Asia and Africa. The first meeting was held in December of 1992 at the Cordillera Studies Centre, University of the Philippines College Baguio, in the highland city of Baguio. IDRC has a considerable history of support for research in this field, starting with a workshop on Mountain Agriculture and Crop Genetic Resources held in Kathmandu in 1987 (Riley et. al. 1990).

The common thread running through these workshops is concern with the disproportionate poverty of mountain peoples and the fragility of the ecologies upon which they depend; the recognition of the complexity and heterogeneity of mountain ecosystems; and, consequently, the importance of the biological diversity they contain as a global genetic resource and for local farming systems. Agenda 21, in its chapters on Sustainable Mountain Development and on Conservation of Biological Diversity, reinforces these concerns and has given research in these fields a stronger popular and political base. Less clearly recognized, is the significance of the tremendous cultural diversity that has resulted from a combination of isolation, inaccessibility and migration, and its relationship with biological diversity as different socio-cultural groups favour and exploit different resources within the natural environment.

A major issue of the Baguio workshop was the marginalization and economic and political powerlessness of most mountain peoples as well as the consequences of inappropriate national policies and "development" activities. The end result has all too often been a vicious cycle of poverty and resource depletion rather than the development of more productive sustainable systems. The violent political consequences of such inequities have been painfully clear in Peru, Chiapas, Burma and India to name just a few examples. As Eric Wolf (1971) has noted, the same conditions that favour cultural diversity also favour protracted guerilla warfare by mountain minorities against cultural majorities. One of the major non-technical challenges in Mountain development, consequently, is the creation of socio-political systems able to encompass ethnic diversity in an equitable manner. The goal of the IDRC workshops on Mountain Agriculture has been to combine the analysis of the economic, social and environmental policy context of Mountain Development with micro level research on community based resource management and natural science research that is aimed at analyzing and improving the state of particular component resources (soils, crops, trees etc.). IDRC believes it is inappropriate to direct natural science research to solve socio-political problems; while, the effectiveness of sound policies will certainly be enhanced through technical and economic innovations which increase productivity in an equitable and sustainable manner.

A further goal of this particular workshop was to bring together researchers from a number of International Agricultural Research Centres (IARC) which are experimenting with eco-regional approaches to mountain resource management in order to benefit from each others' experiences. The
Centres represented were the Centre Internacional de Agricultura Tropical (CIAT), the International Potato Centre (CIP), the International Centre for Research in Agroforestry (ICRAF) and the International Livestock Centre for Africa (ILCA). IDRC has a long history and has made a substantial investment in University, NGO and national programme agricultural and community based research in the Andes, the Himalayas and the African and Southeast Asian Highlands. A number of researchers from these projects, who have experience in interdisciplinary research, participated with the same goal of information exchange among each other and with their IARC colleagues. The papers by Knapp, Rueda, Saleem and Scott, respectively from CIAT, CIP, ILCA and ICRAF indicate the conceptual and organizational approaches, as well as the kinds of research the IARC are conducting and planning within the eco-regional paradigm. Still within the IARC, the paper by Carey, on sweetpotato research in the East African Highlands, shows the way in which commodity specific research fits into a particular agro-ecosystem; the papers by Fujisaka et. al. and by Farley illustrate the importance of working directly with farmers for understanding local knowledge, production practices and constraints as well as the adoption of technology, while Atta-Krah’s paper on the Agroforestry Network, is illustrative of the benefits that can be obtained through research collaboration between a number of national programs.

Concerning the non IARC presentations, the three papers by Cruz et. al., De Raedt and Paré all consider the problems of sustainable natural resource management of a specific area with severe problems of environmental degradation, by analyzing the dynamic relationship between local action and the national socio-political and policy contexts. The paper by Villasante considers the impact of peasant production strategies across the Andean region and concludes that soil erosion is the principle problem of resource degradation. Finally, the paper by Carter et. al. tackles the difficult methodological issue of dealing with the heterogeneity that is characteristic of the highlands and the relevance of this for eco-regional research in the IARC.

In conclusion, it is mountain peoples themselves who adopt, adapt, struggle or resist as the case may be. Experience has shown that researchers who do not gain from these experiences by working, learning and experimenting in close collaboration with a broad cross section of people within their communities may produce interesting results but are usually doomed to irrelevance.

References


Developing a Strategy for Policy Research on Sustainable Development in Tropical Hillside and Mountain Areas

by

Sara J. Scherr

Re-visiting the development challenge for hillside and mountain areas

Most public policy and investment in tropical agriculture in the past 50 years has been oriented to the better endowed agroecological areas with high agricultural potential. Policy makers and donor agencies, at national and international levels, were attracted to these areas by their higher marginal returns on investments, by their relatively well endowed infrastructure that helped the flow of modern inputs, the capacity of these areas to supply food to growing urban districts and by the greater political clout (concerning money, numbers and organization) of farmers in these areas.

Despite the massive evidence of new settlement, the long-term development strategy for most hillside and mountain regions (areas unsuitable for continuous tillage or lands where there were major constraints to economic use of industrial inputs in agriculture) was seen to be depopulation through migration to economic growth centres in urban and high potential areas. In the short- and medium-term, “equity” concerns prompted a minimal level of investment in infrastructure, market development, social services and extension, but rarely at levels sufficient to generate sustainable growth in rural livelihoods.

This strategy can no longer be considered viable. Many high potential areas are now suffering from various forms of environmental stress, which with tapering yield potential, casts serious doubt on the ability of these areas to continue to meet growing food needs on a sustainable basis. Short of major biotechnology breakthroughs, many of today’s marginal lands, including some mountainous areas, will be required to play an increasing role in meeting national and regional food needs.

Population growth and poverty in many steeply sloping lands have also reached the point where serious resource degradation is occurring. Until recently natural resources were generally abundant in many of these areas and damaged resources had time to recover (e.g., the long fallow in shifting cultivation). In areas of longstanding settlement, farming systems were developed to address problems of slope and regulate use of key resources. Moreover many steeply sloping lands were not even farmed in the past and served as forest reserve or watershed protection areas. Today, they must support moderate to high population densities providing not only increasing amounts of basic foods but also fuelwood, water and housing. The resilience of these ecosystems is also suffering, particularly their ability to recover after major stress events (e.g., droughts).

In the long term, migration and economic diversification will be needed to provide a better balance between people and natural resources in fragile areas. Current growth trends in population and non-farm employment, however, is such that the absolute number of agriculturally dependent people will continue to grow for some decades yet in many of these regions. For all these reasons there are therefore an urgent need to increase the productivity of mountainous lands and to diversify the sources of rural livelihood for their populations. This will require significant changes in policy and a much better understanding of farmers’ incentives for maintenance and investment in the natural resource base (crop land soils, pastures, trees, local water systems) in order to guide policy formulation and implementation (Vosti et al. 1990). The International Food Policy Research Institute has embarked on a new research programme to investigate policy issues and options.

In the first section of this paper, sustainable agricultural development in fragile lands such as the dynamic process of adaptation to changing pressures on the resource is investigated. In the second
section, the research strategies of IFPRI's Fragile Land Project are outlined and key methodological and organization challenges are defined.

Patterns of resource degradation and rehabilitation

Large-scale degradation in the marginal lands is a very real phenomenon but its short- and long-term economic implications are less clear. Most of the resources used by the inhabitants of fragile rainfed areas are renewable and their degradation is not a consequence of agricultural development. It is not necessary for steeply sloping lands to remain in natural forest cover. Many land use systems, if well-maintained and managed, can provide key environmental watershed services and control erosion through agroforestry systems, terracing, perennial crops, erosion barriers (Blair and Lefroy 1991). Induced innovation theory (Boserup 1965, Ruttan and Thirtle 1989) suggests that degradation associated with intensive resource use may be self-correcting. The happens because resource scarcity or rising private and/or social costs from degradation induce the development and use of new agricultural and resource management practices. Ruthenberg's (1980) classic study of "Farming Systems in the Tropics" summarizes a large literature documenting the agricultural innovations historically associated with increasing population density and increasing market integration in different agroecological zones. This evidence is particularly compelling in that most innovation was endogenous, or the process of informal borrowing and adaptation of technology between trading zones. Ruthenberg associates many of the technical changes in crop management, crops and landscape management explicitly with crises in soil management. Other work in induced innovation has documented similar evolution of arming systems about mechanization (Pingali et al. 1987) and livestock management (McIntire et al. 1992).

This literature is weaker in explaining the mechanisms by which these innovations developed, largely because of a lack of documentation. Recent empirical research, however, has identified and described similar processes of largely endogenous intensification and has attempted to identify the role played by different technical, institutional and policy factors. These suggest that rural land users are involved in dynamic adjustments to changing the scarcity or degradation of natural resources, although the adjustment process takes some time and may not begin on a large scale until degradation has reached an economically important level.

Figure 1 illustrates the nature of such changes. With increasing population or market pressure on a given natural resource, degradation begins to occur, reaching notable levels after \( t_1 \). Trajectory I represents the results predicted induced innovation theory. As the value of the resource (or costs associated with its degradation) increases, returns to technical institutional and other investments in the resource base begin to increase. After \( t_2 \), the benefits of resource investment become greater than the costs and resource rehabilitation begins to occur during period C.

With continuing increases in productivity and other changes in resource use and investment patterns in period D, the population comes to depend primarily on resources modified by human management. The level of resource supply for human use (NR3) achieved after the period of innovation is higher than the initial level (NR2), though all the ecological services provided by the original resource configuration may not be maintained.

This model suggests that there may be a range of possible interpretations of resource degradation. If observations are made while the resource cycle is in period A, degradation is likely to be not yet economically important to the users. In period B, significant economic costs are occurring, but the benefits to resource users of taking action for rehabilitation are not yet evident. During period C, there is still evidence of a degraded resource but the benefits of rehabilitation have become attractive and innovation and investment is actively taking place to raise the total supply of products and services provided by the resource. Recent case studies illustrate such process (Tiffen et al. 1993, Scherr 1993, Dewees 1994, Gilmour 1994).

This pattern of resource degradation and rehabilitation will not always occur. A wide range of conditions may inhibit the innovative responses of period C and D, resulting in the delay of rehabilitation efforts (trajectory II) or continued degradation (trajectory III). Such "inappropriate" degradation may
Table 1 *Incentive Structure for Farmer Investment in Natural Resources for Production*

<table>
<thead>
<tr>
<th>Necessary Incentives</th>
<th>Disincentives due to:</th>
<th>Intervention Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td></td>
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<tr>
<td>1) Farmer knowledge of investment needs or options to reverse resource degradation</td>
<td>Recent settlement in ecozone</td>
<td>Improve design of settlement programmes</td>
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<td></td>
<td>Rapid pace of land use change</td>
<td>Research on new technology</td>
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<td></td>
<td>Poor information exchange</td>
<td>Improve inter-farmer communications</td>
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<td></td>
<td>Failure to perceive environmental externalities and effects</td>
<td>Extension re: options</td>
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<td></td>
<td></td>
<td>Environmental education</td>
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<tr>
<td>Economic Importance of Resource</td>
<td></td>
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<tr>
<td>2) Farming plays an economically important role in household livelihood</td>
<td>Off-farm business interests</td>
<td>Land taxes to encourage tenancy or sale</td>
</tr>
<tr>
<td></td>
<td>Small farm size leading to dependence on wage labour</td>
<td>Interventions in labour markets</td>
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<tr>
<td>3) Degraded resource plays an economically important role in farm production system</td>
<td>Allocation of resources to higher productivity, non-degraded plots</td>
<td>Land management requirements</td>
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<tr>
<td></td>
<td></td>
<td>Taxes on degraded lands</td>
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<tr>
<td>Willingness to Invest Long-Term</td>
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<tr>
<td>4) Long-term horizons</td>
<td>Acute subsistence insecurity</td>
<td>Food aid, social security</td>
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<td></td>
<td>Unusual short-term profit opportunities from resource mining</td>
<td>Price stabilization</td>
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<tr>
<td></td>
<td>Limited land or water rights</td>
<td></td>
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<tr>
<td>5) Security of future investment return</td>
<td>Temporary settlement</td>
<td>Property rights reform</td>
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<tr>
<td></td>
<td>High production risks</td>
<td>Incentives for permanent settlement</td>
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<tr>
<td></td>
<td></td>
<td>Technology to reduce risks</td>
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<tr>
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<td></td>
<td>Insurance for</td>
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</tbody>
</table>

occur where individuals cannot or do not optimize returns on their resources (e.g., due to inadequate information) and/or because there is a divergence between private and social interests (e.g., externalities or inappropriate public policies). Policy action to resolve these incentive problems can be a key to accelerating endogenous processes of transition into period C and D (Scherr and Hazell 1993).

User incentives for resource degradation and rehabilitation

Understanding and appropriately modifying household and community-level incentives to resource rehabilitation will thus be often the key to effective policies for sustainable natural resource management.
and agricultural development. Particular attention must be paid to such factors as farmer knowledge; economic importance of the resource; willingness to invest long-term management opportunity; relative economic returns; and institutional support.

Some forms of resource degradation are easily observed (e.g., deforestation), but some are only visible after long periods (e.g., loss of soil fertility) or at sites removed from the source of damage (e.g., river pollution or the destruction of beneficial species). Farmers and other users of natural resources may, therefore, be poorly informed about the damage that they cause, even when they have to bear the costs themselves, or be unaware of available alternate practices.

Even where farmers are dependent for livelihoods primarily upon farmland, they may take a strategic approach to land investment. Plots of higher quality, greater proximity, or greatest importance to family livelihood may be selected for high investment in soil amendments, trees or terracing while a deliberate decision is made to allow (or even actively manage) resource degradation in other plots. Investments are, by definition, long-term activities. Farmers will only make such investments where they have a long-term perspective and feel confident they will receive expected benefits. These can be threatened by chronic livelihood security, high production or market risks or insecure property rights. Farmers may, despite knowledge and willingness to invest over the long-term, still be constrained by management factors. They may lack access to the inputs required for investment (labour, cost, planting materials or tools) in a timely or reliable manner or be hampered by regulatory controls.

An obviously critical incentive for farmers to invest in long-term land improvement in fragile lands is that returns from those investments must be economically attractive. Much current resource degradation can be attributed to poor economic returns associated with land conservation investments. Sometimes, this reflects real long-term opportunity costs but in many others, it reflects inappropriate technologies or institutional arrangements, externalities such as market failures or policy-related distortions such as government subsidies, which encourage excessive use of agrochemicals, chronically suppressed crop, livestock and forest product prices.

Because of the bulkiness and indivisibility of some natural resource investment, access by farmers to organizational support beyond the household can often be critical to farmer investment capacity. Such organization may come from self-help groups or community credit cooperatives. Local government, which can mobilize resources for community-scale investments (e.g., through taxes) or regulate resource conservation can assist in this as can local offices of state or national public or private organizations (e.g., NGOs or farmer cooperatives) that can respond to local needs. Weak institutional development may, sometimes, explain farmers' failure to undertake key natural resource-conserving or improvement investments.

Constraints to group action may arise when the costs of environmental degradation are borne off-farm (e.g., pollution of rivers and ground water, soil run-off and the destruction of beneficial species) or when benefits of resource investment are freely enjoyed by non-investors (e.g., protection of a community shelterbelt). Table 1 summarize key types of incentives, along with the common disincentives, which prevent or slows the necessary adaptation to more sustainable farming and also some policy approaches that can be used to address them.

Critical role of policy

The influence of public policy on these incentives appears to be critical, though poorly understood. Public pricing policies for farm inputs and outputs, public land, forest, water or grazing resources, or resource substitutes (e.g., kerosene for woodfuel), affect rural people's economic returns from resource use. Policies of direct public or private investment in land use conversion, transportation infrastructure or product processing industries, may have major effects on patterns of land use. Macroeconomic policies affect such factors as rural credit rates, credit availability, exchange rates (changing relative prices for tradeables and non-tradeable products) as well as wages and employment. These in turn influence farm investment incentives, farmers' and farm workers' decisions to allocate labour to farming, and inter-regional migration. Policies encouraging exports or seeking new government revenues may lead to
pressures for environmentally-damaging resource extraction (e.g., intensive cash cropping in fragile lands without land investments or expansion of logging permits in a protection watershed). Institutional policies for government services, licensing and marketing may affect community organization for resource management; transaction costs for farmers seeking permits for resource use and the distribution of extension and other services to different groups in the rural population. Land use legislation and regulations often impinge directly upon farmers' land use and resource management options. These range from rules prohibiting certain management practices (e.g., tree-growing on commercial cropland); to rules mandating practices (e.g., terrace construction on hillsides or cattle stocking rates); to rules allocating resources among different users (e.g., gathering or grazing rules in public forest). Resource tenure laws and rules have important effects on access, use and management of cropland, tree, forest, fodder and water resources.

Except for macroeconomic policies, these policy issues may arise at many levels of government (national, state, regional, county, village). Simultaneously, non-governmental groups such as farmers' associations, environmental groups and community development agents are increasingly influential in policy choices. There are many perspectives as to ultimate policy objectives, not to mention strategies for achieving them.

The fragile lands project

IFPRI's project on "Policy Research for Sustainable Development of Fragile Lands" will address some key research questions for areas with steeply sloping1 lands:

1) What are the actual socio-economic costs and benefits of natural resource degradation, maintenance and creation under different hillside conditions?

2) What distinguishes households, communities and regions that successfully adapt to intensification pressures in hillside and mountains, while maintaining or improving the natural resource base?

3) How do public policies influence household and community natural resource management decisions? How do public policies influence the formation and effective functioning of local organization for natural resource management?

4) What development strategies are appropriate for areas with steeply sloping lands, considering objectives of economic growth, poverty alleviation and environmental stability?

Field research is underway in the hillsides of Central America (Honduras and Guatemala) with a heavy focus on methodology development. New hillside projects are being developed, with national and international collaborators, for East Africa (Ethiopia), Himalayas (Nepal), Southeast Asia (Vietnam) and possible the Andes. The hillside sites are being selected to reflect differences in socio-economic conditions in the hillside themselves, different economic linkages with urban and high potential areas and in historical policies towards hillside development.

Previous research has identified many factors that appear to explain variation in resource depletion or creation in fragile lands. These include physical site factors (such as rainfall, altitude, soils, topography and slopes); history of settlement and human land use (population density, land fragmentation, degree and pattern of deforestation, previous land and resource investments); economic conditions (access to markets, infrastructure and nature of inter-regional linkages); institutional factors (patterns of local organization and extent of government control); and the history of state policies of resource control and investment. The methodology being developed for the Fragile Lands projects will try to account for these factors in understanding and predicting household and community response to different development and natural resource policies. Clearly, this requires multiple contrasting sites within each policy area as well

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1 The project will address similar problems in rainfed drylands; research is underway in the West African Sahel in Niger.
<table>
<thead>
<tr>
<th>Research Objectives, Methods and Data Needs (Three-Year Project)</th>
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<td><strong>Regional land and resource use patterns</strong></td>
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<tr>
<td><strong>Objectives</strong></td>
</tr>
<tr>
<td>Analyze spatial and temporal trends in regional resource use and quality, policy, population, economy, infrastructure, and institutions for resource management</td>
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<tr>
<td>Select representative study communities</td>
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<td>Review resource policy, programme and project activities</td>
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<tr>
<td><strong>Methods</strong></td>
</tr>
<tr>
<td>Analysis of satellite/aerial photo time series</td>
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<tr>
<td>Geographic analysis of factors associated with changes in land and resource use</td>
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<tr>
<td>Informal survey of resource management projects</td>
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<td>Archival research</td>
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<tr>
<td><strong>Data Needs</strong></td>
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<tr>
<td>Photos and satellite images</td>
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<tr>
<td>Secondary data (population, agricultural census, income, nutritional status, etc.)</td>
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<tr>
<td>Historical materials</td>
</tr>
<tr>
<td>Project activity and impact records</td>
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<tr>
<td><strong>Community landscape analysis</strong></td>
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<tr>
<td><strong>Objectives</strong></td>
</tr>
<tr>
<td>Understand community patterns of resource access, use, management and conflict</td>
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<tr>
<td>Identify variation in quality of resource management</td>
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<tr>
<td><strong>Methods</strong></td>
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<tr>
<td>Landscape analysis</td>
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<tr>
<td>Participatory community mapping of resource access, use and quality</td>
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<td>Oral history</td>
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<tr>
<td>Informal surveys of resource users, NGO and GO project staff</td>
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<tr>
<td><strong>Data Needs</strong></td>
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<tr>
<td>Extent of resource base for different rural groups</td>
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<td>Resource-based output flows within and outside communities</td>
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<td>Aerial photos (current, historical)</td>
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<td>Resource status and trends of degradation/enrichment</td>
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<tr>
<td><strong>Resource management strategies</strong></td>
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<tr>
<td><strong>Objectives</strong></td>
</tr>
<tr>
<td>Understand objectives, rules and decision-making systems used in group resource management</td>
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<tr>
<td>Understand costs and benefits of resource management strategies for different types of users and the role of resources in livelihood strategies</td>
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<tr>
<td>Understand ethno-ecology of local resource users</td>
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<tr>
<td><strong>Methods</strong></td>
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<td>Ethnographic methods</td>
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<tr>
<td>Case studies of farm households with different types of resource access and livelihood strategies</td>
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<td>Case studies of selected groups responsible for resource management</td>
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<td>Household and group economic models</td>
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<tr>
<td><strong>Data Needs</strong></td>
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<tr>
<td>Farmer perceptions of resource quality, vocabulary, management techniques, livelihood strategies and resource dependence</td>
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<tr>
<td>Organizational rules, management practices, levels and distribution of costs and benefits</td>
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<tr>
<td>Household access to resources, land, labour, capital</td>
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<td>Costs and benefits of selected resource management activities (private/social)</td>
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<td><strong>Linking policy, resource management decisions, landscape change, and livelihood security</strong></td>
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<tr>
<td><strong>Objectives</strong></td>
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<tr>
<td>Understand community and household effects of geographic, socio-economic and policy factors on resource management decisions, landscape change and rural livelihoods</td>
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<tr>
<td><strong>Methods</strong></td>
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<tr>
<td>Modelling household and group resource management</td>
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<td>Link case study models to community and regional analysis</td>
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<td>Focus group interviews</td>
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<td><strong>Data Needs</strong></td>
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<td>Case study data</td>
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<td>Patterns of policy implementation and impact in study areas</td>
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<td>Farmer responses to policy incentives</td>
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as sites in contrasting policy areas. Given the major limitations of financial and human resources for research in fragile lands, the project will link a few in-depth field research studies with many related studies using less intensive methods. These will be undertaken by collaborating development projects or local organizations. Both types of methods will be designed, tested and evaluated by the project. Table 2 summarizes the methodological component of the field studies:

1) Regional resource use assessment through analysis of photo images and historical studies,
2) Community resource use assessment through participatory resource mapping and landscape analysis;
3) Development of household and group models of resource management decisions through case studies and surveys; and
4) Assessment of policy effects through simulation models for household, group, and landscape levels.

Parallel methods will be developed and tested for participatory policy assessment by local community groups, and also improved analysis of policy effects.

IFPRI-managed research at a core site will be designed and implemented by an interdisciplinary team, including international, national research institutes, development agencies and NGO. A Steering Committee will be formed of senior policy leaders working in the study region. Satellite sites will be established by national research groups in other parts of the region, adapting the conceptual framework and methods developed at the core site. Comparative analyses of case study results are expected to provide findings of broad international relevance to public policy for fragile lands development. An International Advisory Group will provide input on methodology and focus.

Each case study will be implemented as part of a larger regional, in most cases ecozonal, research network of which IFPRI is already or will soon become a member. Participation in the network will ease institutional collaboration and provide a built-in mechanism to ensure widely-relevant research design, wide distribution of research findings and organization of training activities within the region. Network, or eco-regional consortium activities, will involve IARC and NARS, thus closely linking technical and policy research.

Institutional capacity-building for natural resource policy research is a major objective of the project. This will be achieved through direct participation by national researchers, change agents and farm community leaders in research planning, implementation and analysis; formal training workshops in methodology for individuals from countries in the networks; IFPRI promotion of and input into national and regional policy workshops; methodological support for research efforts carried out at "satellite" sites; and, sometimes, through outposted research fellows. These studies present many difficult methodological challenges. Secondary data are typically very weak for "marginal lands," limiting the policy insights that can be gained through rigorous analysis of existing data. Methods for using alternate data sources (e.g., photographic and satellite images) are not well-developed for policy analysis at the household or community level. There are major questions about appropriate methods of analysing the differential impact of policies on resource use across space and time. Research must be able to link policy action with local management decisions, management changes with actual changes in resource status as well as changes in human welfare, production and environmental stability.

From a practical point of view, there are likely to be difficult trade-offs between the need for many sites and the need for adequate desegregation of response in a single site. Emphasis on the role of development agents and local communities in providing feedback from multiple sites requires a much more participatory approach to research design (to ensure that collaborators will gain sufficiently from the study to justify their involvement). Yet this may pose problems for cross-site comparisons. One can also expect some antagonism between research and development partners due to the lack of shared culture and different priorities. Explicit efforts will be needed to manage these tensions effectively.

The project approach also faces important organizational challenges. The CGIAR eco-regional initiatives, with which IFPRI plans to collaborate in several hillside and mountain sites, are currently
dominated by national agricultural research institutions and have few partners with expertise in policy analysis. Most of the countries where research is being undertaken have under-developed policy research capacity and, commonly, there is little tradition of policy research or input into policy formulation or assessment (particularly in fragile lands and natural resource policy). Significant training and capacity-building will be necessary, and new linkages with policy makers developed.

There is a risk that the transaction costs associated with the large number of international research, national research, local development and policy collaborators will sap the project's human and financial resources. To minimize this problem, IFPRI will seek to integrate its efforts into existing networks of policy research on sustainable development rather than set up new networks of its own.

Finally there are major funding challenges. There is currently strong donor support for initiatives on fragile lands development. However, donations are typically partial and short-term while the project calls for multiple linked components over a period of at least five years as well as basic activities of syntheses of international literature and methodology development. The transaction costs associated with fundraising, donor reporting, etc., seem likely to be high.

Conclusion

In recent decades, many important lessons have been learned at the local level about the successful (and unsuccessful) development of hill and mountain regions. These lessons must now be incorporated into local, national and international policies that will broadly support local success on a large scale. IFPRI's Fragile Lands Project aims to generate and synthesize empirical findings on the dynamics of development and natural resource investment in hilly regions. It will also identify workable policies and interventions for these lands under different socio-economic and assess the environmental impact of specific policy instruments. IFPRI hopes to work closely with other research and development organizations, including the IDRC network on Sustainable Mountain Agriculture, in this effort.

References


The Impact of Peasant Economies on Natural Resources in the Andes

by

Marco Villasante

Introduction: the Andes mountains

There is agreement among scientists that the Andes chain of mountains have unique characteristics. It is frequently mentioned that the chain is different from the Himalayas and Alps because it is perpendicular to the Equator. It has a number of special characteristics such as the high winds generated by the earth's rotation, the height of the mountains and their irregular topography. These features create unique living conditions and challenges for the peasant population attempting to make a living in the region.

A feature of the Andes, particularly in the countries of Peru, Ecuador and Bolivia, is the variety of environments, life zones and ecosystems that are found. This variety makes it possible for people to live above five thousand metres and to practice agriculture above four thousand metres. In this context, the present day Andean peasant has inherited an economy based on herding South American camels and growing a variety of crops including different types of potatoes.

The Andean zone, particularly in Peru, is composed of the Cordillera and the Oriental and Occidental sides of the mountains. This includes the coast, the highlands as well as the forests of the Amazon basin. For the purposes of this paper, the area discussed is limited to the sierra and its small valleys and the associated altitudinal levels and altiplanos. These areas are occupied by Andean peasants with an economy based on agriculture, in the valleys and slopes, while livestock production predominates at higher altitudes.

The community is the major form of socioeconomic organization amongst the Peruvian peasantry living in the Andes. It is composed of the peasant family and it's unit of production and also a wider sphere of community resources, such as services, representation and collective labour. These communal resources are in a process of differentiation. Inter and intra community differentiation is based on the use and management of the natural resources, basically soil, water, weather conditions, vegetation and fauna. All these resources, as in the past, are being modified by human activity to various degrees and for different objectives.

Social scientists have studied the social organization and cultural inheritance found on all types of peasant farms and also present in the majority of peasant communities. In general there are two conflicting conclusions in relation to the future of the peasant economy and the peasant community. On one hand there are those who believe that the peasant community will last for a long time and that it should be considered as the basis for rural development. On the other hand there are those who believe that the peasant community does not have any role to play in rural development and the way to achieve development goals is to place communally owned land on the market as a means of moving peasants into the cash economy forcing them to become part of the national economy.

In general there is an agreement that weather conditions, among all the natural conditions that intervene in agricultural production, have favourable and unfavourable effects upon production. Peasants utilizes all the microenvironments of the region for farming. The Andean peasants change their activities to suite the weather conditions by using an organization of production and a technology proven by centuries.

Two distinct seasons are present, in the Andean region of Peru, a rainy and a dry season. Both seasons are separated by short periods of transition. For farming purposes the land available for
agriculture can be divided into two zones: in the valleys and on the hills and slopes. The valleys, where the 35 percent of the peasant communities are located, have plain soils that are alluvial and profound. The slopes and hill areas, with 45 percent of the peasant communities, have superficial and poor soils generally used for dryland farming. The higher areas (punas), are located above 4000 m and are the region where 20 percent of the peasant communities can be found. Punas have natural grazing and other pastures and are characterized by cold and severe weather and are not suitable for cultivation.

The natural pastures of the Andes are covered with low vegetation, the growing period of which coincides with the rainy season (January to March). Most pastures are located from 3500–3800 m up to the high cordilleras. At higher altitudes, where the humidity is high, are the bofedales, or as the peasants call them oconales. The botanic communities found on these areas varies as a function of location, altitude, topography, latitude and environment. In general, the grass species are stronger than the gramineae. The number of species is variable and go from eight up to sixty-four.

Case studies

The characteristics of the communities studied is given in table 1. Land use characteristics were classified by community and this data is also presented in Table 1. This information has been produced with the

Table 1 The characteristics of the communities studied

<table>
<thead>
<tr>
<th>Community:</th>
<th>Choquecancha</th>
<th>Palacayo</th>
<th>Mahuaypampa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude (range in metres)</td>
<td>2700-3500</td>
<td>3500-3550</td>
<td>4100-4700</td>
</tr>
<tr>
<td>Major crops</td>
<td>Potato, Corn, Wheat, Beans, Cattle, Goats, Sheep, Horses</td>
<td>Potato, Corn, Wheat, Barley, Cattle, Sheep, Pigs</td>
<td>Potato, Alpaca, Ovino</td>
</tr>
<tr>
<td>Number of hamlets</td>
<td>5</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Number of families</td>
<td>290</td>
<td>67</td>
<td>161</td>
</tr>
<tr>
<td>TOTAL POPULATION</td>
<td>1323</td>
<td>369</td>
<td>834</td>
</tr>
<tr>
<td>Actual land use</td>
<td>area (ha)</td>
<td>percent</td>
<td>area (ha)</td>
</tr>
<tr>
<td>Tilled land with irrigation</td>
<td>158.9</td>
<td>12.4</td>
<td>588.3</td>
</tr>
<tr>
<td>Tilled land without irrigation</td>
<td>59</td>
<td>0.60</td>
<td>173.8</td>
</tr>
<tr>
<td>Land of rotational cropping</td>
<td>512.8</td>
<td>5.24</td>
<td>350.2</td>
</tr>
<tr>
<td>Area of forestation</td>
<td>85.7</td>
<td>6.65</td>
<td>86</td>
</tr>
<tr>
<td>Area of protection</td>
<td>148.2</td>
<td>11.5</td>
<td>522.3</td>
</tr>
<tr>
<td>Natural pastures</td>
<td>5780.7</td>
<td>59.07</td>
<td>7936.6</td>
</tr>
<tr>
<td>Bofedal</td>
<td>285</td>
<td>2.91</td>
<td>3.7</td>
</tr>
<tr>
<td>Artificial bofedals</td>
<td>102</td>
<td>1.04</td>
<td>3.7</td>
</tr>
<tr>
<td>Unproductive areas</td>
<td>2046.5</td>
<td>31.13</td>
<td>21.5</td>
</tr>
<tr>
<td>Urban area</td>
<td>10</td>
<td>0.08</td>
<td>10</td>
</tr>
<tr>
<td>Total productive area</td>
<td>6739.5</td>
<td>68.87</td>
<td>1033.6</td>
</tr>
<tr>
<td>TOTAL AREA</td>
<td>9786</td>
<td>100</td>
<td>1289</td>
</tr>
</tbody>
</table>

- 14 -
help of the community leaders using maps and other official information that is available. The table presents a general picture of the complexity and variety of actual land use in the three peasant communities that were studied. The table includes information from peasant systems of classifying the land for agriculture use or for natural pastures. The table has the following points:

- The total area of each community is different. The largest is Choquecancha, which has almost ten times more land than Mahuaypampa. This major difference can be explained by the fact that Choquecancha is an old community with land titles that originated during the Spanish domination that were recognized by the government in 1926. Mahuaypampa has a different origin. Before 1968 it was a hacienda in the hands of a landlord and after agrarian reform it was officially recognized as a community. This intercommunity differentiation is the major feature of the peasant agrarian structure in the region of Cusco.

- The area of land used for agriculture is relatively small. In the three communities studied, the available land is mostly classified as natural pasture. This is reflected as follows: Choquecancha has 81 percent, Mahuaypampa 80 percent and Palcoyo 68 percent. This picture is typical of the Andes, where land for agriculture has limitations.

- In these communities the area of irrigated land is very small, Mahuaypampa has only 12.4 percent and for the others none. This picture is also similar to the region of Cusco. In the Peruvian Andes, there are not many new irrigation infrastructures being constructed and furthermore, the Inca irrigation systems, that in the prehispanic periods were extremely important, are now collapsing.

- The three communities have a variety of land use types. Basically land for agriculture and land for natural pastures predominate. Land for agriculture has three major characteristics, the land with irrigation where up two crops can be produced (in quantitative terms this is minimum); land without irrigation for one crop in a year basically for corn production (minimal); land for rotational cropping, which is generally located on the small hills and slopes known as laymes, which is the most common type in all peasant communities. The land use rotation period is six years in the three communities of this study. In other communities, the rotation period can be up to eight to ten years. Land used for natural pastures is of two types, the bofedales, principally located in the higher areas where running water is available and natural pastures that are dependent upon the rainy season.

### Distribution of resources

There is a skewed distribution of productive resources among units of production in each peasant community. In all three communities under study a socioeconomic stratification by land use and cattle tenancy was found. Land use was measured by calculating the total area of cultivated land and does not

<table>
<thead>
<tr>
<th></th>
<th>Rich</th>
<th>Middle</th>
<th>Poor</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>s</td>
<td>s.d</td>
<td>s</td>
<td>s.d</td>
</tr>
<tr>
<td>Family size</td>
<td>5.5</td>
<td>1.6</td>
<td>4.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Area arable (ha)</td>
<td>4.17</td>
<td>2.24</td>
<td>2.81</td>
<td>1.48</td>
</tr>
<tr>
<td>Land use factor*</td>
<td>.28</td>
<td>.18</td>
<td>.15</td>
<td>.11</td>
</tr>
<tr>
<td>Sheep units**</td>
<td>177</td>
<td>124</td>
<td>101</td>
<td>59</td>
</tr>
</tbody>
</table>

* Land used as a factor of land available
** The number of heads of cattle have been standardized as units of sheep
include fallow areas nor open land used for grazing. It was impossible to calculate the area used as natural pasture because of the special relationship that exists between peasant units of production and community organizations.

Table 2 presents a synthesis of the principal socioeconomic indicators of the peasant strata. The indicator 'degree of parcelation' refers to the degree of land use divisions by each strata and is the result of dividing the sum of the extensions of land under cultivation by its number. In this study a range from 13 to 28 parcels of land under production was found. The indicator of total cattle is the result of standardizing all types of cattle into sheep units.

The following conclusions can be made from table 2:

- The characteristics of the average family are as follows: family size is composed of 5.13 resident members cultivating a number of parcels of land with a total size of 3.07 ha. The average size of an individual parcel is 0.221 ha. The same unit of production has an average of 104 heads of sheep.

- The characteristics by strata are as follows: the number of family members across all strata tends to be uniform, the rich strata has an average of 5.5 members while the smallest size is for the middle strata with 4.8 members. Land size under cultivation for the rich strata averages 4.17 ha, almost double that for the poor strata with 2.23 ha. The rich strata not only has more land under cultivation but the average size of each piece of land is also larger. In relation to the herd size, the rich strata has more sheep than the others: an average of 176. This is 43 percent higher than the middle strata and is close to five times more than the average of the poor strata.

- According to the measured indicators, the strata are not in a social conflict situation and do not have antagonistic positions between members. There are economic differences but these are not big enough to create social conflicts in each community under study.

The unit of production

In each peasant farm in all three communities, labour is characterized by the combination of family labour and extra family labour; principally, as reciprocity and proletarian labour (see table 3). These combinations of forms of labour are present mainly in agricultural production and in secondary economic processes such as arts and crafts and other types of production. They are not present in cattle ranching. In agriculture, labour is principally used for seeding, earthing-up and soil conservation. In the domestic situation, labour is used for the construction of the farm infrastructure such as fencing. The use of family

Table 3 Sources of labour (days) by strata

<table>
<thead>
<tr>
<th></th>
<th>Rich</th>
<th></th>
<th>Middle</th>
<th></th>
<th>Poor</th>
<th></th>
<th>All</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>s.d.</td>
<td>x</td>
<td>s.d.</td>
<td>x</td>
<td>s.d.</td>
<td>x</td>
<td>s.d.</td>
</tr>
<tr>
<td>Male-family</td>
<td>63.13</td>
<td>53.25</td>
<td>51.13</td>
<td>29.51</td>
<td>41.53</td>
<td>24.05</td>
<td>51.93</td>
<td>37.99</td>
</tr>
<tr>
<td>Female-family</td>
<td>20.33</td>
<td>12.56</td>
<td>14.33</td>
<td>11.02</td>
<td>20.67</td>
<td>10.18</td>
<td>20.11</td>
<td>11.05</td>
</tr>
<tr>
<td>Reciprocal</td>
<td>56.53</td>
<td>55.77</td>
<td>59.80</td>
<td>65.24</td>
<td>33.87</td>
<td>34.22</td>
<td>50.07</td>
<td>53.41</td>
</tr>
<tr>
<td>Tipipac*</td>
<td>2.60</td>
<td>5.46</td>
<td>3.13</td>
<td>7.81</td>
<td>1.27</td>
<td>4.91</td>
<td>2.33</td>
<td>6.10</td>
</tr>
<tr>
<td>Tallapac**</td>
<td>9.27</td>
<td>12.76</td>
<td>5.13</td>
<td>8.93</td>
<td>2.47</td>
<td>4.85</td>
<td>5.62</td>
<td>9.63</td>
</tr>
<tr>
<td>Male-paid</td>
<td>31.33</td>
<td>48.33</td>
<td>20.47</td>
<td>35.59</td>
<td>9.20</td>
<td>25.47</td>
<td>20.33</td>
<td>37.90</td>
</tr>
<tr>
<td>Female-paid</td>
<td>0.40</td>
<td>1.30</td>
<td>0.87</td>
<td>1.60</td>
<td>0.67</td>
<td>1.68</td>
<td>0.64</td>
<td>1.51</td>
</tr>
<tr>
<td>Total</td>
<td>190.13</td>
<td>99.68</td>
<td>165.13</td>
<td>89.92</td>
<td>113.00</td>
<td>58.92</td>
<td>156.09</td>
<td>88.77</td>
</tr>
</tbody>
</table>

- 16 -
labour is not homogeneous across strata in all three communities. There is a variability by sex and the source of labour. From table 3 the following conclusions can be made:

- The average peasant farm uses 156 days of labour in a year for growing a maximum of 13 different crops on all its parcels of land. This labour has three sources, family labour (men and women), reciprocity labour (ayni, tallapac) and salaries (men and women). The intensity of use of each source of labour is related to the economic characteristics of each strata. This includes the number of fractions of land cultivated; the needs of the type of crop cultivated (corn and potatoes need more labour than wheat and barley); and the relative size and composition of the family. When the days laboured are compared with the units of production and the strata, the rich strata on the average works 190 labour days, the middle strata 165 days and the poor strata 113 days. This information doesn’t count the days used in stockbreeding, which is continuous throughout the year, and other types of labour done by the peasant family.

- The intensity of family labour has two main characteristics: it is differentiated by sex for each strata and its intensity is different across strata. The number of days laboured by men is higher for the rich strata, with 63 labour days, and lower for the poor strata, with 41 labour days. The labour of women in agriculture is more homogeneous averaging 20 days for two strata (rich and poor).

- Reciprocity (ayni) is a form of labour exchange between peasant farms. These exchanges follow the kindred relationships found within a community. It is used when growing the major crops, potato, corn and wheat, and is the major complement to family labour. Thus it is high in all strata. The general average is 50 labour days. The middle strata is highest with an average of 59 days and lowest for the poor strata with an average of 33 labour days. In the communities studied, this source of labour is provided by men, however, other studies state that women are also part of ayni.

- The use of proletarian (paid) labour is relatively very small. The general average is close to 20
days and becomes, after family labour and reciprocity, the third in importance. It is differentiated across strata. The rich strata use an average of 31 days and the poor strata only nine. The hiring of women is less than one day. This can be understood as indicating the presence of a small labour market that is basically part of the production sources of the well-to-do in the community. It also is an indicator of the level of rural development in this part of the Andes: there are not many full-time labourers.

**Production levels**

In the communities sampled here there were 13 different crops under cultivation. Of these, potato and corn were the most important. They were grown in larger volumes than other crops and are the major staples for peasant diet and, they are also income generators. Potatoes and corn, together with barley, can be considered the commercial crops of the region.

Table 4 presents the average volume of production by strata for all thirteen crops. The levels are differentiated by strata. For the rich strata the commercial crops like potatoes, corn, wheat and beans are the most important but the traditional Andean crops like quinua (Chenopodium quinoa), tarwi (Lupinus mutabilis), oca (Oxalis tuberosa), liza (Ullucus tuberosus), Añu (Tropaeolum luberosum) are more important for the poor strata. From this table the following conclusions can be drawn:

- These communities grow 13 different crops in production systems that have been relatively stable over the last ten years. Studies of other communities in the region of Cusco, however, have shown a reduction in the number of crops cultivated during the same period especially in the number of traditional crops, which have been replaced by commercial crops.

- The levels of production of the commercial crops for the rich strata are almost double that of the poor strata. The quantity of traditional crops are distributed evenly among strata.

The impact of the environment on the farming systems and its effect upon the levels of production was shown when this data was analyzed on a community basis. This data showed that the environmental differences between communities are based upon altitude, on the soil conditions, on location in the Andes and land pressure. The analysis presented the following picture:

- Not all farming systems are present in every community, this is true of corn, quinua, cañihua, beans, calabaza and peas. This means environmental conditions restrain productive systems.

- In each peasant community, not all strata use the same farming system. This is the case for wheat, barley and oat grass for the community of Palccoyo; añu and quinua for Mahuaypampa; and peas

<table>
<thead>
<tr>
<th>Table 5</th>
<th>The percentage of total production consumed by each strata</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rich strata</td>
</tr>
<tr>
<td>Potato</td>
<td>40.80</td>
</tr>
<tr>
<td>Corn</td>
<td>72.50</td>
</tr>
<tr>
<td>Beans</td>
<td>67.90</td>
</tr>
<tr>
<td>Barley</td>
<td>46.80</td>
</tr>
<tr>
<td>Wheat</td>
<td>88.70</td>
</tr>
<tr>
<td>Liras</td>
<td>78.00</td>
</tr>
<tr>
<td>Oca</td>
<td>80.10</td>
</tr>
<tr>
<td>Añu</td>
<td>89.30</td>
</tr>
</tbody>
</table>
and barley for Choquecancha. This fact shows that production of these crops is related to a variety of factors such as the amount of land in the hands of peasant farmers (although the size and number of parcels can change from one year to the next); the economic objectives of production including the characteristics of family consumption; the relationship with market forces (prices of major products); and perhaps the most important, cultural factors that directly influence consumption.

- Farming systems do not have the same importance in all communities. This is the case of barley (malting barley), which is the second in importance for the community of Mahuaypampa, and is not produced in the others. Nevertheless, potato is the crop that is present in all three communities because it is grown by all units of production and the varieties produced are mostly native.

**Characteristics of consumption**

A central feature of Andean peasant economies is that peasant diet is determined by the production system. Most basic diet needs are satisfied by agricultural production but other foods and staples are purchased in local markets. Table 5 shows the variation in consumption levels across different crops. Some crops are used almost completely for consumption by the family while others are largely grown for commercial purposes. The traditional Andean crops are mostly grown for home consumption. For example, ahu (84 percent), oca (77 percent), liza (75 percent) and corn (72 percent). Other crops have different consumption patterns; thus, 44 percent of the potatoes (a typical Andean crop) grown are consumed in the home and 29 percent of the wheat and 64 percent of the beans are used by the family.

Table 6 shows the sales by community and strata of the various crops. This table, and the previous one, show that a major characteristic of peasant economies is that the production system works from the consumers’ perspective and that it is influenced by mercantile considerations. The points to note are:

- That there are no major differences across strata in the levels of consumption as a proportion of total production. For the traditional Andean crops like oca, ahu, liza, quinua and cañihua, their level of consumption is close to 100 percent. This means that their incidence on the market is small and therefore they are secondary crops for income generation.

- That there are other crops (barley and potatoes) that are of major importance for income generation. These crops show differences across strata. Barley, principally for Mahuaypampa, is the major commercial crop and is represented by its level of sales. Thus, the rich strata sells 74 percent of its total production of Barley, the middle strata 94 percent and the poor strata 77 percent. Potato, which has the highest production level, has a different level of economic importance but also is the most consumed, thus, for the rich strata 20 percent is sold, the middle 19 percent and for the poor strata only 11 percent.

- That no crop is predominantly commercial in all three communities. As a result, these peasant economies are not specialized in the production of any one commercial crop. Instead, they farm a variety of crops resulting in a multicrop system heavily influenced by consumption patterns.

In table 6, information on levels of consumption by community are expressed in percentages. The intercommunity differences are as follows:

- Two communities, Mahuaypampa and Choquecancha sell a high proportion of their crops, while Palccoyo sells only one crop (potato) and only four percent of total production. This means that the first two communities generate their income selling agricultural products while Palccoyo, having a livestock economy, sells alpaca fibre and wool.

- One community is more strongly influenced by the market than the others. This is Mahuaypampa where all strata sell potato and barley as a result of the community’s involvement with the credit market: the major brewery of the area offers credit in the form of inputs for barley production.

- 19 -
Table 6 Percentage of the total production of selected crops sold by each community and strata

<table>
<thead>
<tr>
<th></th>
<th>Rich Palccoyo</th>
<th>Middle Mahuay.</th>
<th>Poor Choquec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato</td>
<td>2</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>Corn</td>
<td>0</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Beans</td>
<td>0</td>
<td>74</td>
<td>5</td>
</tr>
<tr>
<td>Barley</td>
<td>0</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>Wheat</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Licas</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oca</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Añu</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- The community of Palccoyo has an economy based on cattle production and produces a small amount of crops. This is typical of populations in the higher altitudes of the Andes, above 4000 m. Income is generated by selling fibres, wools, meat and derivatives. For this reason these communities have a different impact upon natural resources, principally natural grazing.

The impact of farming systems upon soil erosion

Agriculture

Erosion levels, mainly the sheet erosion of soils on the parcels of land belonging to the farmers, was used as an indicator of the environmental impact of peasant farm processes. The effect of potato growing on soils in all three communities was measured. The results show that this crop allows an average of 60.41 t/ha of net soil loss per year. Other crops behave differently, like oca, ollucu, añu, beans and barley have net loss of 19.44 t/ha/ for each agricultural year. From table 8 the following conclusions can be drawn:

- That the impact is different across strata: not all strata have the same effect upon soil erosion as a result of their farming activities. Also, the impact of agriculture across communities is different. It is higher for Palccoyo and lower for Mahuaypampa, this is explained by the fact that agriculture for the first community is practiced on the slopes and small hills, while in Mahuaypampa, agriculture is carried in the flat areas (pampa) controlled by the community.

- Potato farming, which is the basic crop in the region of Cusco and the basic staple of peasant diet, produces the major impact on lands managed under rotation, producing a loss of 60.41 t/ha/year.

- Not all strata produce the same effect upon soil losses. Thus the rich strata have almost double the rate of soil loss (61.87 t/ha/year) than does the poor strata (31.18 t/ha/year). This is explained by the fact that the richest strata controls not only more land in each community but each piece of land cultivated is of a larger size. The average size is 0.284 ha, for the rich strata, and only 0.181 ha for the poor.
Table 7  Impact of agriculture: soil loss by community and strata (t/ha/year)

<table>
<thead>
<tr>
<th>Community</th>
<th>Rich</th>
<th>Middle</th>
<th>Poor</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palccoyo</td>
<td>24.98</td>
<td>17.06</td>
<td>12.98</td>
<td>55.02</td>
</tr>
<tr>
<td>Mahuaypampa</td>
<td>18.33</td>
<td>9.63</td>
<td>10.96</td>
<td>38.92</td>
</tr>
<tr>
<td>Choquecancha</td>
<td>18.56</td>
<td>18.15</td>
<td>7.24</td>
<td>43.95</td>
</tr>
<tr>
<td>ALL</td>
<td>61.87</td>
<td>44.84</td>
<td>31.18</td>
<td>137.89</td>
</tr>
</tbody>
</table>

The impact of livestock

In the Andean region of Peru there are close to 14 million hectares of grazing land of which 69 percent are located in peasant communities. Of the 9 612 000 ha controlled by communities, one percent is used for agriculture with irrigation, nine percent for dryland farming and the rest, 75 percent, produce fodder for sheep, cattle and South American camels. The national statistics show that this natural resource, as the result of the impact created by livestock, has been damaged and some areas are classified now as desert and others have signs of overgrazing.

The principal economic activity for the community of Palccoyo is livestock raising: using alpacas, sheep and llamas. As there are not any cultivated pastures, the system of exploitation is spread over a wide area. For the communities of Mahuaypampa and Choquecancha, the major economic activity is agriculture complemented by livestock raising with a herd composed of cattle and sheep. In both communities the system of exploitation is a mix because the use of natural pastures is complemented with grazing on crop residues.

In general, livestock raising is a private rather than a communal activity. There is one exception in Palccoyo where a herd of alpaca (140 head) is owned as common property. In all three communities the peasant families have up to 7 species (cattle, sheep, horses, donkeys, pigs, alpaca and llamas) with an average of four. There are differences in the size and composition of the herd by strata. The upper strata has from four to five species, the middle strata three to four species and the lower strata two to three. In quantitative terms, the upper strata has an average of 245 sheep (Palccoyo and Choquecancha) and 120 for Mahuaypampa. This is in contrast to the holdings of the poor strata in all three communities where the averages range from 36 to 42 sheep per farm. In other words, the poor strata has from four to five times fewer head of livestock than have the rich strata. Livestock production therefore has a tendency for economic differentiation in strata. This is shown in table 8 where the information is displayed by community and by strata.

In Palccoyo, like all communities at higher altitudes, there is a seasonal grazing system with a type of chronological rotation. The system has some characteristics of specialization, due to the presence of alpacas and llamas, and the existence of more and richer grazing sites. In Mahuaypampa, the grazing system is seasonal and continuous. For this reason the natural pasture is used all year around. Under this condition livestock production is more important than agricultural production and for this reason its calendar is independent of agriculture.

Table 8 shows that there is a differentiation between communities and by strata in the ownership of livestock. Palccoyo is more privileged because on the average each peasant family has 113 head of livestock and the less privileged community is Mahuaypampa where each family owns 88 head. In Palccoyo 99.13 percent of the fodder for the stock comes from natural pastures and the rest from agricultural waste.

The direct impact of livestock upon soil loss, in terms of each of the three communities and the members of the different strata living in the communities, is given in table 9. The following important points may be deduced from this table.
Table 8 Livestock holdings (standardized in heads of sheep) per community and by strata

<table>
<thead>
<tr>
<th>Communities by socioeconomic strata</th>
<th>Nº of units of production</th>
<th>percent</th>
<th>Livestock by Unit of Production</th>
<th>Total in sheep heads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palccoyo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rich</td>
<td>25</td>
<td>15</td>
<td>245</td>
<td>6148</td>
</tr>
<tr>
<td>Middle</td>
<td>71</td>
<td>44</td>
<td>137</td>
<td>9788</td>
</tr>
<tr>
<td>Poor</td>
<td>65</td>
<td>40</td>
<td>36</td>
<td>2389</td>
</tr>
<tr>
<td>Sub total</td>
<td>161</td>
<td>100</td>
<td>113</td>
<td>18 326</td>
</tr>
<tr>
<td>Mahuaypampa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rich</td>
<td>15</td>
<td>22</td>
<td>120</td>
<td>1804</td>
</tr>
<tr>
<td>Middle</td>
<td>25</td>
<td>52</td>
<td>72</td>
<td>2522</td>
</tr>
<tr>
<td>Poor</td>
<td>17</td>
<td>25</td>
<td>42</td>
<td>723</td>
</tr>
<tr>
<td>Sub total</td>
<td>571</td>
<td>100</td>
<td>88</td>
<td>5050</td>
</tr>
<tr>
<td>Choquecancha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rich</td>
<td>28</td>
<td>9</td>
<td>245</td>
<td>6886</td>
</tr>
<tr>
<td>Middle</td>
<td>144</td>
<td>50</td>
<td>137</td>
<td>19 851</td>
</tr>
<tr>
<td>Poor</td>
<td>118</td>
<td>41</td>
<td>36</td>
<td>4337</td>
</tr>
<tr>
<td>Sub total</td>
<td>290</td>
<td>100</td>
<td>107</td>
<td>31 075</td>
</tr>
</tbody>
</table>

- The highest impact is produced by the rich strata from the community of Choquecancha, followed by Palccoyo and Mahuaypampa. The levels of erosion on natural grazing are higher than the erosion created by the same units of production on the yearly tilled land without irrigation. This is explained by the fact that the natural grazing areas are located in fields on the high hills with steep slopes. The families from Choquecancha produce a net soil loss of 8.57 t/ha/year by breeding sheep, 9.31 t/ha/year when pasturing cattle, 14.63 t/ha/year for horses. In sum, the annual lost soil on natural grazing areas is 48.59 t/ha/year. The animals owned by the rich strata of Palccoyo and Mahuaypampa are responsible for a loss of from 27.05 to 10.88 t/ha/year of soil from the natural grazing areas. This losses are small compared to other levels of soil erosion found in both communities as a result of agricultural production.

- The poor strata in all communities behave a little differently. This strata does not have a large impact upon natural grazing areas. Their values can be interpreted as normal for the type of soil.

- If tables 9 and 10 are compared, the production of cattle, rather than agriculture, has a larger impact upon soil erosion. This is explained by the fact that cattle raising in these areas is a type of nomadic economy. The herd is taken every day to the areas with natural pastures in each community. As a result cattle not only create erosion every day but, while eating on the slopes and small hills, physically destroy the top soil.

Table 9 The amount of soil lost (t/ha/year) by the three communities studied due to livestock grazing

<table>
<thead>
<tr>
<th>Community</th>
<th>Rich</th>
<th>Middle</th>
<th>Poor</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palccoyo</td>
<td>27.05</td>
<td>10.88</td>
<td>10.88</td>
<td>48.81</td>
</tr>
<tr>
<td>Mahuaypampa</td>
<td>10.88</td>
<td>10.88</td>
<td>10.88</td>
<td>32.64</td>
</tr>
<tr>
<td>Choquecancha</td>
<td>48.59</td>
<td>26.64</td>
<td>18.2</td>
<td>93.43</td>
</tr>
<tr>
<td>All</td>
<td>93.97</td>
<td>48.4</td>
<td>39.96</td>
<td>182.33</td>
</tr>
</tbody>
</table>
The statistics show that the natural pastures of Palccoyo are overgrazed. The calculated use factor shows that the animal stocking (2.71 sheep units/ha/year) is almost twice its support capacity (1.5 sheep units/ha/year). As a consequence livestock feeding is affected by overgrazing. This picture is also true for Mahuaypampa. The use factor shows that the animal stocking (4.89 sheep units/ha/year) is a little higher than it's support capacity (4.53 sheep units/ha/year) in consequence livestock feeding is affected during the dry season especially for the lower strata because the other strata can use waste and residuals from agriculture. For Choquecancha the picture is better. The use factor is (1.81 sheep units/ha/year), which is smaller than it's support capacity (2.02 sheep units/ha/year). As a consequence, livestock feeding during the summer is not affected.

Conclusions

The majority of peasant communities in southern Peru have an economy based on farming and livestock raising. These are the two major sources of food, income and employment in these communities. This type of economy is organized about the community where economic differentiation between units of production becomes the rule, each having a different impact upon natural resources and especially upon soil erosion.

Agriculture and livestock raising developed in a natural scenario characterized by the presence of slopes typical of higher mountains and ranging in altitude from 2800 to 4200 metres. The weather conditions and the altitude, complemented by the scarcity of natural resources, allow the cultivation of six to eight types of agricultural product and three or four species of livestock. The peasant communities discussed here do not specialize on one system of production. Instead they combine agriculture with livestock production. This means that each family-based production unit has to plan it activities to suite the annual changes of the seasons.

In any given year, agriculture and livestock raising will have short- and long-term effects upon the natural resources of the region. Soil erosion was the most significant factor that was identified and this is considered to be proceeding at a moderate rate. Considered on the basis of strata, the data showed that members of the rich strata had the greatest effect upon the environment. Not only did this group own the largest area of land but, on a per hectare basis, they were responsible for the highest rates of soil erosion.
Alternate Sustainable Development Strategy for a Biosphere Reserve, Sierra de Santa Marta, Veracruz, Mexico

by

Luisa Paré

Introduction

The Sierra de Santa Marta Project is a joint interdisciplinary research group that involves the National University of Mexico and Carleton University of Canada and is sponsored by IDRC. The group has been working in the region since 1990. The Sierra de Santa Marta, southern Veracruz, is part of the Sierra de los Tuxtlas the most northern tropical rain forest of the American continent. It is located on the shores of the Gulf of Mexico (Map 1). The area ranges in altitude from sea level to 1700 m and has 13 life zones and great biodiversity. More than 1500 species of plants have been registered and it is probable that the total number is around 3000. On this 1500 km² area there are more than 410 species of birds (40% of those found in the whole country), 102 mammals, (1149 species of animals, 102 of them in danger of extinction) and 21 endemics. Among endangered species are the jaguar, the anteater and the whiteheaded eagle (Ramírez 1992). This area is the watershed for the Tuxtlas and Coatzacoalcos region and is the water catchment for one lake and two coastal lagoons both of which are important for tourism as well as supporting the fishing activities of over 3000 families.

The watershed of the Sierra, through a catchment dam, provides water to the main cities of the lowlands, in particular the oil-complex city and harbour of Coatzacoalcos. A noted specialist in rainforests, Joseph A. Tosi, has stressed this importance: “The natural forests of the Sierra de Santa Marta should be valued above all for their hydrological functions and services” (Tosi 1993).

Some 50 000 people, mainly Nahua and Zoque-popoluca Indians occupy the territory inhabited 5000 years ago by the ancient Olmecs. Traditionally they have made their living from slash and burn maize and beans cultivation and, to a lesser extent, chayote (Sechium edule), cassava (Manihot esculenta), taro (Colocasia esculenta) y camote (Ipomoea batatas).

Most of the land is either communal or ejidal, with or without individual demarcation, and a smaller fraction is national and private. Private plots vary from 35 to 100 ha and ejidal family land units from 4 to 20 hectares in size. The ejido land tenure system is land given to landless peasants who demand it. The land is either donated national land or private property expropriated from individuals whose holdings exceed the legal limits. Most units are close to 20 ha. Until the beginning of the 1990s, small-scale coffee plantations provided the main cash income for some farmers.

In the 1970s hunting and fishing accounted for more than a third of Indian people’s protein ingestion (Stuart 1986). The Jaguar God, the Lord of the Mountain duly honoured with flowers and candles, guaranteed that the forest and its animals should be conserved. Since the 1940s, the influence of cattle ranching and, later, the arrival of cattle herders resulted in a gradual shift toward this industry. Besides the one or two hectares used for maize production, peasants turned the rest of their forested land into pasture for their own stock or rented the area to a cattle rancher or else entered a sharecropping agreement with a rancher.
Colonization, cattle ranching and deforestation

Since the beginning of the 1950s the region has been used by the agrarian reform authorities as a colonization zone to satisfy demands from landless peasants. Development programmes, supported by official banks and the World Bank, promoted the clearing of the forest to establish pastures (Paré et al. 1992).

As part of the reform process, most of the communal lands were transformed into ejidos. Non-parcelled communal lands were monopolized and fenced by villagers who shared their pastures with cattle ranchers. To reestablish equality, and to avoid land concentration, villagers have gone through or are currently undergoing a process of demarcating communal lands into individual plots. This change in the agrarian structure, which has been carried out without the reservation of part of their territory as a forest reserve, is responsible for the conversion of forest into pastures.

This situation was worsened when the colonizers were compelled by the agrarian reform authorities to fell the forest. This policy was carried out because otherwise the land could be declared unused and non-productive, and could be claimed by landless peasants for their own purposes outside the reform programme. When the land tenure is insecure, as it is in ejidos where settlers have not yet demarcated their lands, the successful introduction of agricultural improvements is a difficult task.

Although the region is part of a protected area since 1980, it lacks any official land use or management plan and no measures have been taken to address the destruction of natural resources nor of the poverty that is a consequence of the use of non-sustainable agricultural models. Even when the responsibility for land use planning was left to the Ministry of Agriculture, this agency continued to support programmes that allowed further expansion of cattle ranching.

As a result, current activities totally disregard land use capability. Lands were still given out to peasants, even after the 1980 conservation decree, without any special management plan for sustainable agriculture. Although no watershed management programmes have been put forward, water catchment infrastructures have been installed to extract water for industry and cities in the lowlands. Moreover, after less than 10 years since their installation, sedimentation has reduced their capacity to nearly half.

Because of extensive cattle raising and the unregulated use of land for grazing, deforestation, soil erosion and the loss of regional self-sufficiency in maize production has taken place. Most of the pasture lands, occupying 58 percent of the total land area, are either on prime cropland or on steep hillsides with a very wet climate. From 1967 to 1986, deforestation averaged between 2350 and 3600 hectares each year. Destruction of the forest by uncontrolled fire has been a major cause of deforestation (14 percent of the total forested area). Some 26 000 ha remain of 81 170 ha that existed only 35 years ago (Ramirez 1992). This destruction of tropical forests is not an exception but rather a reflection of what has happened worldwide. In the whole country only 2 million ha remain of the original 22 million ha of tropical forest.

Main constraints for agriculture and transformation of agricultural systems

The main physical constraint for agriculture in the forested nucleus and surrounding forest margins is the topography. In this 23 584 ha area, which is nearly a third of the declared biosphere reserve, 28 percent of the land has a slope greater than 21 percent and is therefore highly susceptible to erosion when cultivated. Another constraint for agriculture is wind. Northerly and southerly winds blow strongly between October and March.

The average precipitation in the area is 2800 mm with a maximum of 4000 mm. However, this precipitation is concentrated over five months of the year and there is a dry period of around four months. This deluge of rain in a relatively short period can be a constraint to some crops while the dry period affects the availability of pasture. As a result, cattle ranchers overgraze marginal lands on the slopes, which in turn, suffer from compaction.

The elimination of the tree cover has resulted in erosion of the fragile soils found in the region. The expansion of cattle breeding has reduced the availability of fallow plots. The fallow period of five to six
years is now reduced to one or two (Chevalier and Buckles 1993, Buckles and Perales in preparation, Stuart 1986). Impoverishment of soils has reduced maize yields from two to three t/ha, during the rainy season, to an average of 1.3 t/ha and it is common to find villages where it is under one t/ha. In many places a winter crop is no longer possible because of loss of soil moisture and fertility and where it is obtained, productivity is reduced to about 600 kg/ha. "Shorter fallow periods have contributed to the presence of grassy weeds in the fields. Annual burning of crop residues and pastures eliminates productive ground cover and reduces soil organic matter provoking erosion and reducing the capacity of the soil to retain moisture" (Buckles and Arteaga 1993).

Agrochemicals are replacing the traditional fallow system for the recuperation of soil fertility. When the oil boom during the seventies and first years of the eighties brought better working opportunities in the cities than in the fields, peasants adopted the use of herbicides. These became a substantial part of the technical assistance given by development agencies. This technological change caused a modification in the diet of peasants because the herbicides killed many secondary plants associated with maize in traditional agricultural systems. The use of herbicides lowers the production of beans and is not sustainable as it relies mainly on government subsidies and these tend to disappear. The fall of international coffee prices and the structural adjustments policies leading to the privatization of the state agency (INMECAFE or Mexican Coffee Institute) responsible for financing small coffee producers, has also affected the peasant economy in coffee growing areas.

From a social standpoint cattle raising, the dominant agricultural practice in the region, has brought land concentration, erosion of traditional social organization and political conflicts. It accounts for most of the forest fires because of the practice of burning the grasses to hasten regrowth. Although a short term economical activity, and a technically easy one, extensive cattle raising in the tropics does not offer a long term solution to the need for sustainable development in the region. Productivity is low because a density of one to two head per hectare is a maximum. Furthermore the use of non-appropriate technology, such as no rotation and grass monoculture, is resulting in overgrazing and a build-up in pest populations that are now spreading to maize. As a result, not only is there a high ecological cost for short-term economic gain, but also the social cost is very high. In synthesis the effects of these developments at regional level are:

- the loss of the flora and fauna associated with the forests;
- a reduction in the diversity of wild or cultivated plants and changes in food habits;
- a fall in the water level in lowland streams affecting agriculture and water supplies for human use;
- a loss of self-sufficiency in corn and bean production, the basis of the peasant diet, and its substitution with imported poor quality staples; and
- the unequal distribution of economic and political resources to the detriment of most of the population.

The macro-economic context of the region's environmental and social crisis

Over the last twenty years thousands of people in the region reacted to the deterioration of their traditional economy and the crisis of agriculture by migrating on a permanent, seasonally or weekly basis to the industrial cities of the region. Unfortunately, the current worldwide economic crisis combined with the effects of structural adjustment programmes has exacerbated unemployment. In the last year, more than 50 000 people, mainly temporary workers, have been fired from the oil and petrochemical industry. The newly unemployed have reacted by emigrating further north or returning to their home villages.

Since 1982 and, in a more dynamic way since 1988, Mexico has introduced new economic policies. Those directed toward agriculture can be briefly characterized by the following features:

- sale of state owned enterprises to private firms, national or multinational;
• reduction of subsidies for inputs and for agricultural prices as the frontiers open to agricultural imports and exports under GATT and NAFTA;

• the privatization of technical assistance and the centralization under the National Solidarity Programme of subsidies directed toward social assistance and a redirection of subsidies toward consumption rather than to production; and

• changes in agrarian and foreign investment legislation intended to gradually induce the transformation of communally owned land (ejido) into private property and to attract private investment in joint ventures between peasants and capitalists.

While lands are overexploited, they can also be considered underexploited if the possibility of introducing new agroecological techniques and permanent mixed crops and plantations are considered. Against all expectations and guidelines of the neoliberal policies, the solution might be found in the countryside and in the integration of regional markets.

Proyecto Sierra de Santa Marta (PSSM): proposals for a sustainable agriculture

The Sierra Santa Marta Biosphere Reserve is an example of how wrong a conservation policy can be and shows how a simple decree, if not accompanied by adequate agricultural alternatives, is useless to protect and conserve natural resources. The main question is not only what has to be done but who will do it. Since people are not given legal, economical incentives and financial support to protect their own natural resources, these will go on vanishing. The principles that should guide agricultural policies in the region must harmonize the short-term needs of the population with middle-term conservation requirements.

The proposal for the Sierra de Santa Marta Project is based upon the natural characteristics and land use zonification of the reserve and includes conservation and development issues. To reach a greater impact upon both the inhabitants and the natural resources using an eco-regional approach, PSSM defined a strategic zone along the forest-edge. The intention is to create a buffer zone that would limit the expansion of cattle ranching and discourage the use of fire to promote grass growth and reducing the use of slash-and-burn techniques for maize cultivation. To compensate, new ecologically viable techniques, such as the use of green manure and high-value diversified cash crops will be introduced.

The expectation is that changes brought about in the agricultural practices used in the area would release the pressure on the natural resources. In principle: "On steep slopes, which are erosion prone, and along wildlife corridors there needs to be areas of minimal disturbance where the ground is not turned over on an annual basis. This would imply a system of permanent planting of mixed perennials including trees, shrubs and vines with only a few annually" (Evans 1992).

In this article the focus is on the community based agricultural alternatives rather than on the reserve zonification and regional level management planning issues. The zonification is based, on the one hand, on physical characteristics identified from both field work and from satellite images, and on the other hand, on the analysis of land use and socioeconomic data collected during a survey. The management plan, written from an earlier analysis and from ongoing projects, influences conservation, forestry and agriculture policies in the region (Paré and Velásquez 1993). The strategy considers the following aspects:

1. The main target is the recuperation of self-sufficiency in basic staples, mainly maize. The expected result is to reduce the pressure to clear more forest land for cultivation.

2. The rescue of traditional knowledge and the use of native plants, or the successful management of introduced plants, to improve traditional agricultural systems.

3. On-farm trials and the transmission of results through a peasant to peasant extension method and network.
4. To influence governmental agencies in adopting agricultural policies compatible with the environment and the economic conditions.

At the moment, the Proyecto Sierra de Santa Marta is involved in the following programmes to develop this strategy.

**Basic staples self-sufficiency and soil conservation programme**

a) **Green manure**

Figure 1 shows the role green manure can play in the alleviation of the problems associated with maize production. This programme uses traditional knowledge. Buckles and Perales (in preparation) discovered that peasants from one specific area have been using velvet bean (*Mucuna deeringiana*) as a fallow crop to fertilize the soil, eliminate competing grasses and to retain soil moisture. The peasants had developed three practices: use of the bean in rotation during the wet season with dry season maize, in abandoned fields to enhance the fallow period and intercropped with wet season maize for mulch production at the end of the rainy season for use by a dry-season crop.

In this last case, a period of more than 60 days passed after sowing the maize before the bean was sowed so that the maize would not suffer from competition with mucuna. On-farm trials were carried out over two years to establish the optimum date for intercrop management of mucuna and to train the peasants in the basic principles of experimentation. The benefits in the winter cycle are more obvious as it is feasible to obtain a crop where lack of soil moisture made it impossible before. To widen the use of mucuna as an intercrop with maize, an extension campaign was designed. Although increases in soil nitrogen are not yet observable, peasants have shown a great interest in the adoption of the technology as they have seen other benefits such as weed control and labour saving and also retention of soil moisture. Over a two-year period, 1164 peasants from 29 villages have used the velvet bean to improve their maize production. This number represents half of the peasants present at the assemblies where the programme was presented. Meredith Soule's study on the adoption of the technology show that 82 percent of those who were followed up (225) by the project promoters used the legum and 50 percent of those who received it in a village assembly, introduced it to their fields (Soule 1993). The cost of the extension campaign was of USD10000 for a two-year period, which amounts to USD50 per peasant. Including those who were not followed up, the average cost per peasant was USD24. This is equivalent to the loan given to peasants by government agencies for agrochemical purchases (Buckles per. comm.). The difference is that with green manure the investment has to be done only once in the same field or with the same peasant and that the positive effects are cumulative.

Experiments are under way with other legumes as *Canavalia ensiformis* (broad bean), *Vicia sativa* (clover) for higher altitudes or *Vigna umbellate* (cowpea or rice bean) for more humid or partly water logged soils. The reasons why the green manure programme is a mainstay of the Sierra Santa Marta Project are:

- its use would gradually result in the elimination of the slash and burn practices;
- it could stabilize the milpa or maize plot without the need for opening new lands to cultivation or the working of short-fallow land;
- it can increase productivity from one t/ha to an average of five t/ha;
- a second crop per year becomes possible;
- it is a low input technology in comparison with the subsidized techniques that rely heavily on agrochemicals, fertilizers and herbicides; and
- it reduces soil and river pollution with agrochemicals.
The results from this programme are going to be discussed next March at a workshop organized by CIMMYT on maize policies. The participants will include decision makers from federal and state levels of government. The purpose of the meeting is to producing changes in their technological outlook and to introduce agroecology practices as part of their agricultural programs.

b) Hedgerows

In Mesoamerica terracing with live barriers and stones was common (Rojas 1988). In the region discussed here, the division of fields with rows of pineapple as an erosion control technique has been observed. However, today it is common rule to see slopes of over 100 percent inclination cultivated on the direction of the slope and without any barrier. Hedgerows with different plants, mainly madre del cacao o cocuite (Glyceridia sepium) are being established at the experimental level to control or prevent erosion.

c) New maize varieties

Experiments with new maize varieties address the problems created by the six-month long interval between rainy seasons combined with the use of tall local varieties that do not resist the windy conditions. These aspects of the environment have been worsened by the displacement of the population to higher areas and the greater effect of high winds caused by deforestation. As the idea is not to replace the local maize, peasants are trained to select their maize seeds in the field, rather than from the stack at home.

d) Family-farm management

The training of women to produce beans and vegetables in their back yards is also part of the global strategy to diversify production and improve nutrition and self-reliance.

The Management of fallow land

Traditionally fallow areas, even when abandoned to recover fertility, were not considered unproductive but were areas where it was possible to obtain game, firewood and fruit. Totonac Indians in Papantla used it for vanilla production during a seven year-long fallow period. In the Sierra de Santa Marta, since vanilla was known as a wild plant of the rainforest and used for cosmetic purposes, financing of this cultivated cash-crop on fallow plots is supported. Apart from its ecological benefit the use of vanilla could provide additional income to the family economy.

Another management technique, which was developed by people from a community where most pasture land is now unproductive, is to sow cassava in the fallow plots as a feed for pigs. In this way a new and more intensive small-husbandry model can replace extensive cattle raising.

Diversification of coffee production

To address the fall in coffee prices since the quota system of the International Coffee Organization was abandoned, efforts are being made to maintain the coffee orchards and their shade trees so that they are not turned into pastures. Alternatives include growing chamaedora palms in the shade of the coffee trees. The collection of such plants as *Piper auritum* and *Pimenta dioica* or allspice for the production of a herbal tea, to be exported to the American market, brings some cash to village families twice a year. The collection of latex from the tree, *Croton draco* (Euphorbiaceae), for its exportation to a pharmaceutical company that shares conservation objectives is under study.
The management of forest and wetland resources

The degradation of soils suitable for maize production and competition for the land from cattle grazing has driven a greater part of the population, mainly that of the villages on the forest edge, to exploit sources such as palms and birds to such an extent that their reproduction is in danger. The money obtained from the sale of these goods is used to buy the maize and beans that the farmers do not produce anymore. Obviously any strategy to protect the natural resources must aim at recovering self-sufficiency in basic food staples.

Workshops and negotiations are being organized among communities to arrive at a regulated management of the chamaedora palms, the birds, the crabs and the mangrove wood. The difficulties of creating an institutional framework for a sustainable livelihood lie in the lack of organization at the village level and also contradictory interests between villagers and among villages. The traditional way of life was spiritually based and was rather an individual concern sanctioned by religion. The parameter for the extraction of resources was the satisfaction of subsistence needs. The introduction of market forces has brought together the disruption of this value system that has not been replaced by new cultural norms. The depletion of natural resources either by outsiders or by local people cannot be resolved within the existing institutional framework. Government interest in this matter is a combination of lack of concern, corruption and bureaucratic inefficient measures.

Reforestation and forest management

In general there is no tradition of forest management in this region of Mexico and afforestation has to go through a process of estimating and considering the importance of giving back that which has been taken from nature. Traditionally logging was not perceived as a destructive activity but as part of the natural cycle of the death necessary for rebirth (Jacques Chevalier personal communication). Peasants in the area still harvest individual trees from the old growth forests surrounding their communities without the permits required by the Forest Service, an activity that may have decreased in recent years. This timber is used for housing, fencing or is sold outside the Sierra. Unfortunately, government officers often act as intermediaries in this business.

The problem stems from an erroneous belief by the authorities that repressive measures (denial of cutting permits and fines for infringement) will save these forests. The inflexible execution of this policy denies the local communities control over their perceived resources. Illicit cutting and even outright deforestation without use of the timber (e.g., land clearing followed by burning of the slash) are among the consequences (Tosi 1993).

Contradictions exist between federal and state forestry agencies. While the federal forestry agency does not do enough to prevent deforestation and clandestine logging, the state agency tries to promote a forestry culture inviting the population to plant trees that they can cut later as the product of their own efforts. Reforestation programmes on a plantation basis or in an agroforestry plot, were initiated in some communities with support from the Project and the state forestry agency. People are fully aware that the time has come to return what they have destroyed. This programme was started as a response by the Project to the pretensions of a North American company to establish eucalyptus plantations in the region. Opposition arose because the plantations would have been established on good lands, necessary for food production. Furthermore the economical offer was of no interest to the people who would have received less income than what they actually make with their maize agriculture or cattle ranching. Apart from reforestation, the project considers that selective forestry management is necessary to control illegal logging and to give value to areas of pine and oaks that are regularly burnt for pasture.

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1 The trees are obtained at a state nursery and include Meliaceae cedar (Cedrela odorata or mexicana) and mahogany (Swietenia macrophylla, Combretaceae (Terminalia amazonia), and Bignoniaceae (Tabebuia rosea). Meliaceae face pest problems (hepsiphila) and require work that peasants are not always able to provide.
The solution to this problem will require a reversal of public forest policy and the reeducation of well-intended conservation movement militants. It will require that a natural forest management programme based on sustained yield timber production be put into place concurrently with the lifting of arbitrary police controls. Total volume extracted should not exceed that grown in any year (Tosi 1993).

Land tenure problems, the slash and burn technique and especially the practice of burning pastures is a major restraint to a large-scale reforestation programme. In parts of the area, although plots are temporarily under individual usufruct, they are still under communal ownership, that is, not parcelled out. This circumstance is not an incentive to plant trees because they will not bring private benefit when land rights are not guaranteed. After an uncontrolled fire has destroyed a small plantation, peasants often loose interest in reforestation.

Reserved areas for reforestation and agroforestry projects should be established, not only in the buffer zone, but in particular along the streams in the water catchment areas. In these areas, individually usufructed parcels make global planning difficult. This problem is worsened by government programmes that do not establish strategic targets from an ecological standpoint. The logic seems more political rather than ecologically based.

**Community participation in decision making**

Regional development programmes have mostly been designed from the outside and fail to consider neither the natural characteristics of the region nor its social needs. The distribution of land previously occupied by native people or located on unaccessible sites is just an example. Within the actual political system, characterized by a lack of democracy and control by economical and political elites at all levels, it is not easy to achieve communal participation in decision making. When successful, it is often challenged or denied by political structures at national and international level.

Weakened traditional structures have not been replaced by new social institutions involved in regional or local planning. Although cattle ranchers' organizations have powerful links with outside politicians and policies, they deal strictly with animals and sales registration for income tax purposes and with financing. Coffee growers form organizations to receive credit and channel the villager's requests for assistance to government development programmes that might or might not respond. These are more concerned with basic infrastructure works (water and electricity) and welfare programmes (education and health) than with food production. In many villages religion and politics strongly divide people into different groups.

As most issues are excessively politicized and, to maintain a plural programme, PSSM has chosen a strategy that encourages the formation of mixed groups, collaboration with local authorities when possible or necessary, and with other government programmes when convenient. It is within this context of institutional constraints on one side and internal problems within the villages that efforts are made toward developing sustainable agriculture and management of natural resources.

Figure 3 synthesizes the type of problem within the actual institutional framework and the character of our interventions and challenges towards a new institutional design. Expected results are also mentioned. An ecologically sound and equitably based development programme is not only a technical question but a social and political one. The project is not only searching for adequate productive alternatives but for the participation of people in the decisions over their resources. Planning has to become the concern of the communities themselves.

**References**

Taller sobre los métodos participativos de investigación y extensión aplicados a las tecnologías basadas en los abonos verdes. Caminos hacia la colaboración entre técnicos y campesinos. Catemaco. Ver. marzo de 1993. CIMMYT.


Evans I. 1992 Trip report to Sierra los Tuxtlas, Veracruz, Manuscript.


Ramírez R.F. 1992. Mapas de vegetación y de deforestación de la Sierra de Santa Marta. Xalapa, Mexico: Sistema de información geográfica del PSSM.


Rojas T. 1988. Las siembras de ayer. La agricultura indígena del siglo XVI. SEP CIESAS.


Sustainable Upland Agriculture Through the Eyes of the CIAT Hillsides Agroecological Programme

by

E.B. Knapp, J.A. Ashby and P.G. Jones

Introduction

The conceptual approach of defining agroecoregions for aiding priority setting by the International Agricultural Research Centres (IARCs) is not new. For many years the commodity programmes at the Centro Internacional de Agricultura Tropical, Cali, Columbia (CIAT), defined crop improvement priorities based upon collective knowledge ranging from photoperiod and temperature requirements to pest and disease pressure to market preference.

With the organization of the Agroecological Unit at CIAT in 1983, the heuristic approach of the commodity programmes was formalized and improved through digital characterization, categorization and mapping. Environmental and system variables like climate and soil properties were made explicit and were combined with "dot density" thematic maps to assess the distributions of crop by constraint (see tables 1 and 2). The results were state-of-the-knowledge inventories on a continental scale in the form of published crop atlases as well as GIS coverage (CIAT 1992).

A second strategic use of agroecological zoning by CIAT commodity programmes, was to compare and contrast commodity environments. An example of this is the project defining homologous cassava regions across Africa and Brazil (P. Jones per. comm.). Commodity focused agroecological zoning has also been used to characterize, categorize and map more desegregated geographical scales or micro-regions. An example of this is the International Development Research Centre (IDRC) funded Paraguay cassava project (Carter 1986).

CIAT's hillside agroecological programme

Arguably the most ambitious CIAT agroecological zoning project has been the characterization, categorization and mapping project that resulted in the creation of three new agroecoregional

Table 1 The second approximation of rice distribution in Latin America by the season length (number of consecutive wet months where $P>1.2$ PET).

<table>
<thead>
<tr>
<th>Wet Months</th>
<th>Irrigated</th>
<th>Lowland Rainfed</th>
<th>Mechanized (Manual)</th>
<th>Traditional (Manual)</th>
<th>Frontier (Manual)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>187</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>4</td>
<td>209</td>
</tr>
<tr>
<td>1 to 3</td>
<td>216</td>
<td>16</td>
<td>89</td>
<td>48</td>
<td>5</td>
<td>374</td>
</tr>
<tr>
<td>4 to 6</td>
<td>956</td>
<td>328</td>
<td>1699</td>
<td>519</td>
<td>291</td>
<td>3793</td>
</tr>
<tr>
<td>7 to 9</td>
<td>788</td>
<td>40</td>
<td>1586</td>
<td>202</td>
<td>404</td>
<td>3020</td>
</tr>
<tr>
<td>10 to 12</td>
<td>546</td>
<td>25</td>
<td>160</td>
<td>29</td>
<td>44</td>
<td>804</td>
</tr>
<tr>
<td>Total</td>
<td>2693</td>
<td>417</td>
<td>3540</td>
<td>802</td>
<td>748</td>
<td>8200</td>
</tr>
</tbody>
</table>
programmes: the Hillsides Forest Margins and Savannas Programmes (Jones et al. 1991). The goal of the Hillsides Programme is to improve the welfare of farming communities, located on hillsides, by developing suitable sustainable, commercially viable agricultural production systems. Income-generating activities that permit capital accumulation and agricultural intensification, while conserving soil and water resources, are the key to resolving the environmental problems of hillside communities. Numerous technologies to conserve soil and water exist but farmers seldom adopt them without policy inducements. Studies to identify instruments for policy adoption will be a necessary adjunct to technology development in the field.

Given the complexity of the socioeconomic, technical and environmental problems associated with hillsides, initiatives to improve their natural resource management must be part of the overall regional development plan that includes agricultural and nonagricultural activities. This requires strong interinstitutional and intersectorial cooperation to permit accurate identification of the problems and deployment of adequate staff and other resources for their solution. Many other organizations, especially NGOs, already have activities with hillside communities. As a result, development of appropriate models for interinstitutional collaboration to maximize impact is an important feature of the programme’s agenda.

The objectives of the Hillside Programme are:

- to characterize the mechanisms leading to resource degradation and assess technological options;
- to generate agroecologically and economically viable components acceptable to farmers for soil and water conservation and management practices; and
- to strengthen the capacity of national systems to generate and transfer resource-enhancing technology.

### Hillside resource degradation evaluation

The most recent ecoregional characterization and mapping activity carried out for strategic planning purposes by the newly created CIAT Land Use Programme (LUP) and the Hillsides Programme was an assessment of the state of degradation of the hillsides of tropical America. The definition of hillsides was extended from the original restricted one used for the natural resource planning exercise (see Appendix 1). This was necessary to give a broader overview of the problems in Central America and the Andean region.

All land between 800 m and 2000 m was included with the exception of the highlands of Brazil, Chile, Argentina and the Guyana shield and areas with less than 3 growing season months. The image
of rainy months (rainfall >60 mm) was calculated from the CIAT climate database. An image of soil depth was calculated from the image of dominant FAO soil units held in the database in conjunction with tables of soil properties developed by LUP. The levels of degradation were estimated from the World Map on the Status of Human-Induced Soil Degradation (UNEP/ISRIC 1990). This map was digitized and transposed to geographic coordinates. Images of the various types of degradation were formed. These were analyzed to extract and tabulate the areas involved in water, wind and chemical degradation at various levels of severity. Also extracted were the base causes of the degradation and the rates of degradation in the recent past.

Of the 92 000 000 ha identified as hillside in this study, erosion by water was the most important negative effect upon soil stability. Very small areas that were effected by wind erosion or chemical deterioration were noted. Moderate water erosion, which strongly reduces agricultural productivity but which can be corrected at the farm level, was found to occur on 14 000 000 ha. Strong water erosion, unreclaimable at the farm level, accounted for 11 600 000 ha. Altogether some 26 percent of the total area was subject to serious erosion. The main causes of land degradation leading to erosion were equally deforestation, overgrazing and agricultural activity.

Hierarchical agroecosystem analysis

The evolution of the agroecological work carried out by the original Agroecological Support Unit and the newly created Land Use Programme was driven by an internal CIAT demand for decision support information. Recently, however, CIAT, and particularly the Hillsides and LUP programmes, have begun to organize some of their information requirements based upon hierarchical ecological systems theory. This theory hypothesizes that natural systems are organized hierarchically and that sub-systems are coupled or linked by asynchronous rate processes. The practical consequence is that lower level processes determine the potential of higher level systems while higher level processes constrain lower level system behaviour (Levin 1992, Bradley 1991, Müller 1992).

The authors' particular interest in hierarchically systems theory evolved from years of observations that, when carrying out on-farm commodity constraints research, significant production responses at the plot level could often be demonstrated and yet farmers did not adopt the component technologies. One of the reasons is now well known. Farmers are responsible for making decisions at a "higher" system level, the farm level. In simple hierarchal system theory terms, what happens at the "plot" level has an almost immediate impact on a farmer's potential income. However, at the farm-system level, there are multiple objectives for land, labour and capital that may constrain or limit the adoption of production-increasing technologies. It may be that, after observing the apparent success of a few innovative farmer-neighbours, the innovation is tested and adopted. If there is widespread adoption, the farm system may actually shift to a new state or "land utilization type" (LUT). The above observation has now become common knowledge although its formalization through hierarchical theory remains to be done.

For the CIAT Hillsides and Land Use Programmes, the conceptual extension of hierarchal systems theory to higher agrosystems seems intuitively obvious. Specifically, individual farms are components of a system that can be characterized as a LUT. A hillside watershed of 100 000 ha may be made up of several component LUTs. Higher level sub-systems can be defined on up to and including CIAT's definition of hillsides, which is itself a subsystem of a Latin American agroecosystem. The question is: Where does all this lead with respect to our understanding of sustainable resource management?

The simple answer is that concomitant with a hierarchy of geographic scale is a hierarchy of multiple decision makers and by implication, a hierarchy of multiple objectives and information needs. For example, crop management requires information at the individual plot scale while watershed managers are generally satisfied with information about stream quality and flow for catchments of at least 100 000

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1 A LUT is a definition of land use in greater detail than usual (FAO, 1976). A LUT consists of a given physical, economic and social setting, e.g., including assumptions on market orientation, capital and labour intensity, technical knowledge and attitude, land tenure and income.
which is generally more susceptible region around from CVC that clearly shows the relationship between conflicting uses for water for the management and technical assistance Regional Programme Water is arguably Watershed characterized which may eventually determine resource available for cassava production not productivity sustainability of different cassava production technologies This knowledge in and of Hohenheim and CIAT, hierarchal systems theory, levels system as suspended sediment of of of to estimate the soil loss by water erosion, it is possible that as little as five to ten percent of the mobilized sediment actually leaves the system as suspended sediment (Jenny 1980).

A much more challenging, and potentially much more rewarding application of the concepts of hierarchal systems theory, is to test hypotheses relating to the processes that couple or link the different levels of subsystems and actually form and define the behaviour of the system. In the specific case of CIAT, a long-running, commodity oriented soil conservation project carried out by the University of Hohenheim and the CIAT Cassava Programme has resulted in greater understanding of the relative rates of soil loss by water erosion under different small scale cassava management strategies (Reining 1992). This knowledge in and of itself is useful and some general projections about the sustainability of the different cassava production technologies can be proposed.

On the other hand in the CIAT watershed study area, which is in the northern part of the Department of Cauca in southwest Colombia, cassava covers about 2.5 percent of the non-forested area (UMATA 1992), which is not to suggest that it is not of vital socioeconomic importance. The point is that the sustainability of cassava as a component in the land use system may have less to do with the loss of productivity of cassava plots, due to erosion, and more to do with the quantity and quality of the water resource available for cassava production not to mention for domestic needs. The water resource issue, which may eventually determine the sustainability of cassava production, can only be understood at the higher level of the catchment system. In the case of Hillsides agroecosystems, catchment areas are characterized by their heterogeneity of land use.

**Watershed systems and sustainability**

Water is arguably the dominate factor in agricultural production. By that fact alone, water is a resource of utmost social importance. Water, however, has multipie and often conflicting uses. The CIAT Hillsides Programme works closely with a local regional government organization, Corporación Autónoma Regional del Cauca (CVC), which is responsible for hydroelectric generation, natural resource management and technical assistance to the agricultural sector among other things. Table 3 presents data from CVC that clearly shows the relationship between conflicting uses for water for the geographic region around CIAT. Also notable is the dependence, particularly for domestic use, upon surface water, which is generally more susceptible to contamination by land misuse.

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Table 3 *Actual water in use in the jurisdiction of C.V.C*

<table>
<thead>
<tr>
<th>Use</th>
<th>Surface Water</th>
<th>Ground Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>litres per second</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>147661</td>
<td>100825</td>
<td>248486</td>
</tr>
<tr>
<td>Industrial</td>
<td>4943</td>
<td>9082</td>
<td>14025</td>
</tr>
<tr>
<td>Domestic</td>
<td>11755</td>
<td>4391</td>
<td>16146</td>
</tr>
<tr>
<td>Energy generation</td>
<td>150986</td>
<td></td>
<td>150986</td>
</tr>
<tr>
<td>Other</td>
<td>6527</td>
<td></td>
<td>6527</td>
</tr>
<tr>
<td>TOTAL</td>
<td>321872</td>
<td>114298</td>
<td>436170</td>
</tr>
</tbody>
</table>

ha in area. Credit lenders work within guidelines that may best be characterized by land utilization type while national policy decisions require information at a much more aggregated scale.

The point is that the information must be internally consistent, albeit in greatly varying detail. For example, detailed studies of erosion losses at the standard Wischmeier (1959) field plot scale of 22 m by 11 m may indicate potential losses of up to 100 t/ha/yr but it is naive to extrapolate those results to estimate the social costs and consequences of sedimentation mobilization and transport at the scale of watersheds of even a few tens of hectares. With no wish to diminish the importance of the social costs of erosion, it is possible that as little as five to ten percent of the mobilized sediment actually leaves the system as suspended sediment (Jenny 1980).
The geographical limits of watershed drainage systems vary tremendously in Latin America from as little as a hectare to as much as the Amazon system which drains half the continent. In order to make in-depth study feasible, the CIAT Hillsides Programme has selected the 106,000 ha Rio Ovejas watershed in southwest Colombia as a primary research site. The Rio Ovejas watershed is typical of many hillside agroecosystems in the Andes. Primary environmental characteristics include steep topography, microclimate variability and ecological complexity. Secondary environmental characteristics include microclimatic niches high in biodiversity and environmental risk. Socioeconomic characteristics include low resilience, poor physical accessibility and transportation, decentralized economies prone to marginalization but at the same time rich prospects for the use of ecological niches. Culturally, the inhabitants are sensitive to ecological variations and they have a good functional knowledge of local environments. The population density of the watershed is estimated at 48 persons/km².

The Rio Ovejas currently drains into the Rio Cauca forming part of one of the most productive interandean valleys in the Andes. In 1990 a plan was accepted by CVC to divert the Rio Ovejas at a cost of US$25M so that it would flow into a reservoir used for hydroelectric generation. At the same time another regional government organization had developed a small irrigation district for 15 small farmers in the region with prospects for constructing more systems. This has the potential of greatly increasing the productivity of parts of the watershed. No one seems to have noted the fact that water transpired by irrigated crops will not be available to generate hydroelectric power.

Vegetation management is the key to understanding and managing the hydrological cycle at any watershed level. Temporal and spatial organization, however, is more important than the relative proportion of the vegetative components of the system. This is simply a way of saying that a watershed is more than the sum of its individual parts: it is an agroecosystem. Unfortunately a lingering and legitimate criticism of the agroecosystems approach to research is that it promotes examination of all interrelated properties with the result that it delays practical solutions to problems and that the solutions proposed are too complex to be adopted. The CIAT Hillsides Agroecosystem Programme hopes to avoid those pitfalls by improving and expanding farmer participatory research on environmentally friendly agriculture and sustainable resource use.

Farmer participation in resource management research

An issue specifically addressed by the CIAT Hillsides Programme is how to improve the adoption by farmers of conservation practices via the development of participatory research and development approaches. One study for which we have results, was the assessment of the acceptability by farmers of conservation technologies already available and promoted by local NGOs.

It is axiomatic that environmental degradation is a serious problem wherever rural poverty, population growth and land degradation lead to further impoverishment of environment and society in a familiar vicious circle (Blaikie and Brookfield 1987). When the private benefits of conservation practices are too delayed or minimal for farmers to adopt them, because poverty imposes a short-term horizon on farmer-decision making, then environmental degradation is the long-term result.

The range of technological options for improved land management available to the extension worker and to the farmer is very wide. They range from reforestation and agroforestry, to contour earth structures, grass strips, contour cultivation, ground covers and a wide range of combinations of these practices. Yet, in many situations, usually the most critical in terms of degree of degradation, these established practices are not being adopted by resource-poor farmers. A number of other experiences described in the literature (Bellows 1992, Rist 1991, Ashby 1985, Barbier 1990, Barrow 1991, Fujisaka 1989 and 1991, Moldenhauer 1988, Napier et al. 1991, Rivera and Gomez 1992) show that key elements of success in promoting the adoption of conservation practices among resource-poor farmers include:

- farmer-to-farmer transfer of information about practices;
- technology thoroughly evaluated and adapted to local conditions by farmers (without this, farmer-to-farmer transfer cannot be achieved);
• local participation in the design of recommendations, transfer strategies, subsidies and regulatory controls;

• creation of a new opportunity, or reinforcement of an existing opportunity to invest in improving production, income, labour-use, livelihood security or some other objective important locally, via the use of the conservation practices in question; and

• attention to, and if necessary, intervention in marketing, in particular farm-gate prices or policy that affects these, which may vitally assist or impede the investment strategy referred to above (Laing and Ashby 1993).

One reason for lack of adoption may be that technical recommendations for soil conservation have been designed to maximize conservation resulting in additional costs to farmers and a negative cost-benefit ratio. One way to improve adoption might therefore be to adapt existing techniques to achieve a trade-off acceptable to farmers (i.e., less than maximum achievable conservation but greater utility to farmers).

A study was carried out in the Rio Ovejas watershed assessing the potential use of farmer participatory research as a methodology for adjusting and increasing the adoption of soil conservation techniques. Specifically the study addressed the question of whether, using participatory evaluations made by farmers, adjustments could be made to recommended techniques for soil conservation that would increase their adoption.

Study site

This study was carried out in the Rio Ovejas watershed in Cauca, Colombia, where for ten years or more, the regional governmental organization, CVC, and the Coffee Federation have recommended Cassava growers to plant live barriers incorporating Citronella (Cymbopogon nardus) and Limoncillo (Cymbopogon citratus). A survey of the entire population of farmers who could be identified as users of this technique in three principal municipalities of the watershed, where cassava is an important crop, was carried out in 1991. The survey identified twenty-two farmers using live barriers and showed that in all except two cases, use was associated with receipt of credit and/or technical assistance. Virtually no spontaneous adoption of live barriers was occurring (i.e., no barriers were planted without associated credit or extension assistance being provided).

Methods

Extension agents of the CVC were trained in methods of participatory evaluation with their agreement to suspend recommendations and to allow farmers flexibility in determining whether and how to establish live contour barriers. The method of preference ranking was utilized to obtain an acceptability score for ranking a number of optional materials, which in addition to Limoncillo and Citronella, were being tested for incorporation into live barriers in an on-farm trial at Mondomo by the CIAT cassava programme. Farmers asked to participate in the evaluations were initially selected by local agricultural research committees (CIAL) as individuals potentially interested in improved soil management practices.

After the first round of evaluations by these farmers, participation was voluntary. Farmers were taken to the on-farm trial where preference ranking of materials was conducted after they had spent time examining the trial and discussing the characteristics of the optional materials using information supplied by the extension agents who were taking part in the interviews. Farmers had the option to select one or more materials for experimentation on their own farm and to determine the location, spacing and extent of their experimental barrier. After the first round of evaluations, materials for live barriers were sold to farmers at cost with the agreement that they would give other farmers seed planting material, if requested, for a period of up to one year. Follow-up visits were conducted by extension agents to observe the establishment of barriers and to conduct a second evaluation interview. These interviews asked whether or not farmers had extended their barriers voluntarily and if a farmer had supplied seed material to others. Spontaneous adoption was monitored by following up farmers who were planting live barriers...
Table 4  Ranking of optional materials for incorporation into live soil conservation barriers and area sown by farmers, 1992-3, Cauca, Colombia

<table>
<thead>
<tr>
<th>Material</th>
<th>Acceptability Score (1992)</th>
<th>Area planted 1992-3 (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasto Telembi</td>
<td>93</td>
<td>37,865</td>
</tr>
<tr>
<td>Sugar Cane</td>
<td>67</td>
<td>9090</td>
</tr>
<tr>
<td>Citronelía</td>
<td>51</td>
<td>1920</td>
</tr>
<tr>
<td>Pineapple</td>
<td>40</td>
<td>1060</td>
</tr>
<tr>
<td>King grass</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Limoncello</td>
<td>23</td>
<td>1600</td>
</tr>
<tr>
<td>Vetiver</td>
<td>6</td>
<td>600</td>
</tr>
</tbody>
</table>

at the recommendation of participants in the evaluation interviews. A total of 75 farmers were interviewed.

Results

The first round of evaluation interviews produced the preference ranking of materials shown in table 4. Although Vetiver grass is technically the best option in terms of soil erosion control, it was ranked in last place by farmers, who preferred a cut-and-carry forage grass, pasto Telembi (*Axonopus scoparius* var. Telembi), for incorporation into live barriers. Interviews showed that farmers' criteria for accepting live contour barriers were primarily related to the short-term utility they could obtain from materials included in the contour barriers; to the rapidity with which plants in barriers established (the more rapid the better); and to the degree of competition with the associated crop. Farmers also observed that barriers helped to retain soil moisture. Furthermore, farmers chose to locate conservation barriers in relatively good soil, as opposed to poor, degraded soils.

The length of contour barriers planted by farmers in 1992-3 is shown in table 4. It includes the 75 farmers interviewed and an additional 46 farmers who are experimenting with live barriers as a result of the participatory evaluations. The ranking of materials with respect to length planted is similar to that obtained from the preference ranking interviews, showing that this technique provides a reliable picture of farmers' decision-making.

Follow up of the 75 farmers interviewed showed, as summarized in table 5, that 39 percent had decided in 1993 to repeat the practice in another plot. An additional 29 farmers had implemented the practice as a result of a recommendation by another farmer independent of contact with extension agents.

Table 5  Spontaneous adoption on live barriers 1992-3 by farmers, independent of extension intervention

<table>
<thead>
<tr>
<th>Farmers planting barriers:</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>repeating practice in another plot</td>
<td>29</td>
<td>39</td>
</tr>
<tr>
<td>via farmers recommendation</td>
<td>29</td>
<td>39</td>
</tr>
<tr>
<td>via independent initiative</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>75</td>
<td>100</td>
</tr>
</tbody>
</table>

- 41 -
The follow-up exercise identified another 21 farmers planting live barriers on their own initiative without extension contact or a recommendation from farmers participating in the interviews.

In summary, a process of spontaneous adoption appears to have begun. Credit programmes requiring live barriers also increased their activities in the same period and the number of farmers planting these with credit increased to 42 in the same period. Thus the number of farmers adopting the practice without credit incentives (N=75) exceeded the number adopting with a credit incentive.

Conclusions

The results to date show that participatory evaluations of soil conservation techniques can be a powerful tool for improving rates of spontaneous adoption, if farmers' criteria for acceptability of optional techniques are taken into consideration. In this study, a forage grass was found to be acceptable to farmers who were uninterested in materials previously recommended for live barriers. Once this material was made available, the number of users increased from 22 to 121, a five-fold increase, in three planting seasons. This included 75 farmers who adopted the technique spontaneously without direct intervention by extension agents. This result suggests that there may be significant, unrealized potential in the existing array of technologies for conservation, which have hitherto meet with little success in terms of farmer adoption, a potential that could be unlocked by involving farmers in research to identify acceptable adaptations. The development of multiple stakeholder, community-based organizations. The concept of hierarchal ecological systems theory developed with a strong biophysical bias. Likewise, definitions of sustainability for agriculture typically focus on the biophysical dimensions of productivity and resource conservation, while the human dimension is captured in economic terms, such as the concern for intergenerational equity (Harrington 1992). Reflections on the usefulness of the concept can be found that completely overlook the organizational implications (eg., Dixon and Fallon 1989). Others, however, recognize that the sustainability concept involves the reorganization of social institutions and that institutional innovations are the key to solving the problem of overuse of common property resources (Lynam and Herdt 1989). It seems likely that in order to build a consensus among a group of decision makers with multiple objectives, innovative structures that include all interested stakeholders will have to be developed.

As an example, one of the major issues is the organizational requirements for research that involves a search for alternatives to the increased use of agrochemical inputs. As Lynam and Herdt (1989) point out, the demands on research capacity will necessarily be larger than in the past because sustainable alternative technologies are “environmentally sensitive and require in-situ adjustment” Nowhere is the requirement for micro-level, in-situ adjustment of technology more exacting than in hillside agroecosystems characterized by great edaphoclimatic and sociocultural diversity.

Increasing the demand for adaptive research capacity to meet a sustainable agricultural research agenda, at the same time that international and national systems are radically down-sizing, implies a need for a fundamental reorganization of research to meet this demand. Innovative approaches to organizing for sustainable agriculture are likely to require attention to features of sustainable systems that are recognized with respect to the biosystem and which can be translated into organizational terms. For example, system diversity needs to be improved in terms of the types of organizations that are brought together in a system for adaptive research. Improved energy cycling, in terms of the efficient use of human skills and more rapid flows of information, which regulate feedback mechanism within and among diverse institutions, are all likely to be features of sustainable institutional systems.

Capacity for response, in organizational terms, implies improved capacity to innovate and to incorporate change. Traditional agricultural research systems in the public sector are seldom characterized by internal diversity, efficient use of human resources, rapid information flows or the ready incorporation of new ideas. Improving the capacity of research to deliver sustainable technological innovations will require the development of new ways of organizing around these basic principles.

Moreover, the adoption of alternative technologies is likely to require organizational transformations at the interface between research systems and users. Conservation technologies, especially in the context
of hillside watershed management, may generate positive benefits (such as improvements in the quantity and quality of water) that elude individual farmers but may be captured through collective organization. An example is an Integrated Pest Management (IPM) system that requires coordinated action by groups of farmers to achieve effective pest control that is economically attractive to the individual.

The Hillsides Programme is attempting to identify strategic principles of organizing for sustainable agriculture from a case study based on action research with a group of institutions in the Río Ovejas watershed.

Methodological approach

The case study involves monitoring the process of institutional changes, and the relationship between such changes and the transformation of resource management in a pilot micro-catchment area, the Río Cabuyal, selected by the institutions concerned. The micro-catchment area covers approximately 3200 ha, where an estimated 1000 families, mostly small farmers reside.

The process of institutional innovation being implemented, aims to incorporate some of the principles referred to above. For example, increasing the diversity of functional linkages among institutions; introducing mechanisms for changing the characteristics of information flow among different points in the institutional system; and introducing new ways of bringing complementary resources together to perform tasks around commonly defined objectives. Integral to the approach is the introduction of institutionalized mechanisms for the participation of community-based organizations in planning and implementing adaptive research.

Activities and progress to date

A workshop of the more than 50 organizations with programmes in Río Ovejas, held in 1992, led to the organization of a local consortium: Consorcio Interinstitucional para Agriculture Sostenible en Laderas (CIPASLA). In March 1993, a planning workshop was conducted in which key institutions, including NGO, GO and community leaders, identified common objectives and joint projects to achieve them. An organizational framework was developed with an interinstitutional steering committee, a coordinator to manage projects and a committee representing community organizations. The consortium began to implement joint projects in August 1993.

Monitoring of the organizational process shows that new roles and functions have been developed as a result of the formal association of multiple stakeholders. This in turn is related to new, horizontal (as opposed to top-down) information flows among different types of institutions and between farmers their organizations and other institutions. One effect of this improved information flow has been to generate changes in the value system so that conservation practices are being tried that are beneficial to the group even if costly for the individual. In November 1993, CIPASLA initiated an active search for information to permit its members to define a common strategy for investment linking in a coherent fashion, incentives for improved resource management with joint projects.

After training the staff of member institutions in rapid participatory diagnosis methods, 21 communities in a sub-watershed pilot study were surveyed. The results of the diagnostic survey showed that inhabitants in the lower watershed communities, where soils are severely degraded and water is scarce, gave the greatest importance to natural resource degradation problems. In contrast, upper watershed communities where ecologically damaging slash-and-burn agriculture is still practised, gave problems in health and education more importance than natural resource degradation. The results of the survey were utilized by CIPASLA to promote dialogue between farmers on the upper and lower parts of the watershed. Early results indicate a farmer-to-farmer transfer of conservation practices from the lower to the upper watershed. Future research will identify methods to monitor, in both quantitative and qualitative terms, the evolution of this organizational model and its impact on the acceptance of conservation practices in the study area.
References


**Appendix 1.**

In a 1993 study, the CIAT Land Use and Hillsides Programmes carried out an ecoregional assessment of the state of degradation throughout the well-watered mid-altitude hillsides of tropical America. The study defined the following land-use classes:

- hillsides with cattle and coffee on poor soils - 3.02 Mha;
- hillsides with cattle and coffee on good soils - 3.53 Mha;
- hillsides with grazing and shifting cultivation on poor soils - 7.01 Mha; and
- hillsides with grazing and shifting cultivation on good soils - 2.90 Mha.

Even at this level of classification these areas are highly heterogeneous. Natural vegetation is mostly seasonal forest although in some cases humid or pre-montane forest. A small proportion, about 10%, of this remains. Access is generally good but is least in the shifting cultivation, poor soil areas. Population is highest in the coffee areas and quite low in the non coffee poor soil region. Land distribution is uniformly skewed with approximately 80% of the farmers holding roughly 20% of the land. Isolation is generally low to moderate although poor mountain roads give long travel times in some areas. Perennial crops account for up to 30% of the area, even in the better non coffee areas. Annual crops, beans, maize, cassava, etc. are grown on 5% to 20% and between 20% to 60% of the land is in pastures. Bush fallow accounts for the remaining lands and may be from 10% to 30% depending on the area. Approximately 50% of the area can be classed as rolling with up to 40-50% steep nevertheless there is generally about 10% of the area which is flat. The biggest problems are:

1. Erosion, which is a serious problem almost everywhere due to:
   a) Overgrazing on steep pastures
   b) Fire fallow clearance
   c) Poorly managed cultivation
   d) In some case poorly managed coffee

2. Pesticide overuse is prevalent in the coffee crop.

3. Although most of the remaining forest is on steep lands, there is still pressure for felling.

4. Coffee washings are a frequent pollutant of streams and rivers.
CONDESAN: An Ecoregional Approach to the Sustainable Management of Natural Resources in the High Andes

by

Jose Luis Rueda, Hubert G. Zandstra and Hugo Li Pun

Introduction

Since the publication of the Brundtland Commission report in 1987, natural resource use sustainability has become a common objective for resource managers. Frequently it is understood to mean the sustainability of a specific resource such as agriculture or fisheries. Many definitions of sustainable agriculture exist (Ruttan 1991). The Consultative Group on International Agricultural Research (CGIAR) accepted the following definition:

The successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources (TAC/CGIAR 1987).

This definition has the advantage that it does not specify a process for using natural resources. Indeed, the sustainability of natural resources utilization is best defined in terms of identifying the options most applicable to the ecoregion under consideration and then applying them. In this way the well-being of the planet and its inhabitants will be enhanced (Zandstra 1993).

Recent emphasis on sustainability followed or sought to replace productivity as the dominant natural resources management objective. To many observers, the productivity (i.e., the survival) objective contradicted objectives geared at sustainability. This, however, fails to protect unique, often unproductive, habitats that harbour valuable plant and animal diversity. It can be argued, therefore, that the overall objective of sustainability should be subject to having secured the unique ecological niches required for the preservation of biological diversity. In effect, there are multiple objectives for natural resources management. More recently a reconciliation has taken place (U. of F. 1993), although there remains an uneasy disharmony of views among environmentalists and survivalists. Neither view, however, is sufficiently broad. Natural resources management objectives must seek to improve the resource base while simultaneously increasing the benefits that people can derive from responsible resources utilization. This means that in addition to sustainability, productivity and the maintenance of biodiversity, the objectives must also include equity.

A more rational strategy for natural resources management is to maintain or to improve the natural resource base and the balance between its components. In a well functioning land use system this often implies the replacement of utilized natural resources with new resources by natural regeneration at a rate that must equal or exceed that removed by human utilization plus that used by the natural resource use system in maintaining itself. An important exception is the removal of toxic elements from the system to correct fertility imbalances.

The importance of improving the natural resource base becomes evident when we consider the relationship between resource quality and the carrying or production capacity of the land. A high quality resource base provides greater returns in response to additional labour and material inputs (de Wit 1992). When high extraction rates lead to the erosion of natural resources, however, incomes are reduced and the maintenance of the resource base is frequently neglected. This, in turn, frequently leads to a reverse downward spiral in human welfare and the type of resource base degradation that is common in poorer countries (Murqueito 1992). This is amplified by the link between poverty and high birth rates that leads
to production demands well beyond that which can be sustained by an ever weaker resource base. The effects of this phenomenon on the natural resource base is well documented (Lipton 1991, 1985).

This paper describes CIP's Andean ecoregional activities for sustainable management of natural resources. The procedures followed to develop the Andean consortium strategy (CONDESAN) are highlighted. Organizational as well as conceptual aspects are also described. Ideas to promote the horizontal transfer of applicable technologies from the Andes to the highlands of Eastern Africa are discussed.

**The Andean ecoregion**

At the end of the decade of the 1980s, it was evident that the world economy had undergone a prolonged period of sustained growth. At the same time, it was evident that this growth was inequitable and was characterized by increased poverty in certain areas. This is particularly true for the Andean ecoregion, which was once the home of the world's most dynamic cultures having the ability to produce significant food surpluses and which is the current home of more than 135 million people whose main source of sustenance is agriculture. The Andes are the source of several highly productive river basins providing life-support systems for rural and urban populations located in the lowlands. The whole Amazon basin, which supports life in its vast tropical rainforests, originates and depends upon water sources located in the Andean ecoregion. Hence, degradation of natural resources in the high Andes can have dramatic effects downstream.

Over 80 percent of the currently available agricultural land in the Andean highlands is steeply sloping with a broad range of soils and variable patterns of climate and water supply. Production systems vary significantly by country, altitude and latitude. In general, locations closer to the equator are more humid than those further South. Altitude has a profound effect due to the high incidence of frost in drier areas. In the valleys and mid-altitude areas crop production, namely potatoes, maize, beans, ulluco, faba beans and others, is important and is combined with different types of livestock production. In the most marginal areas such as the Altiplano, which supports the world's largest high-altitude population, livestock production (South American camelids) is more important because the range of crops is restricted to bitter potatoes and pastures. In Peru and Bolivia peasant communities are widespread, while in other countries private farming is more common.

Economic conditions have deteriorated seriously in the Andean ecoregion generating increased poverty in the majority of the population. Land degradation (erosion) is the most serious environmental issue affecting the region. In Peru, 21 million ha are endangered by erosion, infant mortality rates have reached as high as 289 per thousand while in Bolivia the per capita income is lower than three hundred dollars per annum in certain areas of the Altiplano. Such conditions have encourage massive rural-urban migration (4.6 percent in the case of Colombia) with resulting social conflicts and migration to the Amazonian ecoregion where non-sustainable slash and burn practices have lead to deforestation and loss of biodiversity.

**Development of the Ecoregional Initiative: CONDESAN**

As a result of the situation described above, CIP's management responded directly to Agenda 21 and recognized the need for an increased emphasis on Andean natural resources management. The goal of the programme developed is to overcome the deterioration of land and water resources, prevent the loss of genetic diversity and to alleviate extreme poverty. Since 1992, CIP developed an innovative strategy for partnership through collaborative research to promote development for the ecoregion. The following are the steps that have helped evolved CIP's ecoregional initiative:

**Early commitment**

Full involvement of NARS, NGO, universities and other partners and to develop a sense of ownership
among stakeholders has been the starting point of the initiative. CIP hosted an International Andean Agroecosystem Workshop in March 1992, at which time it was proposed that the centre, with the support of IDRC, help coordinate research on the sustainable management of natural resources. The approach chosen was to organize a research consortium.

**Broad Involvement**

A programme that would coordinate and catalyze efforts and make more effective use of scarce funds and existing scientific talents will require the participation of all those institutions with the capability to collaborate. Currently, a wide range of institutions are participating in this initiative. Activities will therefore be implemented through collaboration with national, regional and international institutions. It is important to point out that in the Andean ecoregion, considerable work of high quality, in research and development, has been done in the past by competent institutions.

**Participatory programme development**

The Andean ecoregional initiative uses participatory programme planning by objectives (PPPO) as a mechanism to guarantee full participation of stakeholders for joint planning and shared monitoring of projects. This has lead to the identification of well-defined outputs, setting of the research agenda and the division of tasks for each of the components of biodiversity. These components include land and water management, communications, INFOANDINA, policy, livestock, pastures and agroforestry.

**Scientific rigor**

Scientific rigor is required to address the research priorities identified during the PPPO process, to provide support to the research disciplines involved and to support the systems approach. This ecoregional initiative is currently supported by a critical mass of scientists in certain disciplines such as biodiversity, pastures and livestock, modelling, and natural resource economics. It will be expanded to cover such areas as land use systems and GIS. These researchers are strategically located in Colombia, Ecuador and Peru.

**Shared responsibilities**

The PPPO process has raised questions about the assignment of tasks within the Andean consortium. The process also created a participatory decision making structure in the implementation process. This has led to a division of assignments according to the comparative advantages held by the participating institutions.

**Communication links**

The communication and information sharing links between researchers, that will be used to consolidate information on genetic and biophysical resources and on research planning, will be enhanced through INFOANDINA. This is an information system developed by CIP in close collaboration with national communication systems.

**Monitoring and accountability**

Shared monitoring mechanisms created for the project will improve sustainable land use and the maintenance of biodiversity. Supervision will be based on realistic indicators against which performance can be evaluated. This will increase the credibility of the projects within the donor community and enhance confidence in the initiative among stakeholders.
Broad-based funding

Since support for the consortium is based on sharing both the costs and the benefits, stakeholders are expected to fund the activities that are undertaken. This support can be complemented with funding from other sources, if necessary. Donor countries, such as Canada, Switzerland, Germany and Holland have expressed their firm support to the Andean initiative. Multidonor support, longer term funding and funding sources related to Agenda 21 are included in this flexible funding scheme.

Successful strategy

Such a strategy has resulted in the establishment of the Andean consortium: CONDESAN (Consortio para el Desarrollo Sostenible de la Ecoregion Andina), which is operational with the kind support of IDRC. CONDESAN emphasizes partnership through collaborative and complementary work. Through the consortium, research on resource management will be integrated with research on crop/tree improvement and livestock husbandry by adopting a systems approach and by linking policy formulation to technology development and adoption.

The Andean consortium is open and participatory to compensate for imbalances in resources and to allow for membership to be extended to all stakeholders willing to share costs and benefits. This can include networks operating one or more components of the Andean agroecosystem as this would assure that rapid progress is made. The make up of the government of the consortium complements that of the participating institutions. It has an Advisory Council that will include outstanding scientists and representatives of major donors, regional research administrators and IARCs. The Council operates at the senior management level of the consortium and is tasked with oversight on content, approval procedures, monitoring and accountability.

An Executive Committee, which represents all participating groups and the Consortium Coordinator, is provided by CIP and will establish effective mechanisms to link institutions, hold major responsibility for the day-to-day research programming monitoring and the coordination of consortium activities. The consortium will also be the means to transfer results to other similar institutions.

Thematic research areas of CONDESAN

CONDESAN's proposed approach to conduct activities in the Andean ecoregion will be organized under the following main thematic research areas:

- I-Biodiversity of Andean Crops, Pastures and Animals
- II-Land and Water Management
- III-Agricultural Policy and Rural Development
- IV-Commodity Systems

Another important complementary area of work includes the gathering of relevant gender information to support the development of technologies that contribute to the sustainability of the system. Information activities (INFOANDINA) and human resource development will provide support to research themes.

The study of natural resources to address the research areas of CONDESAN requires consideration of multiple levels of resource interactions as these can be governed at many levels (plant, crop, farm, communities, watershed, national or regional). The performance of different systems for using natural resources must be understood in terms of their long-term effects on the resource base and the productivity of the resources used. This analysis should be at the level of the natural resource unit (agroecology or land type) and should allow extrapolation to homologous environments.

Much of the field work will be conducted in benchmark sites, such as heritage sites representative of the Andean ecoregion. These will facilitate long-term evaluation of alternative development initiatives. In the short term these are defined in Colombia, Ecuador, Peru and Bolivia. At these sites, research will be of a participatory nature, involving local communities, executing institutions (NGO, universities,
National Agricultural Research Systems (NARS), CGIAR, United Nations and others), including the private sector. The research will focus on measurement of the dynamic characteristics of systems, modelling to establish priorities for monitoring, evaluating the impact of land use systems, maintenance of biodiversity, and in the design and implementation of policies. The work will investigate intervention points at the commodity level to maintain productivity gains and achieve sustainable production. The benchmark sites will also help in extrapolation of component technologies to similar agroecologies.

One example of the functioning of the Andean consortium is the component of Andean Root and tuber crops. This is done within the area of Biodiversity, and developed through the financial support of the Swiss Development Cooperation (SDC) and Germany’s GTZ. A PPPO held in August 1992 gave well developed outputs. A total of 52 projects are being developed by 24 institutions in Ecuador, Colombia, Bolivia and Peru. Work areas for the lesser known Andean root and tuber crops include in-situ and ex-situ conservation, crop protection, production of planting materials, and commodity systems. Experience in management of small grants, capacity building as an integral part of project implementation, and shared governance gained by participating institutions are recent “byproducts” of this biodiversity component.

The Andes and Eastern African highlands: potential links

CIP has recently assigned (by CGIAR) the role of convener to globally implement Chapter 13 of Agenda 21 dealing with Sustainable Mountain Development. CONDESAN will therefore collaborate with institutions in the highlands of East Africa and in the Himalayas to promote the two-way horizontal transfer of applicable component technologies and to help maintain the options for human welfare worldwide.

One example of technology transfer would be in the area of water management. Indigenous Andean technologies for water management could help increase sustainability of agricultural productivity in selected ecologies of the highlands of Eastern Africa. For example, in Burundi agricultural production in the “marais” or swamps is increasingly important in an area where food is at a premium. The dry season lasting from April to September allows for cultivation in the swamps. Nevertheless, due to flood waters from rains in upstream areas, crops such as potatoes are not planted in April at the onset of the dry season but late in June or July when the water level decreases. In many instances rainfall in the upland areas results in fields becoming waterlogged in September before harvest is possible thus reducing the chances for food security.

An Andean technique “waru-waru” might be a suitable solution to the problem created by these seasonal floods. It consists of a system of water management structures that combine raised beds and with intervening canals. This system was developed by ancient Andean societies for cropping in areas requiring control of the water table. The use of waru-waru in the marais of Burundi, and elsewhere in Eastern Africa, could allow for flexible planting dates that farmers could adjust at will for optimum productivity. Additional benefits furnished by the waru-waru system include a better production and recycling of nutrients, favourable microenvironment for food production (frost protection), maintenance of fish, native plants, birds and beneficial insects. In addition the system can play an important role in providing more land for agricultural production. Another example could be the testing of Andean root and tuber crops in the highlands of East Africa, to explore their potential to complement existing vitamin deficiencies and to help alleviate hunger.

Constraints

There is yet much to do to accommodate diverse research agendas of the participating institutions. In terms of methodology, participatory research methods must be refined to achieve an active role in the life of the communities and in evaluating outcomes. An emphasis must be placed upon the policy area to allow for conflict resolution between urban and rural areas. Further, farming systems research methods need to have an adequate time dimension to measure the long term effects of resources management.
Conclusions

Objectives for natural resources management are multiple and must reconcile a number of interests. Among these are the sustainability of resource use, the ability to provide food, the protection of biodiversity and unique ecological niches and also the provision of equitable access to benefits. These objectives are not incompatible but the importance of each will come into play in different orders of dominance for different ecologies or regions. In this respect, enhancement of natural mechanisms that are favourable for the long term productivity of natural resources in the Andean ecoregion, and similar ecologies, merit the increased attention of researchers.

The institutional consequences of natural resources management research have translated into changes in collaboration. Opportunities have increased for collaboration with a wider range of partners (NARS, NGO, universities, networks and the private sector) to assure that rapid progress is made and to capitalize on previous experiences within the Andean ecoregion. The CONDESAN strategy, favoured by CIP and its partners for natural resource management, allows for better implementation of a multidisciplinary research within a systems approach and also addresses constraints to increasing sustainable production while maintaining the options for future generations. Only in this way can the needs of the inhabitants be addressed in a holistic, sustainable manner. While this is so, CONDESAN provides unique opportunities for spill-over effects to similar agroecologies in other areas thus contributing to human welfare worldwide.

References

Sustainability and Equatibility in Upland Production Systems with Low Autonomy

by

Carol De Raedt

Introduction

The mossy oak forest of northern Benguet Province and eastern Mountain Province, Northern Luzon is one of three areas left of the cloud forest system that once dominated the Gran Cordillera Central (Northern Luzon, Philippines) from elevations of 1600 to 2600 meters (see Fig. 1). Mount Santo Tomas (bordering Baguio City, Benguet Province, Northern Luzon) was a former mossy oak ecosystem now totally occupied by small-scale vegetable and fruit farmers and cottage-scale crafts workers. Progressive degradation at Mount Pulag (northeastern Benguet Province) has resulted in the conversion of forests to agricultural land by an increasing number of migrants moving upwards; a conversion that has almost totally decimated what was Mount Data National Park Reservation, about 50 kilometres northwest of Pulag.

The mossy oak forest is composed of most, if not all, the major water-conserving plant species found in the Philippines (Veracion per. com. 1993). These include the dominant oak (lithocarpus) species (3-6 species according to current inventories) and giant ferns to lichens and mosses. Floras include "epiphytic herbs, orchids, rattans, pandanus, strange bottle-shaped myrmecodias, shrubs and climbers of many different families" (Viray and Penafiel 1992). The fauna species diversity has been thought to be lower than flora diversity (Viray and Penafiel 1992). However, species include now-diminishing populations of deer and wild boar, which once provided an adequate household protein supply, the rare cloud rat, the Philippine civet cat, rare moths, populations of migratory birds and butterflies (including the Himalayan and snow butterfly). Current species indexing by national and international groups has not yet provided a picture of the full range of cloud forest biodiversity.

Mossy oak forests have (at maximum estimates, FMB 1990) about 17 percent of the forest ecosystem diversity of the Philippine archipelago. The highlands of the Cordillera Administrative Region, dominated up to the 1940s by sub-alpine oak and pine cloud forest, retain only 200 000 hectares or 11.19 percent of the regional land area, 18 percent of the nation's mossy forest and 3 percent of remaining national area officially classified as forest. Benguet has 1.9 percent and Mountain Province 18.2 percent of the regional mossy stands (FMB 1990, 1991) all in areas that are least accessible. The mossy oak ecosystem plays a significant role in the hydrology of the Cordillera uplands upon which both the subsistence irrigated rice and commercial vegetable crops depend. The natural regime is characterized by low evapotranspiration rates, capabilities for efficient fog-drip moisture retention and the maintenance of high internal humidity levels during the dry season (November-April). This high-altitude natural recharge zone is a critical regional resource. Indications of reduced stream flow in Benguet and Mountain Province have been attributed to the conversion of mossy forest to agricultural land (DENR-CAR 1992).

Apart from rattan, the oak forest species has not been of significant commercial value to residents in the past. The rattan resource was almost totally depleted between 1970 and 1985 due to commercial

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References were not found for the extent of the mossy forest before resource extraction and agricultural expansion (1920). Anecdotal records approximate the lower elevation boundary of the natural regime at about 1600 metres asl. The current area is approximated from 1983 maps of forest cover, probably reflecting more than the actual area. The mossy oak regime ends at about 2500 metres above which dwarf bamboo and grass dominate up to the highest elevations (2950 metres asl at Mount Pulag).
demand for basketry. Sporadic efforts to propagate rattan have not succeeded and the resource is not considered part of existing forest-use value. Most of the other forest species are not suitable or significant for commercial logging and the dwarf species of oak are used by local residents for firewood or for house posts. With the depletion of wood resources in lower elevation dipterocarp forests, however, the larger oaks and other timber species within the mossy forest are now harvested for sale to craftsmen and construction suppliers and for local house construction. Minor forest products such as giant fern, orchids, sphagnum moss and acorns are harvested commercially for the ornamental and cut flower market in urban areas. The incidence of edible wild fungi has decreased. Hunting and gathering levels over the migration paths of deer and wild boar have contributed to their increasing scarcity in most areas and total disappearance in some others.

Topsoils under the dense multistorey canopy have humus layers as deep as one metre and heavy litter build-up is common in undisturbed zones (Veracion, personal communication 1993), making the cleared forest attractive for agriculture. Only the outmigration of labour from communities in the indigenous production sector and the lack of information about alternate crops has limited the expansion of swidden fields. In an ironic development, the encouragement of fruit tree cropping, intended as an economic alternative with suitable for exposed mountain slopes, has sometimes led to the conversion of mossy oak forest to fruit plantations.

Perhaps the most severe threat to the mossy forest ecology is the expansion of commercial agriculture, stimulated by the spontaneous spread of temperate vegetable cash-cropping as one of few economic alternatives accessible to highland farmers. Since the 1920s, commercial production of temperate vegetables has progressively cleared a 120-kilometre wide swathe of mossy forest along the Halsema Road on the high elevation spine of the Cordillera, moving downslope to encompass most of northern Benguet Province and southwestern Mountain Province.

These areas were too high for productive cropping of the rice and sweet potato common to indigenous farming systems, but are ideal for the production of short-season temperate vegetables (40-90 days) introduced by Chinese, Japanese and American immigrants and later supplied in hybrid varieties by international seed companies. Despite the currently competitive terms and high input requirements of vegetable production and marketing, the system continues to push into the forests of the Cordillera provinces and is undertaken by both residents and migrants from lower elevation communities.

The driving force behind this move to growing temperate vegetables is the lack of economic alternatives under conditions of "uncertainty of land tenure, lack of employment opportunities, underpricing of forest products, poor administration of public resources, among others" (Viray and Penafiel 1990). Most of the residents of the Cordillera are subsistence farmers, with limited access to physical and social resources and a poor support environment of services and infrastructure. For those who did not undertake commercial vegetable production, outmigration of various sorts (including expatriate migration) is a major economic solution.

The poverty catalysts include misdirected or uninformed policies and actions of the government's highly centralized line agencies. With self-critical candour, the Department of Environment and Natural Resources, Cordillera Administrative Region (DENR-CAR) cites the continuing forest and biodiversity damage caused, among other things, by:

- uncoordinated development efforts in Kasamata Hill National Park in Kalinga-Apayao;
- toleration of farming in park reserve areas of Mount Pulag (at the juncture of Benguet, Mountain Province, Ifugao and Nueva Vizcaya) and Mount Data (at the Benguet Mountain Province boundary);
- release of wooded site parks in Balbalan, Kalinga-Apayao to allow logging operations;
- conflicting land use policy and systems as a partial result of inconsistent authorities and overlapping programmes of such agencies as the Department of Agriculture and the Department of Agrarian Reform (the two latter agencies, for instance, having similar programmes but discrete implementation for recognition of ancestral land claims); and
• lack of attention to non-timber resources segregation of water concerns due to administrative allocation of discrete authorities for hydrology and water use (DENR-CAR 1992).

Alternate enterprise and the mossy forest ecology

The extent and inherent value of sub-alpine forest species is yet to be established by time-phased studies that account for seasonal change and the effect of resource exploitation. Planning for the establishment of alternate economic opportunities requires an assessment of the necessary enabling conditions to validate the potentials and constraints involved in ecologically-based livelihoods that conserve biodiversity. The following objectives are to be met given the concern for sustainable resource use, for adequate and equitable household incomes and for viable communal management of biophysical and social resources. These include finances, human energy, information, regulatory authority and access to support services and facilities provided by government.

Enterprise development in the area may provide effective conservation motivation if returns match or improve existing incomes from extractive resource use. These returns will depend on resource access and control at community level, on rationalizing production with improvements in processing, design and forward linkages. They will be sustained if community regulation can counter the trend to maximize immediate gains rather than optimize on long-term conservational production.

Resource management and tenure policies are progressive in their recognition of decentralization, ancestral law and domain tenure and communal management potentials. They, however, need supportive legislation and effective local application capabilities and enforcement mechanisms. Fiscal constraints and imperatives, corporate interest lobbies and the centralized standardization of development programmes are some obstacles that can be mentioned. The direction of government development programmes for indigenous communities in the Cordillera has been ineffective because of an unfounded stress on standard packaging of discrete and short-focus actions. Projects such as infrastructure construction, which have visible if not equitable impacts, are preferred and the conditions of the subsistence sector are not considered. Credit extension and cooperative development programmes have still to address the basic issues of resource control, tenure, support and production requirements so as to achieve a stable household cash flow and then provide the basic requirements for a diversified and integrated, village economy. NGOs working on a necessarily small scale have made the most substantive gains in this effort. Poor communications between NGOs and their discrete operations have worked against a consolidation of these efforts and have therefore contributed to a loss of learning.

Field experience suggests that the following basic types of enterprise are potentially responsive to local economic requirements and motivate the practical interest in conserving biodiversity and securing ecological integrity:

1) Enterprises directly related to forest management (e.g., the maintenance of forest nurseries based on the collection of indigenous plants with high use or market values or the propagation of species like orchids and rattan) taking account of the requirements for consistent and sustained income opportunities and for local regulation of management and marketing.

2) Enterprises based on minor forest products and harvesting of renewable major species (in part or whole), if the use rates do not endanger ecological balance and provided further that the enterprise provides an increase and retention of value added (e.g., shiitake -- oak mushroom -- production with substrate propagation and/or substitution).

3) Pressure valve enterprises that are not based on forest harvesting but which support or augment the local production system (e.g., indigenous small tools manufacture with appropriate fuel use or propagation).

The first critical point is to be able to identify, within the access and capability range of village residents, enterprises that diversify and integrate the local production system. The second is to identify multiple links between the enterprises and mechanisms (or motivations) for the conservation or enhancement of biodiversity in the mossy oak forest and for the regeneration of degraded cloud forest as may be feasible.
While possibly motivating a practical interest in conserving and optimizing productive resources, such a programme must enhance the essential conditions for effective local management. These include, functional autonomy through local resource control, sustained local financial means for carrying out and a structural mix of development responsibilities shared by private and public entities and by local and external authorities. These imperatives operationalize decentralization, recognition of indigenous law and domain, and community-based co-management of resources as provided in the 1987 Constitution of the Philippines, the Local Government Code of 1990 and the National Integrated Protected Systems Act of 1992.

Economic opportunities are expected to open as a diversified network of mutually supportive enterprises emerges. The network is grounded on the augmentation of indigenous technology, knowledge and organization with effective external information, techniques and support relations. Resource conservation is sanctioned by communal regulation and recognition of the effective long-term value of the mossy forest and its component species. While an enterprise development programme may increase interest in forest resources, with negative effects on the forest and resident communities, degeneration is likely to continue if alternatives to current raw materials extraction and clearing are not developed. Past national regulatory efforts and development projects have not been ecologically or economically effective. On the other hand, communal regulation has, for instance, inhibited destructive gold extraction in Mountain Province and has led to reforestation of pines in Sagada, Mountain Province, and of scrub oak in Mayoyao, Ifugao.

The concern for biodiversity and ecological security warns against making use of the forest resource even more lucrative and attractive. The development of a functional interdependence of mutual advantage forged between the forest, its residents and the national segment is required. There are serious constraints to the development of such a relationship.

**Relations across the indigenous boundary**

The situation faced by indigenous people within the national system can be summarized as an increasing constriction of alternatives and an increasing need for goods and services from the encapsulating economy. Indigenous people also have to deal with no access to the legal, political, technical or economic opportunities and services enjoyed by others. Subsequently, this results in a lack of local control of resources and a lack of responsive, user-friendly economic solutions. Despite human rights vocabularies, national efforts at social development, particularly since 1970, have been assimilative. This is presumably to enhance a levelling of the differences between indigenous groups and the generic Filipino. This is attested by the dearth of legislation before 1989 that specifically addressed conditions faced by indigenous peoples. Incorporation into national law of the Islamic Shariya code during the Marcos administration was not a recognition of indigenous law but a late admission of geopolitical fact and force.

Economic development has largely been as exploitation of the resources, in areas inhabited by indigenous peoples, by non-indigenous corporations with non-local capital and with small or short-term benefit to local communities (see Cosalan no date 1 and no date 2, CDPC 1989). Poverty and cultural discrimination have not been reduced and access to services, educational and legal resources have not significantly improved. On the contrary, the gap between the indigenous peoples and the national segment have widened.

Simultaneously, the Mindanao Lumad, the Igorot peoples, and other groups that retain and reflect the range of national social and cultural heritage, are losing their traditional strengths. These include, an independent subsistence economy, supportive local exchange networks, resource base integrity, local knowledge about environment and adaptive technologies and viable custom law and social controls. These assets have not been replaced by alternatives that would open access to the national segment or develop trust in the intentions and abilities of the nation-state. Instead, spontaneous solidarity movements have developed to establish self-conscious political will and to focus the energies of diverse indigenous groups on coordination to achieve recognition or self-determination. The main line of cultural and social
differences appears now to be strongly drawn between the nation-state and its indigenous people. The critical issue continues to be that of resource control.

These competing interests are reflected in the national segment and in the application of policy and law. They are a basic element in the relations between the nation and indigenous peoples living in upland areas like the Cordillera since these more remote uplands are a last frontier for forest resource exploitation.

The behaviour of government is a response to many factors outside forest ecology and economics. Particular incumbents influence the direction and force of policy. National issues, national elections, the state of the national treasury and the play of powers on the national scene are only a few of the conditions affecting the values and the decisions of government. The understanding of local conditions is not a strong factor in national governance.

Other organizational and cultural differences intrude between the interests of the national segment and the interests of local government. The intentions of the framers of the policy may not be what implementing bodies can or will achieve at the level of the community. The action of local units of government is subject to the constraints of their budget, their reporting system, their work force and the degree of their coordination with the interests and life-conditions of local residents as opposed to the degree of their dependence on central parent agencies (Esquejo 1991).

This explains why, though there are national laws adequate to form a basis for insuring the forest-use rights of indigenous peoples, these have not been applied to securing ancestral lands and communal social forest management. The Assistant Regional Director of Region I Department of Environment and Natural Resources (DENR) noted the difficulty of applying DENR forestry management principles to an area like the Cordillera that, he affirms, requires site-specific management and the development of locally relevant operational policy. The National Integrated Protected Area Systems Act, for which implementing orders were issued in June 1992, is an innovative and appropriate response to such conditions (personal communication 1991).

Case: DENR Initiatives towards the recognition of ancestral domain

Lynch (1983) estimated that as of 1982 half of the 7.5 million forest occupants were indigenous peoples who practice swidden (kaingin) agriculture. These populations use the forests according to customary laws and indigenous technologies that have evolved reflexively with the communities through time. In a substantive development, the Department of Environment and Natural Resources (DENR) has recognized that there are rights before those admitted by Philippine national law. The idea of “inherent title” of indigenous inhabitants is to date guaranteed only by the ministerial and administrative powers of the DENR. An ancestral land law awaits congressional action.

In 1990 the DENR created a Special Task Force on Ancestral Lands (DENR Special Order No. 31, Series of 1990) which was empowered to validate ancestral land claims, speed the settlement of disputes between ancestral claimants and claimants under national land tenure laws, and recommend to the DENR Secretary the issuance of certifications of ancestral claim. Only the delegation of executive power by the President to the DENR Secretary supports the authorization. The Task Force is only authorized to operate within the Cordillera Administrative Region (CAR). Even within this limited area of jurisdiction, the Task Force faces problems in the application of the certification program. To date only 58 certificates have been issued in one municipality of Ifugao Province and eight in the Province of Benguet.

The DENR budget was inadequate for the work of validation over a large and dispersed area. Honoraria for the members of the task force were officially charged to the Special Projects Fund of the Office for Northern Cultural Communities (DENR Special Order 31 Series of 1991). There was a delay of at least one year in the release of funds allocated for the DENR programme of claims mapping and validation reportedly due to unavailability of GOP counterpart (B. Pawid, personal communication, April 1991).

Underlining the inadequacy of government fiscal capability was the case of funds appropriated for DENR protection of the 10 000 hectare forest released in 1992 from the control of Subic Naval Station.
(U.S. Military). The fund was 50,000 peso annually. DENR Secretary Fulgencio Factoran noted that at two pesos per hectare, "it is almost a joke to expect serious results" (Philippine Daily Inquirer).

Task Force authorization at this point only recognizes "occupancy" as a criterion for claims and this is interpreted as covering residential lots and agricultural fields. The notion of usufruct is not developed as a basis for action. But forest use and management in the Cordillera is not through ownership by individuals but by communal or clan access to forest areas and through use of the products of forest land.

Swidden fields held by usufruct and the communal lands or commons that are open to general use are still automatically subject to a national-legal idea of individual ownership. If usufruct rights are converted to individual title, one effect would be the denial of land-use rights to many households that do not own permanent fields whose only access to agriculture is through usufruct. Privatization of swiddens and communal lands will both increase the tendency to establish permanent fields (and not necessarily perma-culture) of marginal lands and increase the numbers without access to land.

Access to forest land and control of forest resources therefore cannot be guaranteed by the Task Force. Yet, the forest at the crests of the critical watershed are the hub of community and household economics. They are the recharge area for water sources that irrigate rice terraces and, for most of small farmers, they are also the area used for upland fields.

There is no codification of indigenous law. While the Task Force recognizes, and can validate ancestral claims based on this law, specific provisions applying to communities are not known and cannot be used. Even without codification, ground mapping of locally-recognized ancestral claims and boundaries still must to be done to insure a sound basis for certification. Occasionally elders, who might identify and verify claims according to indigenous law, are dead and failed to pass on the oral tradition that records the indigenous patterns of ownership, use and control.

The use of tax declarations has often overridden ancestral claims. In this way communal lands have been privatized denying land access to a community's poorest sectors. Non-residents of some communities have gotten at least the appearance of legal records and legal rights to the ancestral domain with claimants under indigenous law. Simultaneously, the tax declaration is the basic document recognized as supportive of ancestral claim and prior occupancy, though it is legally not proof of ownership.

Similar problems effect other programmes like Integrated Social Forestry and contract reforestation. Apart from tenurial issues are the problems of enforcement. Enforcement by DENR or by local residents is difficult against armed chain-saw operators. DENR provisions include the possible issuance of reforestation contracts to concessionaires, in the absence of residents who apply for contracts. Non-residents have in several instances overridden the rights of unknowing local claimants by securing reforestation contracts. And, finally, follow through on contract reforestation is weak. The success of the work is measured by the area planted without considering survival rates or species diversity and appropriateness.

Some of the remaining forested area is designated as protected or national park area that is "beyond the commerce of man," which means these areas cannot be harvested. The lack of direct economic benefit to communities and the perception of indigenous groups that government favours corporate interests in the issuance of permits for forest and mineral resource exploitation are all factors that discourage participation in social forestry projects and discourage the cooperation of local residents in maintaining these protected areas. Influential politicians from other provinces, for instance, have established a claim to large areas of Mount Pulag, a national reserve. The situation is not improved by the local residents' legitimate claim that these lands are part of the ancestral domain rather than public lands under national control.

Business interests, which have influence at the national level, must also be considered in implementing the strategy for management of critical watersheds. A major concern in DENR Secretary Factoran's keynote address at the First National Symposium/Workshop on Critical Watershed Management in the Philippines, was that we live in an elitist society but must deal with the problem of poverty. The interests of all potential users of forest products are incipient conflict points.

For instance, it is popular fiction that indigenous communities are the worst offenders in the
denudation of critical watersheds. Chain saw operators, a particular segment of indigenous residents, have recently come under fire for their impact on the forests. While these users undeniably affect forest cover, the corporations and entrepreneurs exploit forest resources on a scale that indigenous forest dwellers are not likely to match. The regulatory provisions and sanctions in timber license agreements are rarely enforced. For example, the enforcement of a total logging ban came into effect against licensed exploitation only in 1991.

The National Integrated Protected Areas System Act of 1991 (NIPAS, R.A. 7586) is landmark legislation for the protection of fragile highland ecologies and the preservation of indigenous rights to land and land resources. The law establishes the state policy for preservation of biological diversity in partnership with indigenous communities. Specific and balanced implementing orders (DENR Administrative Order 25 1992) provide a vehicle for setting up principles of environmental security and indigenous tenure recognition.

The orders focus on consultation at all levels of developing protected areas, providing decision-making roles for indigenous communities as well as for tenured migrants. Zoning and management rules are to be devised and set up without restriction to the “rights of indigenous communities to pursue traditional and sustainable means [sic] of livelihood within their ancestral domain” (DENR 1992). Representation on the management board for each area is provided for representatives of the barangay local government and for indigenous residents.

While the application effort in the CAR goes with goodwill, and has already produced documentation of species in the indigenous mossy oak forest, major constraints remain to be addressed. Leo Viray of the NPAS-CAR notes that microenterprise development linked to bioconservation as a deterrent to over-exploitation of extractive forest uses is an unexplored area. Funds that should be currently available for systematic carrying out have been stalled by competition between two major and reputable metro-based umbrella NGOs for the position of main conduit and implementor.

Problems in Securing Effective Local Resource Management

Case: The Antamok Gold Project

The preference for corporate investments

Potential loss of revenues is a possible factor in decisions to sustain corporate interest when it conflicts with the interests of small producers or with environmental concerns. Enterprises that earn foreign exchange and those that return large revenues in taxes are particularly significant under current conditions of economic stress (Gimenez 1991).

The Antamok Gold Project (AGP) in Itogon, Benguet (earlier called the Grand Antamok Project (GAP)) drew fire from concerns and authorities of the regional Department of Environment and Natural Resources (DENR-CAR 1992). The project was an open-pit mining operation covering 1623 hectares of land, including structures for waste dumps, tailings ponds and disposal channels, river diversion tunnels and canals, mill site and roads. It was intended to increase revenues and cut labour costs. The livelihoods and environments of 3182 pocket mining households would be directly and indirectly effected. Considering the effects on displaced mine workers and farmers, over 93 percent of the Itogon population would potentially feel the effects of the project.

The DENR-CAR Regional Director took an initially strong stance against the GAP project and announced that the DENR Secretary on 28 May 1990 and Environmental Management Board (EMB) would close project operations. However, a 7-June Memorandum of Agreement allowed the Benguet Corporation to continue project operations without interference from effect communities that had mounted opposition. On 27 June the AGP was issued the necessary Environmental Compliance Certificate (ECC) required by law to insure environmental security.

It appears that government interest in the mines prevented attention to the protests of pocket miners. Benguet Corporation had paid 65.9 million pesos in taxes in 1989, despite a 27 percent decline in
earnings. The large-scale development of natural resources also requires the capabilities of large firms with foreign capital.

Ecology and economy

The economic interest also disposed government to validate the corporation's Environmental Impact Assessment (EIS) as required by law. This document admitted to negative environmental impacts but accounted for technical designs that would do least environmental damage and achieve maximum control of toxic wastes under the circumstances of open pit mining. It also stressed corporate investment into the rehabilitation of the open-pit area using backfill, conversion of tailings sites and the diversion of wet season stream flow. The corporation would invest 8 million pesos in social forestry project using fast-growing species, to rehabilitate 196 hectares by the year 2005. Surface owners would be compensated for damage to domestic crops and trees (Alcantara 1991).

Not covered were the effects of loss of natural vegetative cover, interim erosion, downstream siltation, irreversible changes in soil quality and the absorption of toxic wastes, effects on the river system and effects upon the river's effluent area in Lingayen Gulf. Questions were raised by technical experts on the security of the tailings and toxic waste containment and on the effectiveness of both short and long term waste disposal strategies. No baseline had been established to measure the requirements for effective rehabilitation or to anticipate systemic and long-term effects of the mining operation.

Land laws and mineral rights

The AGP case calls attention to deeper dimensions of ancestral domain and land laws. The traditionally gold-mining and gold-panning Benguet people applied usufruct rights and conservation ideas to mineral exploitation. The scale of their operations of course does not match that of a large mining firm and neither can they compete with such a firm's financing or revenue capabilities.

Indigenous rights to sub-surface resources are complicated by the dual system of entitling surface rights and claim-patenting of mineral rights. Sub-surface resources are covered by the Regalian doctrine of state ownership, subject to lease by individual or corporate interests. A person holding land title does not own the sub-surface rights. There is a primacy of mineral rights over surface rights, if sub-surface operations do not affect the surface owner. The surface owner can sue for royalties.

The imposition of American mining law in the Philippines had the same effects as the system of Torrens titling. Few indigenous people were aware that they had to legalize ancestral mining rights or how this could be done. To date, many old mining claims need to be validated or cancelled and the rights of small scale miners protected as provided in the 1987 Constitution (Gimenez 1991). House bills on these issues are still pending. Implementing rules, in view of outstanding corporate and state interests will be a subsequent issue.

Legislative concerns

Ancestral law advocate Perfecto V. Fernandez was optimistic about the democratization of the Philippine legal system even during the latter period of martial law. More important than content, he held, were the pioneering efforts in non-traditional directions for participation of people in legal processes. Most significant for democratization was the incorporation of indigenous or ethnic law into the national system. He noted positive developments in the assimilation of indigenous law (notably the adoption and administration of the Muslim Code) and the establishment of barangay courts for grassroots participation in the administration of justice. Unitary forms in law and legal administration are seen as a legacy of colonial government, unresponsive because they are alien in origin. These forms prevail partly from institutional inertia, partly from conditioning of ruling elite and partly because centralization is appropriate to the needs of post-colonial development (Lynch 1983).

The continuance of post-colonial dependencies, the effects of a previous history of environmental and
social pressures and the continuing ineffectiveness of excessive centralization may work against the establishment of a populist legal order. To date, there are presidential decrees that remain in force despite Constitutional and administrative changes and despite the current objectives of democratization. Effective laws exist, but are not applied, particularly because access to the law is not equitable.

Constraints on access to the law

All citizens of the Philippines are theoretically equal under the law. But the structures and forms of national law in themselves present obstacles to legal access for members of tribal and indigenous peoples. The most apparent obstacle is the denial of indigenous, ancestral land claims and rights over the ancestral domain (Lynch 1983), which is rooted in the non-inclusion of customary law in the national legal system. Despite the stated administrative concern for rights and economic upliftment of indigenous peoples, this basic restriction of legal access to land for the majority who are predominantly land-based has not been remedied by effective legislation.

... the legal existence and full legal capacity of their land-owning entities (nations, communities, or groups) may be denied; various forms of involuntary [sic] trusteeship may be imposed on them. Most indigenous populations also experience such practical disabilities as a lack of legal assistance, the lack of access to records and courts and illiteracy in the officially recognized language. These hindrances make the exercise of any legal rights difficult or impossible. Like the denial of land rights, in fact, the continued imposition of civil disabilities makes any meaningful legal strategy impossible (Coulter 1982).

Costs of litigation are prohibitive for most peoples living in the indigenous sphere of subsistence, particularly given the slow pace of litigation. Many are unfamiliar with legal procedure and requirements. Many are also unaware of the possibility of legal recourse. This is a result of the culture of marginality.

Constraints on customary law and special and remedial legislation

The development of special and remedial legislation will be constrained primarily by the availability of state financing to provide the feasibility assessments and other background studies required for an overhaul of fact and perspective. Legislators' budgets and commitments to constituents limit the range of innovative legislation. The legislative process is often hampered by the representation of conflicting local and sectoral interests in Congress. Bills for reform of the mining law, land laws and even the total logging ban have not been passed. The meticulous work of referring these laws for public consultation and grassroots amendment is not often done. Legislation, which is needed to operationalize the policies on ancestral domain or to resolve inherent conflicts of interest, is not specific enough on recognition of indigenous land rights.

The extent of the land and territorial rights to be recognized has still to be clarified. Will these rights extend to surface and sub-surface resources, to waters and wildlife? Will there be firm provisions against the removal of indigenous peoples from their ancestral lands? What degree of control will indigenous peoples have over minerals and development activities undertaken on their traditional lands? How will these lands be delimited and demarcated? Are all questions that need to be answered (Plant 1989).

Concerning indigenous law, the constraints involve the difficulty of codifying the broad range of indigenous legal ideas without prejudice to specific groups and with a broadly applicable but firm framework. Otherwise, the codification process would be interminable. Codification alone is not sufficient. Customary law involves a file of precedents rooted and expressed in oral tradition. It is administered through customary and village-level forms and authorities. Effective translation and cross-adaptation must occur between the national and the customary systems for any codification to be effective. Once this has been done, a major issue will still be: who are the legal experts in customary law and what will be the venue for their suits?

The application of customary law and concepts of ancestral domain will run against an almost 500
year-old legacy of non-indigenous national-legal precept and practice. It has been by these precepts that the people of the national mainstream have gotten or lost properties and rights. The potential dislocation from affirmation of ancestral rights and properties is likely to elicit resistance from the state and its majority citizenry. Given the potential opening of lands to old claimants and the current lack of specific means to access and use indigenous case law from the oral tradition, some among the indigenous peoples may take undue advantage of their own members who may have superior access or knowledge. The balance point for such cases would be in the practice of custom law if this is recognized and fully translated into the national-legal system.

The force of custom law might be adequate protection if persons of indigenous or other membership or origin does not have recourse to national law as an alternative in cases of conflicting provisions or jurisdiction. The rights in good faith of non-indigenous or non-tribal peoples under national law would require similar protection or compensatory settlement if they are abrogated under custom law.

Inadequate as it is, national law is the only recourse to which indigenous peoples have access. Individuals have paid taxes to declare lands as private claims. This may not be undue advantage but is certainly the only means available now to document ancestral land rights. Since tax declarations are not considered legal proof of ownership, but only substantiation of occupancy, this strategy is not secure from the possible stronger force of external claims on resource use, if not control.

A final consideration is that some indigenous peoples have a social organization and custom law under which non-equitable land allocation is legitimated. In these cases, custom law would not solve the problem of lands or livelihoods for a significant segment of the peoples but would rather validate the claim of an indigenous elite to large tracts of land. It might be clarified whether only custom law or equity as well is a major consideration.

The need for a common definition of basic ideas and terms

The record of advocacy for the rights and participation of indigenous peoples has shown that statements of national policy or the existence of supportive legislation do not guarantee an effective application to the conditions faced by the disadvantaged. The marginal position of indigenous peoples is perpetuated by the absence or inadequacy of implementing rules, by complex and lengthy procedures or by the unresponsiveness of authorized offices. A responsive and systematic application strategy defines the critical path to adoption and observance of any provisions legislated on behalf of indigenous peoples and their production lifelines.

The first limiting condition to such application is the apparent similarity of ideas and terms. Cross-national experiences with both ethnic diversity and development conditions have established a baseline from which present policy and action can go on more effectively than in the past. The vocabulary of this baseline has been widely adopted for instance, with terms such as "sustainability," "consultation," and "development." But the frames of reference for these terms are likely to differ between countries and among sectors within countries.

Principles that would guide effective action then tend to remain at the level of undefined concepts. The follow-through to operational policy and implementing mechanisms are overridden by standard procedures for operation and by standard criteria or indicators for evaluation. Adoption of concepts requires the adoption of defined objectives and of criteria and mechanisms for achieving the objectives. But, the tendency is for established patterns of thought and action to persist in working against the need for systemic change. The impediment of tradition is not only found in pre-industrial societies. Bureaucracy has a tradition of its own. The following should prove the need for common definitions.

Decentralization

Decentralization requires more than a redistribution of central responsibility. Effective decentralization is a shift from hierarchical structures to lateral links of functional interdependence. Decentralized operations assume consensus rather than sectoral competition. Fairly simple issues of representation may
require adjustments in accepted process. The Philippine Senate, for instance, is not composed of representatives who reflect regional knowledge and interest. Since senators are elected at large, contenders with national media exposure who becomes familiar nation-wide have the advantage. This favours residents of the national centre, whatever their qualifications.

The justification for the nation-wide election of senators is to balance the local representation of the House with the broader concerns of the political whole. The question is whether Metro Manila adequately reflects the experience or commitment necessary to manage national issues as a convergence of multiple sectoral and regional interests. In the current composition of the Senate, indigenous peoples of the north or the south have no representative, yet their concerns are of national importance. Media personalities, with their national exposure through the Manila-based media, have a better chance for election than a person whose experience has been with indigenous conditions.

Fiscal autonomy, which is the necessary condition for self-determination, will require reorganization to balance the requirements of poorer areas with the economic initiatives of resource-rich or more productive units. Pro-rata percentages of national or local shares are not an adequate criterion to insure effective decentralization and also fund the administration of national affairs. The major assumption has been that autonomy and decentralization will automatically bring an increase in local budgets. The likelihood of dominance by sectors with a stronger economic position may lead to increased disadvantage for the local periphery. Simultaneously the state's capability for financial support and regulation is reduced.

Under present conditions, the state's supportive capacity is at issue. Start-up budget allocations were in fact proposed for the anticipated Cordillera region and approved for the Autonomous Region of Muslim Mindanao (ARM). In the latter case, under five percent of the allocation has been remitted to the ARM, showing severe constraints on the national budget or on the process of redistribution.

Consultation

Local reactions to consultation reveal the difference between presenting issues and activities developed at centres of authority and eliciting the issues or developing the activities from the context of the sector concerned. Consultations on autonomy, for instance, focused on presenting the standard definition but did not discover the substance of Cordillera or Mindanao experience that was autonomous or in need of it. Information materials, which were distributed by government in preparation for the plebiscites held to ratify the organic acts for autonomy, were incomprehensible to professionals and upland farmers alike. It was unlikely that villagers could understand the content or the national political organization to which the papers referred.

Development concepts

Understanding of standard approaches to development is different from recognizing the need for new approaches that will establish or lead to the conditions for sustainable development. In this effort the tensions have been between the economic imperatives and the ecological requirements; between the urgency of capital infusion, which tribes cannot make, and the need for equitable access to resources, which are now largely under the management of large corporations. Unfortunately not all corporations are controlled by citizens and perhaps none of them are controlled by indigenous peoples.

The Philippines' resource bubble has burst. The country will face the need to commit resources to local control while national funds are in need of replenishment. Concepts, for instance, of agricultural development may include a concern for ecology because of the significance of the land-based resources for production. Yet, almost all government programmes are still founded on the need to increase productivity measured in volume of production or value of production. Productivity is rarely viewed either as a sustainable input-output relation or as a relation between producers and their objectives.

Self-subsistent agriculture characterizes most indigenous groups. Their entry into the national economy is problematic primarily because there are few sources of cash within the local system, yet their
needs for cash to draw goods and services from the national segment are increasing. Efforts to alter this imbalance have been marked by attempts to transform the self-subsistent sector into a cash-cropping sector or a multi-livelihood sector.

Little account is taken of visible negative impacts on the rural resource base arising from the intensification of land use or the extension of inappropriate farming systems into marginal, ecologically fragile lands. The access of indigenous peoples' to the economy is limited by the degree of their familiarity and contact with production and marketing systems. This is so different from their local experience and means they are further disadvantaged by a limited capacity to take risks or make investments. This means they are, from the outset, less likely to take effective control of resources and the terms of production and exchange. Not least among the constraints is the fact that households cannot continually allocate their labour to an infinite range of activities to make ends meet.

When a shift to non-agricultural activities is considered, the indigenous populations are often disadvantaged. Skills alone may provide entry into an existing labour market. But, independent production requires the capability to invest into a production system and knowledge of technologies and markets. Once established, the next consideration is how they may compete with the existing producers, who have had the benefit of prior experience, a network of support relations and entry into a more open economic space.

In meeting the needs of indigenous peoples, government must be aware of the specific terms for their entry into the unfamiliar environment of the national segment and for their survival under its conditions.

**Autonomy and centralization**

The autonomy process has been tested in the efforts since 1987 to establish two autonomous regions. In both cases the basic definition and terms of autonomy for indigenous peoples in the framework of the nation-state have remained unclear. Central authority viewed autonomy largely as the need to retain its control over the nation's territorial integrity, laws and general welfare. Local authorities perceived autonomy in terms of expanded political space. Upper sectors of the citizenry see either civil service employment opportunities or a threat to the status quo. Most of the residents of the Cordillera and Mindanao perceive no basic change that would affect their daily lives.

The actors in the autonomy process were necessarily the most visible and vocal and those who presented the most critical problems in the drive for reconciliation within the national framework. In both Mindanao and the Cordillera, incumbents in government and amenable leaders of dissident political-military groups set the terms of autonomy that would be applied to a broader, largely unconsulted public.

The Organic Charter was developed within the framework and according to the procedures of a national law that does not encompass indigenous ideas or admit indigenous procedures (Fernandez 1983, Lynch 1987). The recognition of Muslim shariya codes (including the internal integration of the customary adat law) has been relatively easy to establish. Though the interface between Muslim law and national law has still to be worked out, both systems have common elements, such as a legal literature, formalized structure and operations, and a history of application within a fairly large area of Philippine territorial jurisdiction. The indigenous (or customary) law of the many ethnolinguistic and territorial groups in the Philippines will show far less commonality with presently recognized legal systems.

The recognition of the variants of customary law and procedures will require a difficult balance between the specifics needed for applicability and the generalization needed to codify and reference legislation and adjudication. Formal, contractual administrative procedures, such as registration and taxation, must be made consonant with local conditions and with the framework of national requirements. If the government were to go on in these efforts with reference only to existing legal concepts and procedures, the likelihood of failure would be high (Fernandez 1983).

Centralization of political initiatives and authority militates against the implementation of any policy or programme that is based on principles of full participation by indigenous peoples in decision-making and resource allocation. The autonomy processes in the Cordillera and Mindanao point to multiple condi-
tions affecting the access of indigenous groups to representation, substantive consultation and therefore to effective and wide-ranging participation in public discourse as well as to the politics of the nation.

Translation and communication issues

One result of centralization is the lack of groundwork to support an active, effective recognition and protection of indigenous systems and rights. This will obstruct application over the short-term. There is a dearth of information on the current form and operation of indigenous institutions including customary law, forms of cooperation, resource management systems, indigenous technology, patterns of production, consumption and exchange.

Some of this information is recorded, in academic ethnographies, wholly or in part for various groups. Studies concerning aspects of the interphase between the indigenous and the national system are not many or focused on the issue of realigning relationships to solve basic problems. Systematic classifications of commonalities are still inadequate and are not in formats that policy makers and legislators would find useful. Much of the information is dated and does not reflect recent social and environmental changes that have influenced the daily life or the life-views of indigenous peoples.

Immediately applicable and sustainable "social technologies" are therefore also inadequate. Appropriate technologies must be developed, usually in an interplay of traditional and other forms of knowledge, to be ecologically sound, socially acceptable and controllable under local conditions of resource and capability (Montanos 1983). The social rather than economic or scientific management of technology is an idea that has yet to gain acceptance in practice.

These issues of translation and communication influence the potential emergence of necessary changes in law, political forms, education, resource management and systemic changes in the relations between the state and its constituent peoples. The Philippine state has been separated from the Philippine nations, following a culture-bound path of its own so that its forms are less like those of its own ancestral heritage. It runs the risk of itself becoming a cultural minority in the view of its own constituents and in the affairs of the world. Somewhat, the problem of national integration has been reversed.

The financial base for implementation

The solution to national economic pressures lies to some extent in the dedication of adequate economic space for the development of community-led and community-based microenterprises. This is the bottom line for any sort of political or social autonomy at local levels. It has also been proven to be possible and effective.

Yet the national resources for effecting this economic guarantee to indigenous peoples are limited and likely to suffer increasing stress in the next decade. Much will depend on the next administration's ability to balance off national debt, the contributions of macroenterprises and the diversification and extension of local production and exchange networks among small producers. The same balance must be struck between the economic and ecological aspects of resource use.

Enforcement

The essence of any international covenant is its effect on conditions, actions and sectors that it addresses. Effective application is dependent on the mechanisms for enforcement of the agreement. Regarding international covenants like ILO Convention 169 on the rights of indigenous peoples:

Apparentely an international instrument should not only guarantee land rights in principle, but also establish procedures by which indigenous peoples and their support groups can seek redress in case of violation. .... An international instrument cannot stipulate the exact penalties and
recourse procedures. But it is very much to be hoped that the principle can be included in a revised Convention, allowing for more detailed regulation at the national level (Plant 1989).

A basic consideration is the relationship between the enforcement potential and the empowerment of indigenous peoples to represent their interests nationally and internationally. To attain full participation, even in their own affairs, indigenous peoples must hurdle not only the barriers of access to national forums but also the greater obstacles to direct representation at international support forums.

It is up to indigenous organizations in individual countries to ensure that they are consulted by governments before the final proposals and comments are made for the text of a revised Convention. In addition, they should press for inclusion on the delegations with full voting rights either as advisers to governments or as members of accredited worker delegations (Plant 1989).

Such a right or obligation, so freely allowed, is rather cheaply extended. It carries nothing of the costs of establishing the conditions under which it may be exercised.

**Summation**

With little regard to the form that a national organization may take, a persisting locus of control and the resulting direction of flows within that system is likely to operate within that form to maintain existing process. As long as the orientation of upland production systems is outwards, militating against necessary investments in internal economic diversification, the force of decision making will remain external to upland communities and their environments. With a continuing lack of reciprocal, if not equitable, exchanges between the local and the national segments, the capabilities and options of local residents will tend to erode progressively, while the most accessible raw materials of the natural environment are traded off for immediate economic relief or for conversion into other spheres than upland production systems. A lack of responsible interdependence among public, private, local and national entities in efforts for either upland rural enabling or for sustainable resource management are critical factors that initiates and concludes this cycle of degradation.

However, movements away from communal responsibility for resource regulation and towards individualized protectionism have become necessary coping mechanisms for upland communities in the Cordillera. Common properties like clan lands and open access forest have been privatized, at least regarding legal documentation, by individuals through tax declaration as the only means of securing claims validated only by long-term residence and customary law.

The resource use system of upland communities cannot be sustained in ecological or economic terms without equity in responsibility and returns. Neither sustainability nor equity is possible without local autonomy in the allocation and regulation of resources. Among the critical resources of the uplands is the resource of communal capacity lost to political and economic centres along with the outflow of raw materials.

**References**


A Parcel-based Watershed Analysis Across Agroecosystems

by

Sam Fujisaka, Pat Elliot and Emelita Jayson

Introduction

The Sustainable Agriculture and Natural Resource Management Collaborative Research Support Programme (SANREM CRSP) has so far conducted preliminary characterization work in the Manupali Watershed (Figure 1) in the Philippines. Four major agroecosystems in the watershed are, from highest to lowest points of the landscape, the forest margin, degraded but cropped grasslands, an area of permanent cultivation of maize and sugarcane and lowland irrigated rice. In support of the SANREM CRSP (but funded wholly by the International Rice Research Institute, IRRI), the authors sought to further understand farmers' use of resources across the watershed and to better identify researchable constraints and opportunities, especially those based on farmer knowledge and practice.

The Manupali Watershed is located in north-central Mindanao in the Province of Bukidnon in the Southern Philippines. The Manupali River drains 80,000 ha and itself into the Pulangi River, which flows on through several reservoirs constructed to supply irrigation water and generate hydroelectric power. Average annual rainfall is about 2300 mm with a May to December rainy season. Elevation ranges from 320 to 2938 m, with the highest point being the summit of the volcanic Mt. Kitanglad.

Some 44 percent of the land in the watershed is steeply sloping (gradient in excess of 40 percent); 29 percent is rolling to hilly; and 27 percent is flatland (FORI 1982). Annual soil erosion rates have been estimated to be about 160 t/ha in the forest margins, 170 t/ha in the grasslands, and almost 600 t/ha in the maize growing areas (FORI 1982). Predominate soils in the watershed are the light to dark brown Aduyon clays and the reddish brown to brown Kidapawan clay loams. The watershed was deforested from the 1920s to present, with 45 percent of forest cover lost between 1950 and 1987 alone (Kummer 1992).

Methods

A preliminary survey indicated that the Lantapan watershed has several agroecological zones, including forest margins, grasslands, an area where maize and sugar cane are the major crops grown for both commercial and subsistence and an area of the lowest portions of watershed were lowland irrigated rice is grown. Forty-five parcels each in the forest margins, the grasslands and the maize growing area, were identified as well as 61 lowland rice parcels. Each user (owner, tenant or lessee) was interviewed about resources and resource use, crops and crop management, perceptions of problems, problem solving approaches and other factors that would give a broad picture of the Lantapan watershed and some of the key issues for research in seeking user-appropriate sustainable resource use management systems. The researchers identified weeds present in the parcels, measured field slopes, and scored soil erosion. A geopositioning device was used in an attempt to precisely locate each parcel and its boundaries. Data is tabulated and presented in the form of simple frequencies and means. Research needs are synthesized from the data and presented somewhat in the form of informal hypotheses in the concluding sections.
Table 1. *Ethnic mix (percent of each subsample) in four agroecosystems, Lantapan, Bukidnon, 1993*

<table>
<thead>
<tr>
<th>Origin/Group</th>
<th>Forest Margin (n=45)</th>
<th>Grassland (n=45)</th>
<th>Maize/Cane (n=45)</th>
<th>Paddy (n=61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talaandig*</td>
<td>60</td>
<td>56</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Dumagat</td>
<td>40</td>
<td>42</td>
<td>80</td>
<td>95</td>
</tr>
<tr>
<td>Mindanao</td>
<td>34</td>
<td>11</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Visayan</td>
<td>56</td>
<td>11</td>
<td>86</td>
<td>85</td>
</tr>
<tr>
<td>Luzon</td>
<td>11</td>
<td>32</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Unspecified</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Mixed</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

* Talaandig are native to the area; Dumagats are members of the main ethnic groups of the country.

Table 2. *Duration of cultivation, Lantapan, Bukidnon*

<table>
<thead>
<tr>
<th>Owners:*</th>
<th>Forest Margin</th>
<th>Grassland</th>
<th>Maize/Cane</th>
<th>Paddy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>1st, 2nd</td>
<td>1st</td>
<td>2nd</td>
<td>1st</td>
<td>2nd</td>
</tr>
<tr>
<td>1 - 5</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>6 - 10</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11 - 15</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>16 - 20</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>21 - 25</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>26 - 30</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>31+</td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Means</td>
<td>20</td>
<td>5</td>
<td>21</td>
<td>10</td>
</tr>
</tbody>
</table>

* 1st, refers to original owners and settlers; 2nd refers to current owners/operators who obtained the land from someone else.

Table 3. *Mean size (ha) and location of parcels studied in four agroecosystems*

<table>
<thead>
<tr>
<th>Origin/Group</th>
<th>Forest Margin (n=45)</th>
<th>Grassland (n=45)</th>
<th>Maize/Cane (n=45)</th>
<th>Paddy (n=61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main parcel</td>
<td>2.54</td>
<td>1.77</td>
<td>2.26</td>
<td>1.78</td>
</tr>
<tr>
<td>Other parcels</td>
<td>2.28</td>
<td>1.08</td>
<td>1.92</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Location of other parcels (percent of each sub-sample)

<table>
<thead>
<tr>
<th></th>
<th>forest margin</th>
<th>grassland</th>
<th>maize/cane</th>
<th>paddy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24</td>
<td>6</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>33</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>21</td>
</tr>
</tbody>
</table>
Table 4. The number of parcels owned by farmers and their location as a percentage of the number of parcels in the agroecosystem

<table>
<thead>
<tr>
<th>Number of parcels</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>2</td>
<td>58</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td>69</td>
<td>67</td>
<td>42</td>
<td>38</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>27</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Results

Thirty percent of sampled respondents were native Talaandig and 70 percent were migrant Dumagat settlers representing the main language groups of the country. Most Dumagat settlers were Visayans from the central Philippines or other parts of Mindanao. The migrant settlers control the lands on the lower slopes while upper slopes are dominated by ethnic natives. Talaandig were dominant in the forest margins, both groups were approximately equally represented in the grasslands and Dumagats dominated commercial maize/sugar cane and lowland rice areas (Table 1).

Somewhat surprisingly, the different upland areas were settled or placed under cultivation more or less simultaneously. For parcels still cultivated by their first owners (de facto or de jure), maize parcels were cultivated for a mean period of 25 years, grassland parcels for 21 years and forest margin parcels for 20 years (Table 2). The paddy fields were cultivated for a mean period of 13 years, reflecting later (i.e., compared to upland areas) development of irrigation infrastructure in the lowlands parcel size was about 2 ha mean size of studied parcels ranged from 1.8 to 2.5 ha across the four agroecosystems (Table 3). More than one-third of the farmers also had other parcels, usually within the same agroecosystem. Twenty-four percent of forest margin farmers had other parcels in the forest margin; a third of grassland farmers had other grassland parcels; 27 percent of maize area farmers had other fields in that agroecosystem; and a fifth of rice farmers had other lowland rice fields.

In terms of resource exploitation across agroecosystems, more than a third of lowland rice farmers also had parcels in the maize area. For farmers having other parcels, additional parcels were of similar

Table 5. Farmers' classification and description (percent of each sub-sample) of soils on studied parcel, Lantapan, Bukidnon

<table>
<thead>
<tr>
<th>Perception</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reddish</td>
<td>74</td>
<td>45</td>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>Acidic</td>
<td>0</td>
<td>27</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Loose/friable</td>
<td>10</td>
<td>30</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Requires fertilizer</td>
<td>0</td>
<td>24</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Sticky when wet</td>
<td>16</td>
<td>9</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Rocky</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Soil</td>
<td>44</td>
<td>11</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>Blackish</td>
<td>30</td>
<td>60</td>
<td>67</td>
<td>50</td>
</tr>
<tr>
<td>reddish brown</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Rocky</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Loose/friable</td>
<td>15</td>
<td>60</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Does not need fertilizer</td>
<td>5</td>
<td>20</td>
<td>33</td>
<td>6</td>
</tr>
<tr>
<td>Not sticky when wet</td>
<td>5</td>
<td>80</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* mean maize of other parcels considering only farmers with additional parcels
Table 6. Farmer’s descriptors of lands and soils, Lantapan, Bukidnon, 1993

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil descriptors</strong></td>
<td>Poor soils</td>
</tr>
<tr>
<td><em>Omag nga yuta</em></td>
<td>Poor soils</td>
</tr>
<tr>
<td><em>pula/pula-pula/pulahon</em></td>
<td>red/reddish</td>
</tr>
<tr>
<td><em>dalag/dalag-dalag/dalogen</em></td>
<td>yellow/yellowish</td>
</tr>
<tr>
<td><em>brown</em></td>
<td>brown</td>
</tr>
<tr>
<td><em>bugkaw/luspad</em></td>
<td>acidic</td>
</tr>
<tr>
<td><em>pili kon mahasa</em></td>
<td>sticky when wet</td>
</tr>
<tr>
<td><em>humok kon mahasa</em></td>
<td>soft when wet</td>
</tr>
<tr>
<td><em>dati malaniok</em></td>
<td>compacted</td>
</tr>
<tr>
<td><em>batoon</em></td>
<td>rocky/stony</td>
</tr>
<tr>
<td><em>pughay/bukagay</em></td>
<td>loose/friable</td>
</tr>
<tr>
<td><em>balason/balas-balason</em></td>
<td>sandy</td>
</tr>
<tr>
<td><em>lamgud/pobre</em></td>
<td>infertile</td>
</tr>
<tr>
<td><em>doot ang tanom</em></td>
<td>poor crop stand</td>
</tr>
<tr>
<td><em>nakaubo na ang ani</em></td>
<td>low, declining yield</td>
</tr>
<tr>
<td><em>banlas</em></td>
<td>eroded</td>
</tr>
<tr>
<td><strong>Tambok/talunok nga yuta</strong></td>
<td>Rich soil</td>
</tr>
<tr>
<td><em>itom/itom-itom</em></td>
<td>black/blackish</td>
</tr>
<tr>
<td><em>itom sagol pulu</em></td>
<td>reddish black</td>
</tr>
<tr>
<td><em>brown</em></td>
<td>brown</td>
</tr>
<tr>
<td><em>pula sagol brown</em></td>
<td>reddish brown</td>
</tr>
<tr>
<td><em>batoon</em></td>
<td>rocky</td>
</tr>
<tr>
<td><em>balason/balas-balason</em></td>
<td>sandy</td>
</tr>
<tr>
<td><em>dift kaayo pilit</em></td>
<td>slightly sticky</td>
</tr>
<tr>
<td><em>pughay/bukagay</em></td>
<td>loose friable</td>
</tr>
<tr>
<td><strong>Land descriptors</strong></td>
<td></td>
</tr>
<tr>
<td><em>lati</em></td>
<td>fallowed (5+ years)</td>
</tr>
<tr>
<td><em>bakilid</em></td>
<td>hilly</td>
</tr>
<tr>
<td><em>patag</em></td>
<td>flat</td>
</tr>
<tr>
<td><em>hanuyhay</em></td>
<td>gently sloping</td>
</tr>
<tr>
<td><em>pongang/bakilid kaayo</em></td>
<td>steep</td>
</tr>
<tr>
<td><em>kamad-an</em></td>
<td>upland</td>
</tr>
<tr>
<td><em>bukagay/hasakan</em></td>
<td>lowland rice fields</td>
</tr>
</tbody>
</table>

Farmers described the inherent productivity of their soils. Their systems of characterization and classification of lands and soils (Tables 5, 6) focused on poorer (*omaw*) versus richer (*tambok*) soils, and were based on colour, texture and its need for inorganic fertilizer. Across agroecosystems, poor soils were described as red or reddish (*pula*) and acidic (*luspad*) while better soils were black(ish) (*itom*) and required less fertilizer. Forest margin and grassland farmers preferred lighter (*balason*) soils which did not become sticky when wet while, on the other hand, paddy rice farmers reported lower productivity from lighter *bukagay* (loose or friable) soils.

Maize was the most extensively planted crop in the forest margin, grassland and maize areas (Table 7). Rice, of course, was the crop of the paddy area. Potato, sweet potato and vegetables were also produced by farmers living in the forest margin. Minor crops included upland rice, coffee and banana. Although the are planted to sugar cane was observed to be substantial in the maize area, only two cane fields, and these in the "grassland" ecosystem, were included in the survey. Farmers produced maize and sweet potato primarily for own consumption, potato and vegetables for cash sales and rice for both for family consumption and for sale (see table 8).
Farmers identified the problems related to their individual parcels and to the crops grown on each (Table 9). In terms of parcels, poor access, soil erosion, low soil fertility and land tenure arrangements were problems for forest margin farmers. Soil erosion and low soil fertility were problems in the grasslands. Farmers in the maize areas saw soil fertility, soil erosion, acidic soils and weeds as major problems. Paddy farmers faced problems of insufficient water and too many weeds. Crop or management problems included insects, diseases and lack of capital in all but the maize area where low and declining yield was also identified.

Crop yields may be declining. Farmers reported yields for 1992 and for past seasons they could recall (see table 10). Current maize yields were reported as about 0.7 t/ha in both the forest margin and maize areas, and 0.9 t/ha in the grasslands. Lowland rice yields averaged 3.5 t/ha. Considering past yields, 60 to 80 percent of the respondents in the different agroecosystems reported declining yields of about 0.7 t/ha of maize and 1.5 t/ha of rice. Sixty-seven percent of forest margin farmers reported a mean decrease in maize yields of 0.65 t/ha (or a 50 percent decrease) for the period 1970 to 1992. Grassland farmers' average maize yield decrease was 0.76 t/ha (45 percent reduction) for 1964 to 1992. Eighty percent of maize area farmers, the highest proportion, reported a 0.74 t/ha decrease (or 52 percent, the greatest reduction) for 1950 to 1992. Finally, rice farmers' rice yields decreased an average 1.48 t/ha (30 percent) for the period 1952 to 1992.

On the other hand, a few farmers (11 percent) and maize areas reported maize yield increases of about 0.5 t/ha while 20 percent of the rice farmers reported increases of 1.38 t/ha. Why two-thirds of the rice farmers reported an approximate 1.5 t/ha decline in yields while one-fifth reported a similar increase was not determined. Overall, sustainability of the upland production system appears to be in danger.

Almost all maize area farmers, and about half of the farmers in the forest margin, grassland and paddy areas, identified indicators of soil nutrient depletion (Table 11). Forest margin and grassland farmers had observed low or declining yields and poor crop stand; while maize area and rice farmers reported that more fertilizer was now needed to produce the crop. Clearly, the maize area farmers are the most concerned about soil nutrient depletion, as evidenced by their increased use fertilizer. Some 40

<table>
<thead>
<tr>
<th>Solution</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>73</td>
<td>80</td>
<td>89</td>
<td>2</td>
</tr>
<tr>
<td>Potato</td>
<td>24</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>24</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Vegetable</td>
<td>16</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rice (irrigated)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>98</td>
</tr>
<tr>
<td>Rice (upland)</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Coffee</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Banana</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8. Farmer (% each sub-sample) use of major crops, Lantapan, Bukidnon

<table>
<thead>
<tr>
<th>Crop/Use</th>
<th>Forest Margin</th>
<th>Grassland</th>
<th>Maize/Cane</th>
<th>Paddy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cash</td>
<td>Consumption</td>
<td>Cash</td>
<td>Consumption</td>
</tr>
<tr>
<td>Maize</td>
<td>12</td>
<td>100</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Potato</td>
<td>100</td>
<td>9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>9</td>
<td>91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vegetables</td>
<td>100</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rice</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 9. **Farmers' reported problems (% each sub-sample), Lantapan, Bukidnon**

<table>
<thead>
<tr>
<th>Problem</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Related to land or parcel</td>
<td>20</td>
<td>20</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>Difficult access</td>
<td>16</td>
<td>33</td>
<td>69</td>
<td>10</td>
</tr>
<tr>
<td>Soil erosion</td>
<td>16</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Low soil fertility</td>
<td>0</td>
<td>4</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td>Land tenure</td>
<td>0</td>
<td>2</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>Acidic soils</td>
<td>16</td>
<td>2</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Weeds</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>54</td>
</tr>
<tr>
<td>Insufficient water</td>
<td>16</td>
<td>2</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>None</td>
<td>58</td>
<td>51</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Insects and diseases</td>
<td>51</td>
<td>73</td>
<td>40</td>
<td>43</td>
</tr>
<tr>
<td>Lack of capital</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Low market price</td>
<td>2</td>
<td>13</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Weeds</td>
<td>2</td>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strong winds</td>
<td>2</td>
<td>2</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Low and declining yield</td>
<td>13</td>
<td>13</td>
<td>7</td>
<td>11</td>
</tr>
</tbody>
</table>

Related to crop(s)

<table>
<thead>
<tr>
<th>Perception</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current yields (t/ha)</td>
<td>0.66</td>
<td>0.94</td>
<td>0.69</td>
<td>3.51</td>
</tr>
<tr>
<td>Yields have decreased (% farmers)</td>
<td>6.7</td>
<td>58</td>
<td>80</td>
<td>64</td>
</tr>
<tr>
<td>Mean reported decrease (t/ha)</td>
<td>0.65</td>
<td>0.76</td>
<td>0.74</td>
<td>1.48</td>
</tr>
<tr>
<td>% decrease</td>
<td>50</td>
<td>45</td>
<td>52</td>
<td>30</td>
</tr>
<tr>
<td>Yields have increased (% farmers)</td>
<td>0</td>
<td>11</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Mean perceived increase (t/ha)</td>
<td>-</td>
<td>0.45</td>
<td>0.50</td>
<td>1.38</td>
</tr>
<tr>
<td>No change (% farmers)</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Do not know (% farmers)</td>
<td>27</td>
<td>22</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

To 80 percent of respondents from each agroecosystem identified causes of soil nutrient depletion (Table 12). Reasons were maize monocropping or continuous cropping on the one hand and soil erosion on the other.

Portions (24–62 percent) of the farmers in each agroecosystem identified solutions to the problem of soil nutrient depletion (Table 13). Use of more fertilizer was the most frequently reported "solution," although grassland farmers named contour ploughing and planting as important and maize area and rice farmers mentioned the application of lime. A few forest margin farmers also correctly regarded fallowing fields and shifting cultivation as solutions to soil nutrient depletion.

A problem across upland fields (Table 14). Fields in the forest margin, grassland and maize areas all have similar proportions of fields with low (27 to 43 percent of fields), medium (36 to 51 percent of fields) or high (16 to 22 percent of fields) levels of soil erosion. The forest margin had a slightly lower proportion of fields showing no erosion and a slightly higher proportion of fields having high erosion compared to the two other upland systems. Reflecting and contributing to the problem, almost one-fourth of forest margin and grassland fields had slopes of 20 to 50 percent while forest margin fields were the steepest and included the highest proportion of highly irregular within-field slopes, followed by the grasslands and then by the maize areas (Table 15).

Table 10 **Farmers’ maize and rice yields and their perceived changes**

<table>
<thead>
<tr>
<th>Perception</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current yields (t/ha)</td>
<td>0.66</td>
<td>0.94</td>
<td>0.69</td>
<td>3.51</td>
</tr>
<tr>
<td>Yields have decreased (% farmers)</td>
<td>6.7</td>
<td>58</td>
<td>80</td>
<td>64</td>
</tr>
<tr>
<td>Mean reported decrease (t/ha)</td>
<td>0.65</td>
<td>0.76</td>
<td>0.74</td>
<td>1.48</td>
</tr>
<tr>
<td>% decrease</td>
<td>50</td>
<td>45</td>
<td>52</td>
<td>30</td>
</tr>
<tr>
<td>Yields have increased (% farmers)</td>
<td>0</td>
<td>11</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Mean perceived increase (t/ha)</td>
<td>-</td>
<td>0.45</td>
<td>0.50</td>
<td>1.38</td>
</tr>
<tr>
<td>No change (% farmers)</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Do not know (% farmers)</td>
<td>27</td>
<td>22</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

- 74 -
Almost all farmers were aware of the problem of soil erosion in that they readily described the processes and its associated problems (Table 16). About half of all upland farmers reported using practices that helped to reduce soil erosion (Table 17). These included contour ploughing and planting; construction of protective drainage canals around fields; planting or maintenance of perennials at the foot of slopes to slow runoff and trap sediments; and the use of contour hedgerows or strips. As an issue for further investigation (e.g., where did the idea or practice come from? How much adoption has there been?), more than one third of the grassland farmers identified contour strips as a solution to soil erosion.

Some forest margin and grassland farmers may be underestimating the problem of soil erosion. The approximately one-third of forest margin and grassland farmers not using soil erosion control measures reported that their lands were sufficiently flat such that soil erosion was not a problem (Table 18). On the other hand, a similar proportion of maize area farmers not practising soil conservation measures indicated that they lacked knowledge of appropriate corrective measures. Fields were monitored for weed composition (Table 19). Fallowed fields in the forest margin were dominated by the grasses *Paspalum conjugatum* (found in all of the fields), *Imperata cylindrica* (all fields) and *Saccharum spontaneum* (found in 67 percent of the fields) and to a lesser degree, by the broadleaved weeds *Bidens pilosa*, *Ageratum conyzoides*, *Elephantopus spicatus*, *Crassacephalum crepidioides*, and *Tithonia diversifolia*. Major weeds in the cropped forest margins were *Bidens pilosa* (60 percent of the fields) and *Ageratum conyzoides* (60 percent of the fields). In addition to the same broadleaves *Bidens pilosa* and *Ageratum conyzoides*, grassland fields were infested with the grasses *P. polystachion* (56 percent) and *Rottboellia cochinchinensis* (42 percent). Weeds in the maize areas were *Borreria laevis* (53 percent) as well as *Bidens pilosa* (62 percent) and *Ageratum conyzoides* (44 percent) and an increase in the presence of the difficult to control grasses *Rottboellia cochinchinensis* (69 percent) and *Digitaria longiflora* (27 percent). Lowland rice fields faced problems with the grasses *Echinocloa glabrascens* (in 67 percent of the fields) and *Ischaemum rugosum* (in 62 percent of the fields; Table 20).

Farmers identified their main weed problems as *Bidens pilosa* and *Ageratum conyzoides* in the forest margins, *Rottboellia cochinchinensis* and *Bidens pilosa* in the grasslands; *Rottboellia cochinchinensis* in the maize/sugar cane areas; and *I. rugosum* and *E. glabrascens* in lowland rice (Table 21). Farmers'
Table 13. *Farmers' (% each sub-sample and % those naming causes) perception of causes of soil nutrient depletion, Lantapan, Bukidnon*

<table>
<thead>
<tr>
<th>Solution</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% sub-sample responding</td>
<td>36</td>
<td>24</td>
<td>62</td>
<td>46</td>
</tr>
<tr>
<td>Fertilizer and Manure</td>
<td>44</td>
<td>27</td>
<td>68</td>
<td>86</td>
</tr>
<tr>
<td>Fallow fields</td>
<td>19</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Shifting cultivation</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Contour ploughing, planting</td>
<td>6</td>
<td>73</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Liming</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 14. *Estimated erosion on parcels (% of parcels in each) in four agroecosystems*

<table>
<thead>
<tr>
<th>Erosion</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Low*</td>
<td>35</td>
<td>27</td>
<td>43</td>
<td>0</td>
</tr>
<tr>
<td>Medium</td>
<td>40</td>
<td>51</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>High</td>
<td>22</td>
<td>16</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>

* Erosion scored by the researchers

Table 15. *Parcel (%) slope in four agroecosystems, Lantapan, Bukidnon*

<table>
<thead>
<tr>
<th>Slope</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>77</td>
</tr>
<tr>
<td>Rolling (01-19%)</td>
<td>61</td>
<td>69</td>
<td>86</td>
<td>23</td>
</tr>
<tr>
<td>Steep (20-50%)</td>
<td>24</td>
<td>22</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Highly irregular*</td>
<td>14</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* slopes within each of these parcels highly varied (e.g. 5-40%)
### Table 16. Farmer knowledge and practice (% of each sub-sample) relative to soil erosion, Lantapan, Bukidnon

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No ideas expressed</td>
<td>2</td>
<td>11</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Idea* but no practices</td>
<td>24</td>
<td>11</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>Idea + practices**</td>
<td>58</td>
<td>60</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Idea but &quot;no problem&quot;</td>
<td>16</td>
<td>18</td>
<td>13</td>
<td>100</td>
</tr>
</tbody>
</table>

* Described soil erosion processes and problems  
** Described in next Table

### Table 17. Farmers' reported practices (% each sub-sample and % of sub-sample using particular practice) to control soil erosion, Lantapan, Bukidnon

<table>
<thead>
<tr>
<th>Practice</th>
<th>Forest Margin</th>
<th>Grassland</th>
<th>Maize/Cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>% sub-sample reporting practice</td>
<td>58</td>
<td>47</td>
<td>56</td>
</tr>
<tr>
<td>Contour ploughing/planting</td>
<td>35</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Drainage canal around field</td>
<td>15</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>Plant perennials on slope foot</td>
<td>15</td>
<td>16</td>
<td>44</td>
</tr>
<tr>
<td>Contour hedgerows/natural strips</td>
<td>12</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>Pile residues on contour</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fallow and shifting cultivation</td>
<td>8</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Dibble planting</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No ploughing on steep slopes</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No cropping of steep lands</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Leave grassy field boundaries</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 18. Farmers' reasons for not practicing erosion control measures

<table>
<thead>
<tr>
<th>Practice</th>
<th>Forest Margin</th>
<th>Grassland</th>
<th>Maize/Cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>% sub-sample not using practice</td>
<td>42</td>
<td>29</td>
<td>36</td>
</tr>
<tr>
<td>Rate of erosion is low</td>
<td>5</td>
<td>31</td>
<td>6</td>
</tr>
<tr>
<td>Land is flat</td>
<td>21</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>Lack knowledge of prevention</td>
<td>21</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>Existing perennials control</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No answer</td>
<td>42</td>
<td>38</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 19. **Absolute frequency** (% of fields) of weed species in cropped and fallow areas of three upland agroecosystems, Lantapan, Bukidnon

<table>
<thead>
<tr>
<th>Weed species</th>
<th>Fallow**</th>
<th>Cropped fields</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forest Margin (n = 45)</td>
<td>Grassland (n = 45)</td>
</tr>
<tr>
<td>Bidens pilosa</td>
<td>67</td>
<td>69</td>
</tr>
<tr>
<td>Ageratum conyzoides</td>
<td>67</td>
<td>60</td>
</tr>
<tr>
<td>Paspalum conjugatum</td>
<td>100</td>
<td>37</td>
</tr>
<tr>
<td>Sida rhombifolia</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>Peristium aquilinum</td>
<td>67</td>
<td>24</td>
</tr>
<tr>
<td>Galinsoga parviflora</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>Pennisetum polyziacanthos</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>Imperata cylindrica</td>
<td>100</td>
<td>18</td>
</tr>
<tr>
<td>Elephantopus speciosus</td>
<td>67</td>
<td>18</td>
</tr>
<tr>
<td>Crassocephalum crepidioides</td>
<td>67</td>
<td>16</td>
</tr>
<tr>
<td>Rottboellia cochinchinensis</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Rhynchelemum repens</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>Borreria laevis</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Euphorbia heterophylla</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>Digitaria longiflora</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>Hypsia cypribrides</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Stackhutarpa jamanacens</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>Lamara camara</td>
<td>33</td>
<td>-</td>
</tr>
<tr>
<td>Saccharum spontaneum</td>
<td>67</td>
<td>-</td>
</tr>
<tr>
<td>Hypoxis decumbens</td>
<td>33</td>
<td>-</td>
</tr>
<tr>
<td>Tithonia diversifolia</td>
<td>67</td>
<td>-</td>
</tr>
</tbody>
</table>

* Absolute frequency is the number of parcels on which a given species occurred. Total no. of parcels = 100.

** 2 fields fallowed for two years and another for one year.

perceptions basically agreed with those made by the researchers carrying out the field observations but there was more emphasis upon the species of weeds that are the most difficult to control.

Reliance on the forest for products, mainly firewood and timber for house construction, was highest in the forest margins and lowest (nonexistent) in the lowland rice zone (Table 22). While relative use of forest resources across different agroecosystems is probably correct, the non-use of forest products (from 27 percent of respondents in the forest margins to 100 percent in the rice area) may have been underestimated due to legal sanctions against such use. Reliance on credit, as opposed to self-financing,

Table 20. **Absolute frequency of lowland rice weed species, Lantapan, Bukidnon, 1993**

<table>
<thead>
<tr>
<th>Weed species</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echinochloa glabrescens</td>
<td>67</td>
</tr>
<tr>
<td>Ischaemum rugosum</td>
<td>62</td>
</tr>
<tr>
<td>Echinochloa colona</td>
<td>31</td>
</tr>
<tr>
<td>Fimbristylis miliacea</td>
<td>23</td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>29</td>
</tr>
<tr>
<td>Cyperus iria</td>
<td>13</td>
</tr>
<tr>
<td>Echinochloa crus-galli</td>
<td>11</td>
</tr>
<tr>
<td>Cynodon nep (stargrass)</td>
<td>11</td>
</tr>
<tr>
<td>Cyperus difformis</td>
<td>10</td>
</tr>
<tr>
<td>Monochoria vaginatae</td>
<td>8</td>
</tr>
<tr>
<td>Brachysia mutica</td>
<td>5</td>
</tr>
<tr>
<td>Ludwigia octovalvis</td>
<td>5</td>
</tr>
<tr>
<td>Paspalum distichum</td>
<td>3</td>
</tr>
<tr>
<td>Scirpus juncoides</td>
<td>2</td>
</tr>
</tbody>
</table>

- 78 -
for crop production decreased as parcels moved up-slope, with 41 percent of lowland rice and 76 percent of forest margin farmers being self financed (Table 23). Almost all farmers using credit did so by obtaining loans from local informal (sukt) sources. The exception was that one-fifth of the maize area farmers (or 35 percent of those obtaining credit) borrowed from a bank.

With reference to the problems associated with land tenure arrangements, roughly one-third of the upland farmers and two-thirds of the lowland rice farmers were tenants (Table 24). Most upland tenants paid 25 to 50 percent of their production to their landlord (Table 25), with higher proportions paid if the landowner provided inputs such as draft animals, seed and fertilizer. A few tenants cultivating fields owned by relatives kept all of their production. In the lowland rice areas, farmers normally paid a 25 percent share to the landowners.

Finally, and in terms of parcel accessibility, forest margin and grassland parcels were located somewhat farther from farmers' houses compared to the maize area and lowland rice parcels (Table 26). As expected, some forest margin parcels were quite far from the nearest road (15 percent were located at a distance of 6 km or more). On the other hand, about 70 percent of both maize area and lowland paddy parcels were located 1.0-5.0 km from the nearest road while a similar proportion of grassland fields were closer, within one kilometre of the road.

**Research issues**

Several issues, which can be addressed by research or which need to be considered if such research is conducted, were identified from the parcel survey and analysis. These are artificially separated into four

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**Table 21. Farmers' (% reporting) problem weeds, Lantapan, Bukidnon, 1993**

<table>
<thead>
<tr>
<th></th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Lowland rice (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bidens pilosa</td>
<td>33</td>
<td>23</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>Ageratum conyzodes</td>
<td>25</td>
<td>16</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Hypoxis decumbens</td>
<td>17</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Paspalum conjugatum</td>
<td>17</td>
<td>5</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Galinsoga parviflora</td>
<td>6</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Digitaria longiflora</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Raphiaella cochinichiena</td>
<td>-</td>
<td>27</td>
<td>60</td>
<td>-</td>
</tr>
<tr>
<td>Digitaria setigera</td>
<td>-</td>
<td>2</td>
<td>11</td>
<td>-</td>
</tr>
<tr>
<td>Pennisetum polystachion</td>
<td>-</td>
<td>9</td>
<td>13</td>
<td>-</td>
</tr>
<tr>
<td>Borroeria laevis</td>
<td>-</td>
<td>-</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>Cynodon dactylon *</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Mimosa invisa</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Mimosa pudica</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Stachytarpheta jamaicensis</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Ischaemum rugosum</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>48</td>
</tr>
<tr>
<td>Echinochloa glabrescens</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>Cynodon spp.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>Cyperus spp.*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>9</td>
</tr>
</tbody>
</table>

* Cyperus iria, Cyperus difformis, Cyperus rotundus and Fimbristylis miliacea

---

**Table 22. Farmers' (% each sub-sample) use of forest resources, Lantapan, Bukidnon**

<table>
<thead>
<tr>
<th>Solution</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>27</td>
<td>60</td>
<td>87</td>
<td>100</td>
</tr>
<tr>
<td>Firewood</td>
<td>49</td>
<td>27</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Timber (housing)</td>
<td>67</td>
<td>36</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

---
Table 23. *Sources of capital (% each sub-sample) for crop production, Lantapan, Bukidnon*

<table>
<thead>
<tr>
<th>Source</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-financed</td>
<td>76</td>
<td>62</td>
<td>42</td>
<td>41</td>
</tr>
<tr>
<td>Local lenders</td>
<td>22</td>
<td>38</td>
<td>38</td>
<td>57</td>
</tr>
<tr>
<td>Bank</td>
<td>2</td>
<td>2</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Cooperative</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 24. *Land tenure of parcels (% each sub-sample), Lantapan, Bukidnon*

<table>
<thead>
<tr>
<th>Tenure</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>42</td>
<td>51</td>
<td>64</td>
<td>20</td>
</tr>
<tr>
<td>Tenant</td>
<td>36</td>
<td>31</td>
<td>31</td>
<td>67</td>
</tr>
<tr>
<td>Mortgage</td>
<td>22</td>
<td>16</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 25. *Tenant-owner shares (% each sub-plot), Lantapan, Bukidnon*

<table>
<thead>
<tr>
<th>Tenant-owner shares</th>
<th>Forest Margin (n = 45)</th>
<th>Grassland (n = 45)</th>
<th>Maize/Cane (n = 45)</th>
<th>Paddy (n = 61)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 - 75%</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>50 - 50%</td>
<td>75</td>
<td>45</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>70 - 30%</td>
<td>-</td>
<td>9</td>
<td>14</td>
<td>-</td>
</tr>
<tr>
<td>75 - 25%</td>
<td>-</td>
<td>18</td>
<td>43</td>
<td>88</td>
</tr>
<tr>
<td>80 - 20%</td>
<td>-</td>
<td>9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>85 - 15%</td>
<td>-</td>
<td>18</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>100 - 00%</td>
<td>25</td>
<td>-</td>
<td>14</td>
<td>5</td>
</tr>
</tbody>
</table>
"biophysical" and four "socioeconomic" issues.

1. Declining productivity due to soil nutrient depletion.

Farmers clearly characterized and assessed the potentials of their different lands and soils and were quite cognizant of soil nutrient depletion as a problem especially as a result of continuous cropping. Although they presumably matched crops and management practices to local constraints and potentials, farmers indicated that systems productivity is low and declining.

Soil nutrient status within the different agroecosystems needs to be determined and corresponding crop yields need to be monitored possibly by crop cut sampling over many fields and over time. Rice and commercial maize farmers have resorted to using more inorganic fertilizer to maintain yields while others are simply faced with lower yields. Clearly, research to improve nutrient cycling within the watershed is needed and such research can investigate alternatives to reliance upon inorganic fertilizers (e.g., inorganic fertilizers combined with recycling of legume biomass from either cover crops or woody perennials).

2. Declining productivity due to soil erosion.

Many of the upland farmers suggested soil erosion as a cause of low and declining crop yields. Soil erosion may be a problem on some fields and needs to be monitored. Farmers' awareness of such measures as contour ploughing and contour hedgerows may be an advantage if soil erosion is a problem and if such measures are shown to be appropriate in portions of the watershed (Fujisaka forthcoming a).

In light of research indicating that soil movement within watersheds is not necessarily highly correlated to movement within fields (Hamilton 1983), soil movement at the watershed level also needs to be monitored in order to analyze the relationship between up-slope systems and management practices, on the one hand, and downstream effects on the other.

3. Weeds

Farmers identified their problem weeds as being those difficult to control. Weed management techniques appropriate to the upland areas of the watershed would need to build upon farmers' current practices and knowledge and would most likely involve crop management systems that incorporate perennials (e.g., agroforestry systems), live mulches and cover crops. Such work on weed management would overlap considerably with research to develop improved soil nutrient cycling in the upland systems. In addition to weed management research, however, work is needed to characterize weed communities and their patterns of succession over time, given different farmers' management regimes and the different ecosystems in the watershed.

4. Continued conversion of forest resources

Farmers did not identify deforestation as a significant problem. Farmers in the forest margins continue to extract timber and fuelwood from the remaining forest areas. The relatively long period
that farmers have exploited the parcels in the forest margins implies that conversion of forest to cropland may be slow or is no longer taking place and that expansion into lands suitable for agriculture has already taken place. Further monitoring to determine if patches of primary or mature secondary forest growth still exist and if farmers are still converting such areas into cropped lands is needed.

5. Lack of or high cost of capital as a farmer constraint.

   Farmers' complaints of lack of capital combined with the fact that one-third of the upland farmers and about half of the lowland rice farmers rely upon local lenders, implies that further investigation regarding availability, costs, uses of and returns to credit is warranted. Policy recommendations may be called for if local credit markets are shown to be inefficient or inequitable.

6. Land tenure as a possible constraint to adoption of improved management techniques.

   With a third of the upland parcels and two-thirds of the lowland rice parcels leased, researchers need to keep in mind that tenants may be less likely or able to adopt improved land and crop management alternatives (Fujisaka forthcoming b).

7. Opportunity costs of technology adoption for farmers with multiple enterprises.

   The eventual adoption by farmers of technical alternatives meant to improve the sustainability or productivity of particular agroecosystems within a watershed must consider that some farmers manage lands located in more than one subsystem (e.g., farmers with lowland paddy and upland maize fields). Such farmers may not be attracted to technologies specific to a particular agroecosystem if their incomes depend more upon another part of the watershed (Fujisaka 1993). Further research is needed to determine the relative allocations of labour and resources such farmers allocate to their different enterprises.

8. Conflicts among resource user groups as a constraint to improved resource management.

   Conflicts over access to resources can heavily influence users' adoption of more sustainable resource use strategies (Fujisaka forthcoming b, Fujisaka and Wollenberg 1991). In the case of the Manupali Watershed, it was not determined if conflicts existed between the native Talaandig and the now dominant Dumagat settlers. Research needs to define the relationships between the groups and the relative access each has to current and future resources. Not touched upon, but very important, are the relationship to gender of resource access and management issues.

Conclusions

Results of research conducted at the parcel level emphasizes problems and the potential for developing alternatives at the watershed level. Probably of more importance is the need for research to quantify interactions among the subsystems within a watershed. Change trends in soil nutrient status across the whole system need to be understood. Researchers need to determine if overall soil organic matter levels are declining in the uplands and if so what are the implications for sustainability. Potentials to increase overall organic matter levels in upland portions of watersheds need to be examined.

Soil erosion may be negatively affecting some of the upland plots. This means that knowledge of soil movement within the whole watershed will be necessary in order to prioritize research across the different agroecosystems. It may be that soil moves from the uplands downstream to negatively affect irrigation and hydroelectric systems. Such soil movement may or may not be the result of farmers' land management practices, however.

Although weeds obviously affect crop productivity, research also needs to determine if and how weed communities are changing within different portions of the watershed as a result of human activities.

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The easy to control broadleafed weeds are possibly being replaced by more noxious grasses. The implications of conversion of previously forested areas into expanses of *Imperata* needs to be examined.

Research needs to determine how much forest is left in each watershed, how fast the remainder is being converted to other uses and what are the implications of such conversion. Research must determine what is the optimal amount of forested land and for what purposes can it be used. Policy decisions must be made regarding the degree to which biodiversity is well represented by the remaining forest and can and should such diversity be maintained? The goals of government policy in light of such questions must be fully considered. Research must seek a balance between attempts to improve the well-being of current resource users and, the necessity of protecting the welfare of future global inhabitants.

Finally, the more "socioeconomic" factors examined should not only serve to alert researchers to resource users' constraints. They should also help determine to what extent do combinations of such factors as high rates of tenancy, possibly expensive local credit sources and to what degree do potential conflicts among resource users limit the possibility that such users can work towards a more sustainable Manupali Watershed.

**References**


Fujisaka S. Forthcoming b. Learning from six reasons why farmers do not adopt innovations intended to improve sustainability of upland agriculture. *Agroforestry Systems*.


Agricultural Commercialization in the Sustainable Development of the Cordillera

by

Gladys A. Cruz, Victoria C. Diaz, Alicia G. Fолосco, Lorelei C. Mendoza, Steven Rood and Bienvenido P. Tapang, Jr.

Introduction.

The Cordillera Studies Centre (CSC), University of the Philippines, Baguio, is an interdisciplinary social science research institution with special interest in understanding development issues in the uplands of the Cordillera Region of the Philippines. Over the years, CSC has consistently shown an interest in the study of natural resource management issues as they relate to people's pursuit of improved standards of living. The fact that agriculture is, and is likely to continue to be, a major livelihood source in the Cordillera implies that the quality of life of people in the region will depend largely on the quality of their natural resources. At present, the Cordillera is experiencing rapid forest denudation and land degradation due to a combination of factors. These include population pressure, increased agricultural commercialization and inappropriate government policies.

This paper explores these factors as they affect sustainability. Some preliminary data from two (out of the six) communities studied under an IDRC-funded research entitled, "Indigenous Practices and State Policy: the Sustainable Management of Agricultural Lands and Forests in the Cordillera," are presented. These two communities are the commercial vegetable producing areas of Paoay, in Atok, and Mount Data, in Bauko. Where appropriate, data from the Agroecosystems Programme (hereafter referred to as AES), a CSC research programme, will also be used to provide a broader context in analyzing the social and biophysical changes in the region brought on by commercialization, population pressure and government policy.

The Cordillera

The Northern Luzon highlands are composed of a vast mass of mountain ranges covering an area of 18,293.6 square kilometres. Known as the Cordillera Administrative Region, it is politically subdivided into the provinces of Abra, Benguet, Ifugao, Kalinga-Apayao and Mountain Province (figure 1). Its unique physical as well as socio-cultural features allows one to describe it as a composite of diverse agroecological zones. The main landforms of the Cordillera are mountains, plateaus and valleys. The topography has been described as generally rugged with 60.77 percent of the total land area having a slope of over 50 percent. The rest has slopes that are almost evenly distributed from 0 to 50 percent. About six percent of the land area has slope ranging from eight to eighteen percent (figures 2 and 3).

The length of each mountain range ranges between 20 and 50 kilometres. Elevations vary from 5 metres (Abra) to a maximum of 2,922 metres above sea level (Mount Pulag, Benguet). This means that rainfall and temperatures are unevenly distributed even within short transects (figure 4). The average normal temperature during the coolest months, from December to February, is 21°C in Mountain Province and 25°C in Abra. During the summer months of April and May, temperature peaks at 25.06°C in the hills to 29°C in the lower elevations. Trends in the past show that in an average year, 95 percent of the rainfall occurs from April to November. Based on this, the region's climate may be described as a combination of humid and moist (NEDA-CAR n.d.).

The Cordillera is often seen as a separate region distinguished by a population that supposedly shares a common cultural tradition. The term is a convenient label often used to refer to the various
Figure 1  
Location of the Cordillera Region

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ethnolinguistic communities inhabiting the five provinces located in the Cordillera Mountain Range. The label implies unity among these communities, perhaps in terms of group identity or cultural origins. And in fact, there is what De Raedt (1987) refers to as a “unity of cultural tradition” as manifested by the technology used, the livelihood system combining swiddens and rice cultivation, prestige rituals and “leadership style.” The label may be convenient for administrative purposes but it belies the fact that there are major differences in terms of specific combinations of culture traits characteristic of each ethnolinguistic group or even communities of such groups.

For instance, although the communities are composed of predominantly indigenous peoples, there are those that are quite heterogenous demographically. Communities established in the 1950s are composed mainly of migrants from different ethnolinguistic groups within the region. Older communities (those settled much earlier) are usually homogenous and have evolved clear-cut social and political organizations. Here, some “traditional” institutions and mechanisms in resource management may still be found, albeit undergoing change to fit changing conditions.

However, these differences across communities are not as visible at first glance as the differences in their livelihood systems. Thus, a common way of categorizing the various communities found in the Cordilleras may be in terms of the degree and frequency of their interaction with the market system.

Table 1 Location of birthplace (percentages of household heads)

<table>
<thead>
<tr>
<th>Community</th>
<th>On the site</th>
<th>In the same province</th>
<th>Elsewhere in the Cordillera</th>
<th>Outside the region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambassador</td>
<td>49</td>
<td>32</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Paoay</td>
<td>56</td>
<td>30</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Mount Data</td>
<td>9</td>
<td>61</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Sinto</td>
<td>19</td>
<td>49</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Patay</td>
<td>60</td>
<td>32</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Suyo</td>
<td>47</td>
<td>41</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cudog</td>
<td>68</td>
<td>26</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Communities may be considered subsistent, transitional (shifting from subsistence to commercial production) or commercial. Subsistence communities tend to be traditional (for example, they still adhere to old practices or customs), while commercial communities may have lost such traditions because of modernizing influences resulting from the communities’ commercialization.

In agricultural terms, commercialization may be seen in three forms: first, the traditional crop is produced more efficiently such that a surplus over household needs is realized and marketed; second, high value crops (temperate vegetables like cabbage or potatoes) take the place of the subsistence crops; and third, the subsistence crop is combined with the cash crop. The latter is the most prevalent as households try to meet their basic food needs and cash requirements using their available agricultural resources previously devoted entirely to subsistence production. Some communities however, have responded to market opportunities by clearing the forests at elevations of about 1500 metres where temperatures are lower and rainfall higher and European type vegetables can be grown. Not all communities, however, are capable of producing vegetables. Primarily due to biophysical constraints such as temperature and elevation, some communities like Samoki, Bontoc, have remained subsistent with community practices revolving around the major activity of rice production.

The Cordillera is in fact composed of various ecological regions ranging from low lying areas with rolling and undulating hills, to areas characterized by hilly and mountainous topographies with steep
Figure 2  Topography of the Cordillera Region
slopes of 50 percent or more. Each ecoregion may be characterized by certain livelihood practices and perhaps even particular types of social and political organizations.

Issues of Sustainability

A central focus of the policies intended by the Philippine government to promote sustainability is the forest. This is seen in the 1990 Philippine Strategy for Sustainable Development in which forests were identified as indicators of sustainability for the following reason: "Since the Philippines was almost all forest in its natural state and since the country's topography and ecology appear to be significantly controlled by the ecological dynamics of the forests, the state of the forests could serve as a qualitative surrogate of environment quality," (Rood and Casambre 1993).

Having been identified as the "watershed cradle of Northern Philippines," because the "upper streams of river basins emanate from these watersheds," forest policy is of essential interest to the Cordillera region. Such policies necessarily impinge upon any regional development process in the area. In consonance with the government's position on land use in the Cordillera, the Regional Physical Framework Plan of 1991, formulated by the Regional Land Use Committee of the National Economic and Development Authority of the Cordillera Administrative Region, states that "as a general rule, only developmental activities consistent with the preservation/conservation role of the Region will be allowed." Consequently, areas devoted to agriculture "will be allowed provided they do not encroach on critical watersheds and forest preservations" (Rood and Casambre 1993).

The government is in a seemingly strong position to enforce these rules since most of the land is publicly owned (that is, all lands with slopes above 18 percent are forest lands and belong to the public domain). According to preliminary data for 1992, compiled by the Department of Environment and Natural Resources- Cordillera Administrative Region (DENR-CAR), of a total area of 1,829,368 ha, 81.4 percent is public/forest land of which 33 percent (or 26.9 percent of the total land area) is protected. The balance of 67 percent is available for production and of this, 6.8 percent (or 3.7 percent of total area) is available for agricultural production. Alienable and disposable land constitutes 18.6 percent of the total area (figure 5).

Land use data for the Cordillera region, reported in volume 1 of the 1992 Regional Forestry Master Plan, reveals that forest (mossy oak, pine, old growth dipterocarp and residual dipterocarp) constitutes 40.37 percent; extensive land use (cultivated/open areas, grassland and mixed crops/shrubs) constitutes 52.91 percent; and intensive land use (croplands and others) constitutes 6.72 percent of the total area of the region. The same document indicates that 57 percent of the pine forest areas in the Cordillera has a greater than 50 percent slope, which DENR-CAR considers unfit for any sort of development.

The data clearly show that alienable and disposable lands constitute less than 20 percent of total area while extensive and intensive land use covers 59.6 percent of the total area. This means that land use extends into what the government calls "public lands" and part of this area includes what the indigenous communities call their "ancestral lands."

That many of the communities in the Cordillera can be classified as indigenous is often noted and is easily garnered from table 1. It summarizes data from a census conducted by the CSC in 1992. As can be seen, two of the communities (Mount Data and Sinto) were established within the current generation as indicated by the fact that few household heads were born in the site. However, most of the current residents are from the Cordillera having been born of Cordillera parents. The relative "age" of the communities can be implied from this table. In Paoay, 56 percent of the household heads were born in the same barangay. In comparison, only 9 percent of household heads were born in Mount Data. In fact 51 percent of the parents of the household heads from Paoay were born there. Responses from Mount Data show that the majority of parents of the household heads were born elsewhere: 52-55 percent born in the same province but not the same barangay, 12-14 percent come from La Union (a lowland province).

A common trend among upland communities in the Cordillera is the shift from subsistence rice cultivation into commercial vegetable production. Full-scale vegetable production, where crops are
Figure 3  Slope map of the Cordillera Region
produced primarily for the market, may be found in communities along the Halsema Highway especially in the higher elevations of the municipalities of Atok, Benguet and Bauko, Mountain Province. However, many other communities, which traditionally produced rice, have also begun experimenting with the planting of temperate crops for selling in the market. These communities are typically found in more inland areas where the road system has been improved. Thus, the use of arable land for vegetable production may be observed in the municipalities of Sagada and Besao (in Mountain Province) and recently also in the municipalities of Kiangan, Hungduan and Lagawe (in Ifugao). Moreover, villages along what used to be the Bokod-Nueva Vizcaya Road also started to transform their fields into vegetable gardens in the 1980s.

Here, in a nutshell, is the dilemma. Whereas, the conservation of the Cordillera region as a watershed is imperative, particularly from a larger trans-regional and national viewpoint, the activity of temperate vegetable farming, which more and more communities in the Cordillera are engaging in, threatens the achievement of this objective. Forested lands have been converted into vegetable farms during this century, with the last two decades witnessing "encroachment" into critical areas like the Mount Data plateau. Temperate vegetable farming therefore appears to be the "culprit" for the failure to conserve the Cordillera as the watershed reserve for Northern Philippines.

If commercial vegetable farming is done on fields that formerly grew rice, then the shift in crops does not appear to threaten the forest cover. As preliminary field data reveal, traditional Cordillera communities desire the maintenance of forests together with their rice fields. Forests and fields are viewed as complementary. But will the perceived need for the forest change when vegetable crops rather than rice are grown? When forest lands are cleared for vegetable farms then a real threat arises. With a growing population, the search for land suitable for temperate vegetable production will continue and reach out into forest lands. To cast the issue of sustainability in the Cordillera in terms of the necessity to preserve the region as a watershed reserve is to focus attention on the limitations imposed by the natural characteristics of the Cordillera as a geographical region. It is a limitation that has in times past been successfully accommodated by the customs and practices of the traditional upland communities. But, the "opening up" of the Cordillera to modernizing influences together with the growth of new communities has weakened the effective control of "traditional" rules on individual initiative. The conversion of the Mount Data National Park into vegetable gardens is a clear example of how individual initiative combined with the government's lack of enforcement capacity can lead to a decline in sustainability.

The limitation imposed by man's physical environment can not be ignored. However, its accommodation in human activities will necessarily be mediated by man's conception of his possibilities at the individual, household, community and even national levels.

The Agricultural System

The ultimate objective of the production activities of households is the enhancement of their welfare defined in terms of adequate food, health care, schooling and the availability of consumer credit, among other indicators (Crisologo-Mendoza 1991). Here is some preliminary data about commercial vegetable production in two research sites: Paoay in Atok, Benguet and Mount Data in Bauko, Mountain Province. While Mount Data barangay (the smallest political unit in the Philippines) was established in the 1940s with the creation of the Heald Lumber Co. Paoay was settled much earlier in the 1900s.

In Paoay, vegetable production was undertaken on a commercial scale in the 1940s while in Mount Data only in the 1970s. Mount Data barangay is located within the Mount Data National Park, one of the critical watersheds in the Cordillera. Only 89 ha is left of the original 5512 ha due to forest conversion. Current census data show that 88 percent of the households in Paoay and 81 percent in Mount Data are engaged in farming. Practically none of the households plant the staple subsistence crop of rice.

Of the farming households, 83 percent in Paoay are engaged in growing cabbages and 91 percent plant potatoes for cash crops as do 94 percent and 92 percent, respectively, in the community of Mount
Figure 4  Elevation map of the Cordillera Region
Data. Some 48 percent of farming households in Paoay say they plant two cabbage crops; about 45 percent claim two potato crops per cropping year. In Mount Data, 23 percent and 29 percent plant 2 crops of cabbages and potatoes respectively per year. A smaller number of farming households plant sweet peas: 25 percent in Paoay, 11 percent in Mount Data.

Commercialization, is the interaction of the local community with the market. It has penetrated the life of these communities to the degree indicated by input use and output disposal. On the input side, farm operation on a commercial scale is seen in the proportion of hired labour used versus unpaid family labour, and the percentage of material inputs purchased compared with those that are internally generated.

Agricultural commercialization on the output side is seen in the proportion of harvest sold on the market compared with home consumption. Needless to say, in Paoay and Mount Data agricultural production is intended for the market. The "market" being Baguio City, the major tourist destination in the north, and Metro Manila, the nation's capital. Census data show that 15 percent of cabbage producers from Paoay sell their produce directly in Baguio while some 53 percent deliver to the La Trinidad (the Benguet provincial capital) trading post where produce is bulked for subsequent retail in Baguio and Manila. Approximately the same proportion of households do a similar thing for the potato produce. For the farmers from Mount Data, from 62 to 65 percent of the produce is delivered to the trading post and respondents claim to sell some 18 percent to "any buyer." If observations about similar upland communities studied in the AES programme (see Prill-Brett 1991) apply, the following may be expected from our two study sites.

Access to Inputs

Land

Paoay, being the "older" community of the two, has a higher incidence of owner-operated farms than Mount Data as might be expected. Census data show that three-fourths of the Paoay households currently engaged in vegetable production own their lands while only 61.2 percent claim ownership to lands devoted to the same purpose in Mount Data.1 There are more farm operators in Paoay who hold Torrens titles to their lands compared to Mount Data: 48.9 percent and 10 percent, respectively. This gives Paoay farmers relatively more secure claim compared to the rest who only have tax declaration certificates.2 The higher incidence of Paoay farmers with Torrens titles is the result of government efforts in the 1950s to legalize land occupancy of early settlers in the Cordillera on condition that they adopt soil conservation techniques. Hence, there are more likely to be bench terraces and hedgerows in Paoay than in Mount Data.

As in most parts of the Cordillera, tenancy is not a common form of access to land in Paoay and Mount Data. Borrowing, or using for free, lands owned by kinsmen is a more prevalent practice. Farm operations are more usually characterized by their small size. As in the other sites in the Cordillera where the CSC has worked the already small landholdings are fragmented further into parcels.3 In some sites, a parcel size is considered by residents to be further divisible into rows for possible strip cropping combinations at any given time within the parcel. This is a mechanism used to distribute market risk.

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1 The ownership claims made by the Mount Data households need to be validated since it is not clear exactly which part of the national park has been legally alienated from the public domain.

2 Tax declaration certificates are evidences of tax payments on lands that are "public" but used by individuals for agriculture or residential purpose. Holders of tax declarations cannot sell these lands nor can these documents be used for credit collateral.

3 The number of parcels is often the more useful and the more familiar unit of area used by respondents to designate the size of their farms on the mountain slopes than are the standard units of measures such as hectares or square meters.
Alienable and disposable areas in the Cordillera Region
Labour

Previous findings from the AES programme show agricultural households as having access to three kinds of labour resources: first, unpaid family labour that includes the farm operator and spouse, their children and other relatives; second, hired labour that typically, but not exclusively, includes those without farmlands who earn their livelihood by selling their labour either on a daily or contract basis. Hired labourers usually work alone, although labour gangs may be hired; and third, exchange labour, which is a tradition of mutual aid among members of social networks, consisting of long-standing crisis-tested relationships is now progressively lost in the process of commercialization.

When off-farm employment opportunities are present and when the skills and qualifications of a household member, not exempting the household head, fit the job requirements a household reallocates its labour resources so that farming tasks are not neglected and the cash-generating opportunities are not foregone. These opportunities provide the cash that augments farm income and which is necessary to purchase inputs like fertilizer, as well as for hiring the farm labour in the employed person's stead.

When opportunities for non-farm employment present themselves, the relative attractiveness of farming as a livelihood activity pales. A fairly recent phenomenon in the Cordillera is employment overseas as contract workers. Thus, in many households, considerable resources are currently invested in human capital in the hope that someday someone can land a "better" job and redeem the household from farming. Many do not see their sons and daughters taking over the family smallholding. An overwhelming number of respondents across sites desire to send their children for higher level education, predominantly to college.

Variable input utilization

In Paoay, 81 percent of households claim that about one-fourth of their harvest is used for planting materials for the next potato crop, thus, being internally generated. In Mount Data 86 percent of households generate the potato seedlings for the next season's crop internally. The balance of the requirements is purchased from outside of the communities or is brought in from outside. Farm operators in Paoay and Mount Data indicate that they apply commercial, inorganic fertilizers. Using chemical pesticides is likewise the norm. Since the use of farm chemical preparation is now the practice, price fluctuations can be a source of production instability as are swings in the foreign exchange rate.

The consequences of agricultural commercialization

It cannot be denied that due to increased agricultural commercialization in the Cordillera, farmers have experienced an improvement in their access to services and have enjoyed a diversified consumption pattern. In areas where there is electricity, some households enjoy modern amenities like television sets, refrigerators, and washing machines. Water for domestic use is generally considered sufficient although water supply usually dwindles during the summer. Water from communal springs is, however, available to communities during these times. In terms of the overall food consumption level, households generally claim sufficiency in food; except for marine products, which are scarce in the highlands (Prill-Brett 1991). Respondents describe their usual meal intake to consist only of rice and vegetables. Another very obvious change is the improvement in housing facilities in terms of construction materials. Although houses may be described as elemental, people are now better able to afford houses made of more durable materials. Vegetable producers also enjoy greater geographic mobility as they transport their produce to the market, usually in their own trucks or jeeps.

But perhaps the most important change observed is the improved access by farming households to higher education. With higher cash incomes, farmers are able to invest in college education for their children, with the hope that this would open up non-farming opportunities for the next generation. Apparently, schooling is perceived to be an investment that will generate higher returns in the future. Here is a potential threat to sustainability as farmers tend to maximize short-term productivity in order
to generate enough capital for human investment. Hence despite the material benefits from agricultural commercialization, adverse consequences on the environment brought about by forest conversion, monocropping, shorter fallows, increased use of chemical inputs and the absence of conservation measures have been observed. Many farmers mention three specific problems: soil erosion, loss in soil fertility and soil hardening and dryness. Although bench terracing and hedgerows are practiced by some farmers in Paoay, very fertile top soils have been lost due to run-off in areas where no soil conservation methods have been adopted. In Mount Data, farmers seem to find the cost of terracing prohibitive so that no effort has been exerted to use this method.

In order to compensate for decreased soil fertility, farmers have resorted to using more inputs both inorganic as well as organic (e.g., chicken manure). Internally generated organic fertilizers like compost, animal manure and ashes used to be major inputs in vegetable production in Paoay. With the introduction of chemical fertilizers, however, all farmers have shifted to these noticing improved yields at first that progressively declined with time. Farmers say that they need to progressively use more fertilizer in order to maintain yield levels.

Another important consequence of the shift to vegetable farming is the loss in biodiversity primarily due to forest denudation and monocropping. With the conversion of forests into vegetable gardens, existing genetic material may be permanently lost. Pest infestation due to monocropping is a major sustainability problem especially in Paoay, although government agencies like the Department of Agriculture have embarked on integrated pest management to control this problem.

In the social sphere, changes in the social organization are also taking place as tradition and customs are weakened by the increased orientation of these societies towards the market. A common practice in many traditional communities, that is increasingly being lost due to commercialization, is that of exchange labour. This practice, formerly used to augment labour resources during the peak season, has given way to the hiring either of permanent workers or of por dia (daily) workers. Some farm operators in both Mount Data and Paoay also report doing por dia work as a secondary activity. Loss than 15 percent in Paoay and a little over 30 percent in Mount Data claim that exchange labour is practiced in farming, gardening and house building.

In terms of community organizations, more respondents report knowledge of production-oriented organizations like cooperatives and irrigation associations than of traditional mechanisms in resource allocation (e.g., council of elders). Apparently, traditional social structures are less used these days although the barangay as a political structure may have increased in importance especially in resource management. This is seen in Paoay where the community has maintained access to water resources emanating from a privately-owned watershed. The owner has agreed to transfer the management of the watershed to the barangay thinking that it is probably the best way of stopping any encroachment into the remaining watershed. Although logging and gathering of forest products is prohibited, water is available to all community members who in turn will help in its management (e.g., monitoring and reforestation). This shows that as long as it is in the interest of the owner to keep the forest intact, the community will continue to derive benefits in the form of adequate water supply, a greener environment and a more balanced ecosystem. Since control over how the resource will be used continues to rest with the owner, the community must provide the necessary incentives for the owner to include all these positive externalities in his calculations of the costs and benefits of conservation. Here, the issue of sustainability is viewed more from the perspective of the community rather than just that of the owner and his household.

A more dismal picture may be drawn for Mount Data. Except for the remaining 89 hectares of mossy oak forest (from an area of approximately 5512 hectares in 1940), most of the Mount Data National Park has been converted into vegetable gardens. This is critical since the National Park is the headwaters of three major river systems in the Cordillera. Inconsistent policies as well as government's inability to protect the National Park against encroachment has seriously undermined the sustainability of the area and its environs. For instance, the construction of a road leading to the Mount Data plateau may have been intended to uplift the economic condition of farmers, but it has inadvertently contributed to the destruction of the forest. The community is also not in a position to enforce protection because of the
absence of traditional mechanisms for resource allocation. It should be pointed out that the community we find now is no longer the same community established in 1946. The Heald Lumber Co., which had a pine concession in the area, was instrumental in the maintenance of the mossy oak forest until its closure in 1987. The lucrative vegetable market, however, led to uncontrolled in-migration from the surrounding areas as farmers expanded their farmholdings into the National Park. These forest occupants until now have not been awarded titles although 55 percent of households claim to have tax declarations.

The hypothesis that farmers with more secure land tenure tend to have more sustainable practices may be raised. Are people with tenous claims likely to invest in labour-intensive and very costly land conservation measures? Initial findings reveal that due to the uncertainty of long-term benefits, a short-sighted view of resource use is promoted where only current private benefits and costs are considered. This may be the case in newly opened vegetable areas like Mount Data. Residents are, legally speaking, "squatters" in the forest and because the area was settled only in 1946 they may not qualify as ancestral land claimants and are unlikely to be granted land titles in the future. Ancestral lands are those that have been occupied or utilized since time immemorial.

It is evident therefore that upland communities are responding to the market opportunities provided by full-scale vegetable production. As a result, there is fierce competition among farmers not only over natural resources like land, water and forests, but also over input and output markets. Inasmuch as they belong to the same industry, producing the same crops, selling in the same market outlets and using the same inputs, the economic and natural factors to which they are subject are also common. This encourages highly individualistic strategies of coping with prevailing market and climatic conditions. The absence of a community-wide (or region-wide) agricultural calendar where production is programmed to maximize market opportunities for all community members is an obvious indicator of this. In order to maintain the viability of his livelihood, the farmer must be innovative and must possess the managerial skills necessary for him to overcome the production constraints with which all farmers are faced. The importance of the proper timing of production activities and the farmer's willingness to take on risks (e.g., planting the "suicide" crop during the rainy season) may spell the difference between bankruptcy and high profits. Being rational economic actors, farmers behave in response to opportunities as quickly as the circumstances allow. Since production and consumption activities are oriented toward market opportunities, the market mechanism allocates resources efficiently as farmers use information derived from past experiences and observed trends to guide their actions.

This raises an important point. While farmers are highly individualistic in their production activities, like all other farmers dependent on natural resources for their livelihood, they need to contend with common concerns as a community. The conservation and protection of forests, soils and water as well as the management of pests are just some of the issues that require collective action because of market failure.

When trees are cut so vegetable gardens can be established, the private cost-benefit calculation of the farmer extends only to that which he foresees in the short-term. The profits that he will immediately realize when he brings his produce to the market, and which allows him to send his children to school, will most likely encourage encroachment into the forests. And yet, the long-term effects on-site and off-site of intensive vegetable production are activated. Pesticide pollution, soil erosion, water scarcity and loss in biodiversity continue to undermine the productive capacity and sustainability of natural resources.

Mechanisms and approaches that not only identify such externalities, but also allow their internalization by the proper agents, are necessary. Similarly, the adoption of resource conservation measures is likely to increase when adopters are compensated for the benefits that accrue to society. Hence, terraces, hedgerows and agroforestry appear to be cost-ineffective because farmers bear all the costs of conservation. Either beneficiaries are made to pay for benefits derived or an incentive scheme should be created to compensate those who conserve. Mechanisms that encourage collective action and work towards the sustainable use and management of so called public goods must be instituted. A necessary prerequisite for this to work is the creation of a sense of "community" whether on the local, provincial, regional or national level. For newly established communities composed of diverse cultural
groups, this may require some organizing. Where they exist, mechanisms that build on indigenous structures and processes should be encouraged. Local practices that lead to conservation efforts must be identified and strengthened.

**Regional policies**

In recent years, there has been an increased emphasis on regional responses to government problems. In this section, we look at how the Cordillera Administrative Region (CAR) offices of national agencies have taken a more sympathetic look at the problems of indigenous people's control over resources.

**Forest Resources**

After the formulation of a national Master Plan for Forestry Development, the regional office of the DENR went through a planning exercise to produce the 1991 Regional Master Plan for Forestry Development. Although the general outlook was the same, the regional office gave more prominence to land claims, particularly those of indigenous peoples. For example, it set the following goals for forestry development (Rood and Casambre 1991):

- To achieve sustainable development and management through optimal production and efficient use of forest resources and to promote social equity in order to attain ecological stability in the region.

- To satisfy the needs of the people through sustainable stewardship of the forest resources.

- To improve on a sustainable basis the production of food, water, energy and other life-support systems by properly managing the watersheds and forest resources.

- To protect the forest resources of the region against degradation through land management system and production.

- To conserve and improve forest ecosystems and their diverse genetic components.

- Grant security of land tenure for the upland farmers through the recognition of ancestral land rights and the issuance of certificates of stewardship.

- Implement/use indigenous and other appropriate upland farming practices to increase upland productivity and income.

It can be seen that the regional office of the DENR has taken note of the same problem noted by others:

To carry out successful reforestation, the government must recognize the ownership rights of both the estimated 3.4 million tribal peoples and the rest of the upland population. Fear of being deprived of their land tenure rights has made both tribal and non-tribal upland farmers suspicious of government agroforestry programs. Conferring unconditional land rights on upland occupants and turning primary responsibility for forest protection, tree-growing, and land conservation over to upland communities are the first steps toward establishing a new political relationship between government and the upland population (Porter with Ganapin 1988).

As noted, non-tribal upland farmers are not a problem in the central Cordillera, hence, the attention is focused on ancestral land claims. More specificity is found in the regional plan than in the national plan, although numerical targets for the process were not included:

Ancestral Lands Management Activities to be pursued further under this component shall be the survey and delineation of ancestral land claims and the processing and issuance of the corresponding Certificates of Ancestral Land Claims. No quantified targets are presented because the accomplishments shall depend upon the details of applications received by the DENR-DENR-CAR (sic) for certification (Porter with Ganapin 1988).
Ancestral Land

To carry out this process, the DENR-CAR organized a Special Task Force on Ancestral Lands. The aim of the Task Force was to accept, identify, evaluate and delineate ancestral land claims in the Cordillera Administrative Region. The Special Task Force on Ancestral Lands (STFAL) was set up by DENR Special Order 31 (17 January 1990), as amended by SO 31-A (28 March 1990). The STFAL then issued (30 April 1990) "Rules on the acceptance, identification, evaluation and delineation of ancestral land claims by the Special Task Force." For example:

Ancestral land in Baguio City and the rest of the Cordillera Provinces shall consist of all territories exclusively possessed, occupied or utilized since time immemorial by the following indigenous cultural communities in accordance with their customary laws, traditions and practices irrespective of their present land classification and including such lands used for residences, farms, burial grounds, communal and/or private forests, and others to wit [after which follows a list of cultural communities] .... Other indigenous cultural communities that may be identified later (DENR S.O. 31).

The guidelines go on to state (among other things) that possession for fifty years creates a presumption that possession has been since time immemorial; to give application deadlines of three months for Baguio and twelve months for the rest of the Cordillera; to list documentary, oral, or physical proofs (such as improvements to the land) that might be accepted; and to consider how environmentally critical areas might be handled "with the full participation of the Indigenous Cultural Communities (ICC) concerned."

By the end of the STFAL's existence thousands of applications had been received. Benguet province (the most economically advanced) was best covered by applications but even there, more than one-third of all barangays had no applications. In other provinces, proportions covered ranged from less than one-half to almost nil.

One reason for the low number of applications was the STFAL's insistence on granting applications for only what it termed ancestral lands as opposed to ancestral domain. In short, only lands actively used by an individual or group would be covered and the surrounding forest lands on which the whole community depended (what Prill-Brett refers to as "communal" lands) would not be covered. It is worth noting that, whatever the merits of the STFAL's position, the recently issued DENR Special Order No. 25 (January 1993), creating Provincial and Community Special Task Forces on Ancestral Lands, explicitly provided for the recognition of ancestral domain by the provincial task forces and left ancestral lands that are not part of an ancestral domain to the community task forces.

Another criticism of the work of the STFAL, which also applies to the newly created task forces under S.O. 25, involves "Certificates of Ancestral Domain/Land Claims." These fall far short of giving secure title to the land in question. In fact the STFAL often characterized the "certificates" as documents that would gain more force if the Philippine Congress passed a law granting titles to indigenous claims over the public domain.

It is clear however that by limiting itself to ancestral lands, government applied a perspective to the land problem that is alien to the indigenous people's perspective. The fact that the chief agencies involved in the discussion have divergent mandates poses problems. The Department of Environment and Natural Resources (DENR) is conservative, protecting the natural resources of the land from unwarranted exploitations; while the Department of Agrarian Reform (DAR) is specifically an agency for redistribution of resources for purposes of exploitation.

Moves to consolidate their efforts resulted in a Memorandum of Agreement (MOA) between the two agencies for joint undertakings for investigation, verification, delineation and survey of ancestral land claims. The problem with this however is that it encourages individual appropriation of land that had previously been under other sorts of collective control. Since the Special Task Force on Ancestral Lands (STFAL) was not granting claims to ancestral domain, and since the DAR's mandate covers only agricultural lands, the upshot is a large incentive to convert forests into agricultural lands as the only way to gain secure tenure.
Conclusions

There are many factors impinging on the sustainability of natural resources in the Cordillera. Notable of these is agricultural commercialization. The expansion of temperate vegetable production even in forest lands and the intensive practices concomitant with it pose serious threats to the Cordillera's role as the watershed cradle of Northern Luzon. As farmers aspire to higher education for their children, they may tend to adopt exploitative techniques that maximize short-term productivity at the expense of sustainability. Government policies, which recognize indigenous people's rights to land and other natural resources, may help facilitate the creation of community mechanisms that promote sustainable resource use. Needless to say this entails the recognition and reinforcement of indigenous structures and mechanisms where they are already in place.

References


Integrated Natural Resource Management Research for the Highlands of Eastern and Central Africa: The Highlands Initiative

by

R. Bruce Scott

Background

As the national agricultural research systems (NARS) and the International Agricultural Research Centres (IARC) belonging to the Consultative Group on International Agricultural Research Centres (CGIAR) continue to grapple with the problem of improving the productivity of African agriculture, it has become increasingly evident that the new agricultural technologies developed by these systems are not making the expected impact on agricultural production. The agricultural sector in the highlands of Eastern and Central Africa continues to decline in terms of both per capita food production and contribution to national GDP. Some of this decline can be attributed to inappropriate national agricultural policies, internal strife, insecurity and the escalating costs of agricultural inputs. However, it is strongly felt that a major contributing factor is the diminishing capacity of the natural resource base, under existing management systems, to support the needs of the rapidly growing population. This situation is considered particularly acute in the highlands of East and Central Africa. In this region, problems associated with natural resource management are threatening the capacity of the land to maintain its traditional role of providing most of the food and agricultural raw materials needed for national development.

It was against this background, and the apparent neglect of research on issues of natural resource management, that the Directors of NARS of seven countries (Burundi, Ethiopia, Kenya, Rwanda, Tanzania, Uganda and Eastern Zaire), and Directors of the CGIAR/IARC met at ICRAF in June 1992 and decided to explore the possibility of a new collaborative regional research initiative. A task force comprising two of the Directors of NARS, representatives of IARC with programmes in the East and Central African Highlands, and several donors, was established to further develop this idea. ICRAF was requested to chair the task force and to assist in the search for, and coordination of, the initial financial support for planning the initiative.

Preparations for the initiative started with meetings of the Task Force and the appointment of a team of two consultants to prepare a position paper. The consultants travelled widely throughout the region, met with personnel involved in agricultural research, development and natural resource management. They compiled a report (Loevinsohn and Wangati 1993) outlining the major characteristics of the highlands, suggesting research themes that could be undertaken and a possible organisational structure.

This report was intensively reviewed by the task force and by a workshop organised at Entebbe in Uganda and attended by NARS Directors, representatives of IARC, regional organisations and donors. The workshop adopted the report as the basis for the design of the new initiative and assigned priorities among the various themes proposed for research (Wangati and Kebaara 1993). It also made recommendations regarding organisational issues and suggested that a planning workshop be organised. This would enable senior researchers from the region to define in greater detail the research activities that could be undertaken under each of the themes selected, the existing capacities at national level and the additional resources that would be needed to carry out the work. This work plan embodies the conclusions and recommendations of the planning workshop and additional comments arising from consultations at national level.
Table 1 Proportion of national populations settled in the highlands (1500 - 3200m asl) of some countries of Eastern and Central Africa

<table>
<thead>
<tr>
<th>Country</th>
<th>population in highlands (000)*</th>
<th>highlands percent (estimate)</th>
<th>percent population in highlands*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi</td>
<td>4408.7</td>
<td>&gt; 80</td>
<td>73.34</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>38607.1</td>
<td>&lt; 60</td>
<td>72.65</td>
</tr>
<tr>
<td>Kenya</td>
<td>12782.1</td>
<td>&lt; 30</td>
<td>49.48</td>
</tr>
<tr>
<td>Rwanda</td>
<td>6984.1</td>
<td>&gt; 80</td>
<td>88.02</td>
</tr>
<tr>
<td>Tanzania</td>
<td>3554.8</td>
<td>&lt; 5</td>
<td>12.52</td>
</tr>
<tr>
<td>Uganda</td>
<td>2207.0</td>
<td>&lt; 2</td>
<td>12.16</td>
</tr>
<tr>
<td>Zaire</td>
<td>2237.9</td>
<td>&lt; 2</td>
<td>5.44</td>
</tr>
</tbody>
</table>


**Defining the Highlands Ecosystem**

It is observed that, even within the region, definitions of what is a highlands ecosystem differ according to the purpose, perspective and preferences of the country concerned. A major purpose of the initiative is to focus research on high-potential agricultural land where rainfall is not a limiting factor. In these areas, problems related to natural resource management will have become a major limiting factor to growth and sustainability of agricultural production.

Therefore it has been agreed that for the purpose of the initiative, highlands will be defined as land above 1500 metres in altitude and receiving a minimum average annual rainfall of 1000mm. Emphasis will be placed on agricultural systems, actual and potential, and the commonality of natural resource management problems. This may lead to a relaxation of the altitude criteria, where necessary, to say 1000 metres. This will include agricultural lands, especially in Uganda and parts of northern Tanzania, where land use systems and resource management problems are similar to those at higher altitudes.

Highland ecosystems are further delineated in terms of their land forms and associated uses and resource management problems. These include:

- **Hill tops.** These may be covered by natural or plantation forests and are usually conserved as water catchment areas. Where the soil is too shallow to support tree growth, hill tops are often bare or covered by relatively poor pasture and shrubs.

- **Very steep slopes.** Cultivation on such slopes is discouraged or prohibited by government in many countries, but these regulations are proving increasingly difficult to enforce.

- **Moderately steep and gentle slopes.** These are areas of intensive cultivation. Soil erosion and landslides are a major problem and soil conservation measures, eg. bench terraces and cut-off drains, are encouraged and often vigorously enforced.

- **Plateaus.** Characterised by undulating topography and relatively flat plains.

- **Relatively flat plains which are marginal for crop production due to aluminium toxicity and soil acidity.** These areas are mainly used as grazing lands.

- **Highland valleys.** These may be relatively narrow valley bottoms. Others are extensive, periodically flooded plains and marshes (wetlands).
Justification

The highlands are a vital natural resource for socioeconomic development of the region

The highlands of Eastern and Central Africa constitute a vital natural resource in the region. They comprise varying proportions of the land area of the countries concerned ranging from about five percent in Uganda and Tanzania to over 70 percent in Ethiopia, Rwanda and Burundi (see table 1). The highlands are regions of high agricultural potential, high population density and population growth, diverse land uses and economic opportunities and, irrespective of their relative size, are major sources of water and national GDP. For example, coffee and tea, which are the major export crops, and over 50 percent of the major staple foods in the region such as maize, beans, bananas, wheat, barley, teff and dairy products are produced mainly in the highlands.

Research and other agricultural development programmes have been initiated in the semi-arid lowlands in an effort to improve their productivity. It is nevertheless realised that agricultural development of these lands will require large amounts of capital investment and their productivity is unlikely to match that of the highlands. Research and developmental priorities are therefore focused on the highlands where the natural resource base provides the widest variety of options, opportunities and the best return on investment.

Stagnation of agricultural productivity in the highlands

Highlands ecosystems are threatened by degradation and depletion of natural resources and diminishing capacity to support the growing population. Major efforts have been made by NARS to develop new agricultural technologies to increase productivity of the highlands ecosystems in the region. The IARC have also initiated many collaborative research and training activities in support of the national efforts. The consultant's report, and subsequent workshop discussions, have confirmed that the majority of the research efforts have concentrated on the introduction of higher yielding and better adapted varieties of crops. The overriding assumption by NARS, IARC and donors has been that farmers will be motivated by the higher potential yields of these improved varieties to apply the necessary levels of fertilizers and other farm inputs to maintain a productive ecosystem. New extension programmes in the region such as the "Global 2000" and the Training and Visit Systems are following the same principles.

However, the above assumption has not been realised to a scale sufficient to prevent degradation of the natural resource due to a variety of reasons including:

- insufficient participation in the design of technology by land users, especially the small scale farmer;
- inability of the farmer to absorb initial investment costs;
- unreliable infrastructure and supplies of farm inputs;
- emphasis on limited and broadly adapted technologies that optimize yields without giving farmers a range of alternatives for various micro-environments;
- ineffective extension services in some countries; and
- separation of conservation from production, in particular in soil conservation programmes.

Some of the negative effects of the yield optimisation strategy, for example erosion of the genetic diversity and environmental pollution, have also not received commensurate attention.
Conflicts between productivity and natural resource conservation

As farmers run short of fertile land on the gentle slopes, they have increasingly resorted to cultivation of very steep slopes and the encroachment of forests, valley bottoms and wetlands. These areas play a key role in the protection of the environment, regulation of water resources and conservation of the genetic diversity of flora and fauna. The result has been a severe shortage of wood fuel, drying of springs and streams, genetic erosion and in some cases irreversible damage to the ecosystem.

Heterogeneity and complexity of problems

The heterogeneity and complexity of the problems associated with natural resource management in relation to land use and production systems in the highlands has been a major bottleneck in the development and extension of technologies. For example highland valleys differ greatly in terms of soil and water quality while diversity of size of holdings, preferred staple foods, farmers' access to markets, labour, fuel and fertilizers, influences the types of technology that can be adopted. Appropriate methods of solving these problems and facilitating their wider applicability need to be developed.

Lack of capacity for integrated natural resource management research

The NARS are faced with a number of problems that limit their capacity for integrated natural resource management research. These problems include:

- lack of coordination in the setting of priorities and conduct of research;
- shortage of funds and trained manpower; and
- inadequate linkages between research and extension.

New and more innovative approaches to the generation and extension of agricultural technologies are therefore urgently needed if research is to have its expected effect on national development. In order for these efforts to be successful, sustainable and appropriate policies and incentives need to be developed that encourage land users to invest in the protection and management of their natural resources. Such innovative approaches need to include effective participation by farmers, and other land users, in the processes of problem identification, prioritization, the planning and conduct of research as well as the evaluation and dissemination of research results.

It is felt that such a process will ensure adequate review and incorporation, where appropriate, of traditional technologies employed by farmers to maintain a reasonable level of land productivity using affordable and locally available types of inputs. It will also ensure a community-based approach to the conservation of natural resources. It is also expected that an increased emphasis on socioeconomic studies will lead to a better understanding of the value judgements made by farmers, and other land users, on how government policies influence the way natural resources are managed.

The need to improve interdisciplinary and interinstitutional collaboration

The existing research institutions, programmes and even personnel are strongly oriented along disciplinary lines and collaboration has proved difficult to organize. In many cases, however, non-governmental organizations (NGO) are in closer contact with the farmers, and other users of the natural resources, than formal government institutions. NGO could, therefore, provide the much needed link between researchers, extension workers and land users.

The consultant's study confirmed that there are NGO and donor-aided projects that are involved with, and have a valuable wealth of experience in, the management of natural resources. It is expected that since the management of natural resources is a matter of concern to all such groups, a new initiative based on this topic will facilitate collaboration.
Opportunity for IARC to re-orient their programmes

IARC based in the region have well defined research mandates, with ICRAF's focus on agroforestry systems being somewhat broader than many. IARC, in collaboration with the NARS, have also established five principal research networks that operate in the region. These networks are primarily organised around commodities but include various aspects of natural resource management. The focus and impact of this research will be enhanced through cooperation in the initiative. The initiative also provides a framework for IARC to integrate their commodity research, where the focus has been primarily on improved varieties, with research on management of complex cropping systems and the underlying natural resource base. This initiative allows CGIAR to broaden its mandate in East and Central Africa and to explore innovative research methodologies, always working directly and in concert with NARS.

Promotion of regional collaboration

The proposed initiative is in line with the desire on the part of the Directors of National Programmes (NARS) to establish more effective regional collaboration in agricultural research. This is currently being developed in the Framework for Action (FFA). The initiative is also being developed in recognition of the priority that CGIAR has placed an Ecoregional Mechanisms (ECOREM). Specifically there is a recognition that the Highlands Initiative must contribute to:

- reinvigorating the NARS; and
- promoting regional collaboration and IARC integration.

Shortage of trained personnel

In all the countries of the region there is a major shortage of scientists trained in the field of natural resources management. Scientists in commodity programmes are trained entirely within their disciplines and have a limited appreciation of the effect of the technologies they develop on the natural resources. The proposed initiative will provide an opportunity to rationalize and broaden current training programmes. It will also provide a mechanism for the organization of special courses with an emphasis on the sustainable management and utilization of natural resources. Training in social science methods and multi-disciplinary research methods will also be a priority for all scientists.

The need to improve information and documentation

Agricultural research in the region is characterised by the dispersion of scientists in small groups at isolated research stations. Communication between these groups and with the wider scientific community is often limited by poor library, documentation and communication facilities as well as a lack of funds to subscribe to journals. Networking has helped a great deal. Since the information available through networks is, however, narrowly targeted to commodities and scientific disciplines, it does not contribute to an integrated approach to natural resource management research. Like training, a focus on information and documentation will be a major theme contributing to initiative efficiency and sustainability with the Highlands Initiative region.

Principal components of the initiative

It was concluded at the Entebbe consultative workshop (Wangati and Kebaara 1993) that the highlands initiative will, in its first phase (1994-1995), concentrate on five major themes but will support whenever possible and collaborate with programmes covering other facets of relevance to the region. The central
focus for research will be on the problem of enhancing sustainable land productivity in intensive land-use systems. This will be addressed through two main research themes:

- the maintenance and improvement of soil productivity; and
- management strategies for plant protection.

Three supporting activities will also feature prominently in the initiative:

- diagnostic and socioeconomic studies;
- training; and
- information and documentation.

The supporting activities combine some research, especially on methodologies. These are aimed at sharpening problem definition and priority setting, reaching a better understanding of farmers' approach and also defining the constraints to the management of the natural resource base. The activities will also provide assistance to the building of capacity within NARS necessary for the attainment of the overall goal.

The five themes constitute broad areas of research and research support. They have been arrived at through the consultative process described in this document. Consensus on the importance of a few research topics, especially within the theme of plant protection, have also emerged from the consultative process. The bulk of the activities to be undertaken under the initiative will, however, be based on the knowledge gaps or capacity shortfalls identified through diagnostic studies and review processes.

**Theme activities**

**Theme 1: Maintenance of soil productivity**

The maintenance of soil productivity is undoubtedly a major problem contributing to the lack of sustainability of farming systems in the highlands. This is also a field of research within and outside of the region that has, and continues to, receive a lot of attention through fertilizer trials, studies on the role of organic matter and fallow systems, agroforestry interventions, nutrient mobility. There is therefore a wealth of relevant information that has accumulated from both research and development projects. Unfortunately this information is scattered and may easily be overlooked. It is therefore proposed that, without prejudice to the diagnostic exercises, an exercise should be started early during the first phase to synthesize information from past research. This activity will identify some of the important gaps and to encourage the relevant institutions to initiate or strengthen research activities to fill such gaps if deemed feasible during Phase 1. The main activities will therefore comprise:

(i) Synthesis of information available on relevant past and current research activities in the region on the above topics.

(ii) Participatory on-farm and on-station research to fill technological gaps. The initiative will support integration of on-going activities with new topics identified and prioritized through the zonal diagnostic studies.

The theme will embrace research on all land forms within the highlands, especially steep cultivated slopes that are experiencing extreme demographic pressure and declining soil fertility to which erosion is a significant contributor.
**Theme 2: Management strategies for plant protection in intensive systems**

Research under this theme is intended to further explore the relationships between problems caused by pests and diseases and the intensification of agricultural production in the highlands. It is intended to design appropriate control strategies based on integrated soil and crop management. As in the case of soil productivity maintenance, there are many research projects studying integrated pest management in the region. It is proposed that an effort be made during the first phase to synthesize available information, identify the critical gaps (especially those related to natural resource management) and to initiate research activities designed to develop appropriate technologies.

**Research activities**

Notwithstanding the need to conduct diagnostic studies, the participants of the consultative technical workshop referred to in section 1 of the Draft Work Plan 1994-1995 document, recommended that the following pest/disease problems be accorded high priority: banana nematodes, bean stem maggots, bean root rot and potato bacterial wilt. The selection is based on the current understanding of their socioeconomic and regional importance, apparent linkage to intensification of production, potential for solution and the existence of a good level of on-going research.

**Theme 3: Diagnostic and socioeconomic issues**

The activities envisaged under this theme fall into two categories:

(A) **Zonal diagnostic studies**

It is now accepted that integration of natural resource management perspectives in the agricultural research programmes requires a fresh approach to diagnostic studies. In some cases, most of the basic information has already been collected and the main requirement would be a synthesis and fresh interpretation of the information. In other cases, comprehensive diagnostic studies will have to be undertaken in the field. In both situations, there is need for the development, refinement and testing of the methodologies and training of national teams in their application. This activity will therefore be implemented in stages as follows:

i) Development of diagnostic methods

The first exercise will be to develop appropriate diagnostic methods that are acceptable to all the participants in the initiative and which can be applied uniformly at zonal sites to define the problems and arrive at research priorities.

ii) Regional diagnostic workshops

The first regional workshop will be organised to give national team leaders an opportunity to evaluate and agree on the diagnostic methods developed by the panel of experts and the mode of implementation. This will include guidelines for the selection of initial field sites, collation and evaluation of existing information, data management and the exchange of information.

iii) Regional training workshops on diagnostics

The above workshop will be followed by two regional training workshops for English and French speaking countries respectively. These workshops will be used to expose members of the national diagnostics teams to, and train them in, the use of the agreed diagnostic methods. An average of four participants from each country will be expected to attend.
iv) Diagnostic research at the national level. At the national level, diagnostic studies will start with the appointment of a small multi-disciplinary team of experienced scientists comprising at least a socioeconomist, soil scientist, agronomist, animal scientist, agroforester and a hydrologist/agricultural engineer. They will be drawn from participating institutions. One of the scientists will be designated as the Team Leader.

(B) Natural resource inventory/regional characterization

Up to now, decline in productivity of the highlands as indicated by reduced crop yields, shortages of fodder and woodfuel and a general failure to close the gap between actual and potential land productivity is only articulated in qualitative terms that do not help in separating the contribution of various technical and socioeconomic factors. An important aspect of regional characterization is therefore the establishment of a regional database on the characteristics of specific highland ecological zones. These include the productivity of various land use systems, trends in soil fertility, the impact of pests and diseases, demographic and occupational trends as well as markets for agricultural commodities.

It is therefore proposed that specific resources be provided to create a regional database. A small regional team will be established to initiate this activity by developing systems for compilation of zonal data from specific areas targeted for research. Its terms of reference would be:

- to develop a methodology and framework for natural resource inventory/characterization at regional scale;
- to promote the contribution of information to the regional database through interaction with zonal field programmes, starting with the zonal field diagnostic teams;
- to coordinate the inventory of relevant documents available in the region, including review and synthesis of NARS experience, methods, secondary and biophysical site data; and
- improved access to spatial and numeric data.

There are important sensitivities limiting the exchange of data and cooperation on this matter cannot be taken for granted. A major and early responsibility of the technical advisory panel for this activity will therefore be to work out guidelines for access and use of the data and other information contributed by the partners into the regional database. The Directors' Committee will facilitate formal agreements and memoranda of understanding on this matter if these become necessary.

Theme 4: Training

Training will be a central theme in this initiative and will involve the rationalisation of training activities, for example, in CGIAR/IARC. Training will also be tied to the research activities on-going under the initiative and will need mechanisms for coordination of the facilities and resources available. The needs of the other programmes, which may include the design of specialised courses, will also be considered.

Training will be focused on research scientists, technicians, extension/development workers, library/information personnel, farming communities and other land users and also upon policy makers. Emphasis will be placed on problem-solving ability; communication skills, skills in building linkages within R&D and in involving the farmers; and research and information management skills.

Theme 5: Information and Documentation

The overall goal of this theme is to provide a comprehensive and integrated information support within the framework of the initiative that facilitates both the acquisition and dissemination of information. There is need to improve the flow of information between scientists nationally, regionally and outside the region and to improve communication among the various target groups.
Lessons

The following is a brief overview of some of the lessons that have been learned during the planning and formulation phases of the Highlands Initiative.

- It was necessary from the beginning to have an endorsement for planning the initiative from the Directors of national institutions and the Directors General of the international centres. Equally important, the Task Force has endeavoured to keep the Directors informed on their progress throughout the process and to maintain the Directors interest and involvement. The recent establishment of a Regional Directors Committee, which will form the umbrella for the Highlands Initiative, will provide legitimacy for the governance of the Highlands Initiative as it moves to the phase of implementation.

- The planning and formulation of the initiative has taken 18 months. This is very long. On the one hand it has taken time to involve all of the institutional partners in the process. It has taken time to seek their input, for them to understand the concepts behind the initiative and to build a consensus on the priority themes. However, there is a risk that if one continues to prolong the planning and formulation process that the partners will begin to lose interest in the implementation.

- The initial selection of land forms and the identification of themes has been arrived at through discussion and consensus. It has been largely "supply" determined in the sense that the professionals that were consulted established the work programme. The criticism of this process is that the agenda setting exercise should have involved the users, that is, the managers of natural resources: the farmers. It is for this reason that major emphasis in Phase 1 will be research aimed a more carefully diagnosing needs on a “watershed” basis and further developing the research involvement and participation in the process of constraint determination and working at developing solutions. It has also been recognized that solutions to natural resource management issues must move from the farmer/household level of articulation to a community resource planning level because of the interactions throughout the watershed.

- There has been a lengthy discussion on the commitment of national programmes to work together on a subject such as natural resource management in a regional context. In other words whether the initiative would eventually become a combination of the collection of national programmes, or whether indeed there was a regional agenda in which there were clear benefits for each partner to work together in a regional framework. The commitment to work together within the regional framework has been established and this has been given additional legitimacy with the establishment of the Framework for Action for Agricultural Research in Eastern Africa (FFA). However, the benefits of regional cooperation will only become clear when the initiative begins to implement the agreed work plan and starts to see the benefits of sharing results.

- A major issue has arisen dealing with the establishment of priorities for natural resource management issues in national programmes; the incorporation of natural resource management research into the national agricultural research agenda; and issues related to inter-institutional collaboration at the national level so as to implement natural resource management research. The inter-institutional issues relate to linkages between formal and informal agricultural research institutions; the involvement of universities in natural resource management research; linkages between research, linkages between research and development; and the involvement of extension agents, NGO and development projects. The Highlands Initiative cannot at this stage provide answers to all of these issues. As it moves to the phase of implementation, however, it should provide a forum in which to explore all of the above arrangements and linkages in a flexible and creative format.
Natural resource management research is costly and long term. Although in some cases the funding of this research will be managed by re-allocating existing resources, the bulk of the new activities will require additional resources to ensure implementation. This is a critical issue that requires addressing at this time when internal and external resources available for agricultural research are stagnant or declining.

Finally, the task force is acutely aware of the complex nature of the issues related to research on the management of natural resources. At the same time there is an overlay of complex interinstitutional issues that have led to the development of a complicated process to develop a common agenda in the regional context of the Highlands of Eastern and Central Africa. Planning and formulating the programme has been easy compared to the major challenges that lie ahead in the implementation stages of the programme. We will continue to monitor the process closely. Mistakes will inevitably be made. We do feel, however, that many of the key ingredients are in place (the guiding principles) and that there may be many important lessons to be learned in the future.

Conclusions

Research on the management of natural resources is important, particularly in the highlands of Eastern and Central Africa, if future generations can expect to survive from the productivity of the systems that have traditionally produced the bulk of the food and cash crops for the region. The highlands have been and will continue to be the "engine of economic growth" in the region and therefore maintaining and enhancing the productive base of the Highlands is crucial to the future of the region.

The expectation that a regional research programme to deal with these issues will be effective, is the major challenge and goal of the Highlands Initiative. The planning and formulation of the programme has shown that there is a desire in a regional context to undertake this work. The major challenge for the future will be to move from regional planning to regional implementation.

References

Spatial Variation as a Factor in Natural Resource Management Research

by

S.E. Carter, P.N. Bradley, S. Franzel and J.K. Lynam

Introduction

A spatial perspective is an essential departure point for research on natural resource management since it provides the means to develop, order and refine the understanding of management within the context of different system levels and spatial scales. The complex of resources used by farmers is located in a geographical space, farms and their surrounding hinterland, so that this spatial area (and its associated external linkages) is the logical focus for natural resource management research.

Spatial variation has not been adequately dealt with in agricultural and agroforestry research for natural resource management (NRM). This paper highlights two radically different perspectives on how to handle spatial variation, the one predictive, the other exploratory. The objective is to identify a structured approach to handling spatial variation that will further the understanding of NRM and lead to better applied research and more appropriate interventions.

Spatial variation is generally seen as a complicating factor in agricultural research, while location specificity is often considered the downfall of farming systems research. This perspective stems directly from the desire of agricultural research institutions to develop and transfer technologies that will have a wide geographical and therefore socio-economic impact. Geographers have a quite different perspective on spatial variation. Space has long been seen as integrating interactions among phenomena. To study landscape and its change over time is to begin to unravel the complex interactions between the natural and human worlds. The study of spatial variation can therefore be seen as a means toward a better understanding of these interrelationships.

Our knowledge of human-environment interactions, and therefore of resource management systems, is often pitifully inadequate. This is perhaps nowhere more true than in the complex socio-cultural and agro-ecological milieux of the tropical highlands. Ecological diversity in highland ecosystems, by presenting a diversity of potential niches, has been associated with the development of diverse human agro-ecosystems, such as the "vertical archipelagos" of the Andes (Brush 1977, Mayer 1979). In the East African highlands today, one can readily observe the way that the spatial orientation of farms runs down slope to gain access to soils of different texture, base status and moisture regime. Farms are sometimes no more than 15m wide yet are hundreds of metres in length. This orientation is also manifest through fragmentation. The economic complexity of these systems is also readily proved in East Africa, where a diverse range of farming activities (such as coffee, tea, livestock raising, pyrethrum and staple food crops) is found.

The particular balance among enterprises in a given place at a given time varies according to factors such as male outmigration, fluctuations in world commodity prices and government controls on export and marketing. Cultural and social complexity also has direct ramifications for research on agriculture or natural resource management. For example, in parts of Western Kenya women, who are responsible for day to day farm management, food and fuelwood provision and provide most of the labour, are not allowed to own land or trees; in contrast, this is not so in Kikuyuland to the East. These differences, by effecting the willingness to invest labour or the ability to plant trees for fuelwood production, have vital significance for the design of appropriate research.

Because of the complexity described above, changes demanded of the system by internal and external forces, for example to improve soil management, may require significant changes in resource allocation.
and social relations. New biological components of farming systems may diffuse quite easily with little external (eg. governmental) assistance. This has happened in the past in East Africa with American crops and with trees such as eucalyptus, wattles (*Acacia mearnsii*) and *Grevillea robusta*. However, it is not clear to what extent this spontaneous diffusion is an example of an efficient means to cause change in resource management in these systems.

The complexity of resource management issues has led to significant re-structuring of the members of the Consultative Group on International Agricultural Research (CGIAR). This is the subject of the second section of the paper. The theory of the functioning of farming and resource management systems is incomplete. This has led some scientists toward the development of more sophisticated predictive models that try to take greater account of spatial variability. We examine critically this approach below. We then briefly introduce a geographical alternative that takes spatial variation as the starting point for the analysis of resource management systems.

From a spatial perspective, expressions of resource management on a spatial basis exhibit an underlying order rather than random complexity. It is the inadequacy of theory that limits predictability so that the study of spatial relationships becomes essential for the improvement of theoretical understanding. A prime issue for research on natural resource management then becomes the creation of institutional structures that can deal with the need to explore spatial variability and make generalizations from the experience and strengthening links between researchers, farmers and grassroots institutions. These issues are examined briefly in the final section of the paper.

**Coming to grips with NRM research in CGIAR**

The incorporation of NRM research within CGIAR has required significant reorganization and restructuring of research programs the centrepiece of which is the ecoregional framework. This idea must be interpreted primarily as an organizational device to decentralize the research process within CGIAR to the principal ecoregions. In practice these ecoregions are an adjacent set of countries grouped together under a broad climatic zonation (TAC, 1991). This decentralization has three principal functions.

The first is the accommodation of NRM research. NRM technologies are perceived within the CGIAR to have a narrower location and system specificity than germplasm technologies and not to have the economies of scale inherent in large centralized research breeding programs.

The second function is to integrate NRM research with commodity research. Such integration depends very much on the structure of the dominant farming systems. An underlying assumption here is that farming system differentiation is relatively limited within the ecoregions. This function implies a major organizational challenge of how best to integrate the research activities of the different members of CGIAR.

The third function follows from the organizational challenge presented by NRM research. Its major component is to rationalize the interaction of many IARCs with national agricultural research systems (NARS). Training, diagnostic studies, farming systems, participatory research methodologies and systems research cut across the joint activities of the various IARCs and NARS. The ecoregional framework is expected to provide an organizational structure to better plan, coordinate and rationalize the outreach activities of IARC. The ecoregional concept thus represents both research and organizational challenges. The research challenge has several components. First is merely the conceptual problem of how to define NRM research problems within CGIAR where, in the past, priorities have been defined in relation to specific crops. The issues raised by the shift towards NRM research highlights the hierarchical nature of agricultural systems. It extends the research problem from cropping or farming systems to higher organizational levels such as the watershed, the land use system or the landform. At these levels issues such as wetland conversion, the social cost of soil erosion, buffer zone management of forests, management of common property resources and the interaction between land use change and hydrology can be studied. Nevertheless, farmer management of resources is still principally defined within the framework of the farming system while the impact on the natural resource base is defined by the aggregate effect of these individual decisions across the watershed or land use system.
The second, and probably dominant, issue is how to undertake and organize systems research. Commodity programs organize themselves around the cropping system where genetic modification of the variety is the principal entry point to the system. At a minimum NRM research must organize itself at the level of the farming system because entry at the cropping system level is inadequate to understand and resolve soil and water management problems (Lynam, 1992). Moreover, there is a tendency toward multiple entry points into the system.

Current NRM research tends to be organized around strategic research on basic processes (organic matter dynamics, soil chemistry or root studies of multi-purpose trees) and the assembly of technological or management components into systems. To date how and where this assembly process should take place is an unresolved issue. Agroforestry research is probably the most advanced example of this type of organizational model and has been struggling with the problem for more than a decade. A major issue is how to add the system dimensions, which are critical to the resource management functions of agroforestry, to the introduction of trees into farming systems.

The ecoregional idea raises the question of what is an optimum level of decentralization to address the problems of NRM research and what is the conceptual basis for organizing research at such a level. A solution must resolve several issues in particular how to allocate most efficiently limited research resources and personnel, the potential for economies of scale in NRM research and the scope for the broad adaptation of NRM technologies. What is clear is that the nature of NRM research requires different responses to these issues than that of commodity research. This is especially true of the varietal component, although breeding for rainfed conditions has started to face similar issues. The nub of the problem is how, within the research process, to deal with spatial and temporal variation.

Research and technology generation, dealing with the complexity outlined, above will need to work on multiple entry points into the systems such as the relation between livestock forage, soil management, and crop components. The heterogeneity problem can best be addressed through selection made by farmers from a range of technological alternatives. Such an approach connects very closely with farmer first or participatory research techniques in that good problem diagnosis can provide limits on the types and number of alternatives that a farmer would want to explore.

System assembly from multiple components will rely heavily on the role of farmers as experimenters. To the extent that it will also require greater farmer-researcher interaction, however, it raises the question of how research effectively services the target population within its resource constraints. At a minimum this puts considerable pressure on farmer first methods to be extremely efficient in problem diagnosis and the introduction of technology alternatives, in other words, using as few institutional resources in the shortest period possible. The experience to date suggests the opposite is required. That is, focussing substantial resources on a few sites for a significant time.

For the transfer of technology model, achieving an impact over large areas therefore becomes problematic. "Location specificity" is even more of a problem for NRM than for commodity research. From this perspective, NRM research is faced with a dilemma: Namely that it relies upon either single components, for example the experience with soil conservation in East and Southern Africa (Stocking, 1992), or system assembly in some sites as has happened with agroforestry. To date the experience with agroforestry system technologies suggests that their autonomous diffusion potential is limited.

Many problems inherent in the above, relate to the degree of focus on technology generation. Sustainable resource management will be equally dependent on institutional and policy innovation. Such innovations could include changes in tenure arrangements, community regulation structures, pricing of resources such as water or common grazing lands or remuneration for downstream costs such as soil erosion. The processes of social innovation, just as technical innovation, can be helped by research.

Sustainable use of natural resources requires technical innovations with a large management component and institutional and policy innovations that must usually be formulated at local rather than national levels. Simultaneously, there is a need to be able to generalize from local-level experiences. This need to generalize forces researchers to examine spatial variability and requires a framework and appropriate methods. The way that spatial variation has been dealt with in commodity research is unsatisfactory because it often ignores the human agency or treats it positively when this is not merited.
From this perspective, technology can be extrapolated over space and spatial variation is reduced to a technical problem to which sophisticated predictive models are seen as the solution.

Our argument in this paper is that spatial variability is not random rather, there is an underlying order. Our knowledge of human-environment relations, however, is insufficient to specify the sorts of predictive models that a technology transfer/diffusionist approach requires to generalize geographical space. This is as true for research on commodities as it is for NRM research. An alternate approach to spatial variation is required which recognizes the integrative function of space and exploits this to investigate the relationships between phenomena that are incompletely understood.

If spatial variation is an obstacle to generalization then it has to be studied to better understand the relationships between the phenomena of interest. Currently, we simply do not understand the human agency sufficiently well to predict the demand for technology, or change, in natural resource management systems. Furthermore even if we can predict the behaviour of system components we cannot presume that the combination of this knowledge will allow us to predict the behaviour of the whole system. For the technology transfer model, the important point is the difficulty of predicting human behaviour, priorities and reactions to changing circumstances. All of this is not to argue against the development of causal explanations, but it does demand a more cautious, iterative, approach to generalisation. In time this can lead to the improvement of theoretical explanations but alternatives to a positivist epistemology need to be explored in doing so. An example is provided in part 4, below. It has important implications for the institutional organization of NRM research, discussed in part 5.

Problems with prediction

Spatial variation is of immediate concern in several spheres of agricultural research. In research planning, information on agriculture and environment can be used to rank areas for research and to select broad regions in which to conduct more detailed studies. Examples of this use of spatial data are provided by Becker and Diallo 1993, Jones et al. 1991, 1992 and Hassan et al. 1992. The work of these authors has largely been concerned with the gathering of information or the structuring of research and therefore has used spatial information to help make better decisions about research priorities. Part 4 below builds on this type of approach.

A different use of spatial information is in the selection of research sites thought to be representative of wider areas and also the generalization, or extrapolation, of research results. Interest in these sorts of applications stems directly from the transfer of technology model. Extrapolation depends on the ability to predict conditions at places distant from the chosen research sites. Prediction has at least two separate sets of activities: linking models of crop response to databases describing environmental conditions and their stochastic distributions and assessing farmers' goals, priorities and resource endowments.

There has been considerable interest in, and a growing experience in the use of, the prediction of environmental conditions through stochastic models and geographic information systems (eg., Harris and Goebel 1987, Nix 1987). The way in which biophysical scientists perceive production systems, as something inherently predictable, is illustrated well by Nix: “I have argued that if it were possible to predict the performance of any crop at any location given a specified minimum set of site, soil, crop, weather and management data, we could indeed prescribe appropriate and relevant technologies at the farm or even the field level” (1987, p.113).

Harmsen and Kelly (1992) illustrate the thinking on how spatial variability can be handled by modelling in their discussion of the perceived site specificity of NRM research: “The advantage is that, if the environment is well-defined, at least one knows exactly where the research results or a certain technology or management package will apply and why. The disadvantage is that one would have to repeat the research in each environment. The latter problem can be overcome, however, with the use of

1 The epistemological challenge to positivism represented by realism and hermeneutics (Johnstone et al., 1986) casts doubt on the likelihood that a positivist approach to the study of open systems can provide an adequate basis for the prediction of outcomes.
simulation modelling. If functional relationships can be established *between the processes studied and soil and environmental variables*, then the results can be extrapolated, provided the models have been properly calibrated and validated," (1992, p.13) (our emphasis). Wortmann (1992) echoes this felt need for more information to aid while extrapolation. When the focus of interest becomes the whole system, as indeed it must for resource management research, then there generally is a shared assumption that socio-economic factors can be included in predictive models. However, as the quotation above from Harmsen and Kelly (1992) shows, socio-economic factors may still be avoided because of the increased complexity they are perceived to imply for model development. The expectations by bio-physical scientists of their socio-economic colleagues have been high: "Methods [in agro-ecological characterization] should consider the current situation, and also be able to detect and/or predict the effects of social change in the performance of the system" (Harris and Goebel, 1987, p.9).

It is expensive to collect quantitative information for large areas of smallholder agriculture. The use of surrogate data that pertains to higher system levels, such as remotely sensed land cover data, census information and published maps, is often used as an alternative to primary data collection. Since there are no methodologies available by which to predict system behaviour at the farm level from these surrogate data, considerable resources would have to be invested in methodology development with no guarantee of success. The volume of data necessary to deal with temporal change similarly demands considerable resources for data collection, processing and analysis. Lack of resources, if nothing else, will limit the extent to which research programmes can undertake this type of modelling.

As has been suggested above, environmental conditions are most easily utilized in attempts at extrapolation. Biophysical conditions are described in large digital data sets that are increasingly available to researchers (e.g., Jones, 1987). Since biophysical conditions change less over time, or are more amenable to stochastic prediction than socio-economic variables, they can be used in spatial models to predict the potential performance or productivity of species or even varieties and hybrids across broad geographical areas (e.g., Thornton et al. 1993).

Unfortunately this sort of modelling tells us nothing about the implications of introducing a biological component into resource management or into a farm system as a whole. By implication, important questions about the likelihood of farmers adopting such components remain unanswered. Furthermore if biological components are part of a package that requires management changes, such as trees in hedgerow intercropping, the biophysical suitability of species is a minor issue compared to the questions raised about the relevance of the management package itself. Hedgerow intercropping, for example, requires changes in labour allocation, changes in the spatial configuration of cropping systems and the resolution of inter-species competition for light, nutrients and water. It therefore seems a particularly daunting challenge for modelling of this type.

Few social scientists have broached the subject of predicting the adoption of technology. Smith (1992) attempted to predict the likelihood of farmers adopting different types of technology (fertilizers, resistant varieties and alley farming) based on economic criteria (the intensity with which they require different resources per unit of output). It is this sort of model that biological scientists envisage linked to crop models and spatial databases. Data problems apart, this type of approach raises the question of whether economic models are appropriate alone or indeed at all to predict farmers' preferences. More sophisticated models that consider noneconomic factors have not been attempted and would depend on a "meta-theory" of nature-society relationships (Turner 1989), which simply does not exist.

The prediction of behaviour presupposes that an adequate understanding exists of how a system works. Whilst this is increasingly feasible for biological sub-systems, it is not at all practical for the social and cultural spheres found within most rural societies. Prediction may be preferred to the more qualitative understanding that comes from studying social, cultural and political-economic aspects precisely because the prediction of social, cultural and political-economic factors deals with quantifiable answers; however inaccurate or inappropriate they may be (Bradley, 1991). Put simply, how do we propose to predict what we do not really understand? Allied to this is the conviction that a mechanistic understanding of biophysical systems does not provide sufficient basis by which to predict appropriate changes in farming systems. Bradley (1991) notes that a lack of deductive power is a particular weakness
of predictive modelling: if predictions fail to come about, what is the reason? Changes in kind, shifts in production systems rather than linear changes, are not easily adapted to in mechanistic models. Ultimately the question is raised about whether it is possible to conduct research for development without being aware of the particular. That is, the local circumstances affecting the way that farmers respond to opportunities and problems. Delahanty (1993 p. 46–48), based on his experience in the Kenyan Highlands, emphasizes the central importance for research of the expert knowledge of local conditions. How such expert knowledge is incorporated into research can be seen as first a problem of data collection, second a problem of the institutional structures and mechanisms of the research process or both.

These alternate perspectives suggest that understanding how farming systems or resource management systems function requires much greater attention to the means to incorporate locally generated knowledge into a framework for analysis of resource management systems that takes spatial variation as its starting point rather than better predictive tools. It also requires an institutional structure that is explicitly organized to deal with spatial variability.

An example drawn from Western Kenya is presented here to illustrate some of the problems referred to in this section. *Sesbania sesban* is a rapid growing (though short lived), nitrogen fixing tree found throughout Western Kenya (Bradley and Huby, 1993). It is generally scattered and is mostly found in poorly drained valley bottoms. In some parts of Western Kenya, however, it is found growing in a much wider range of environments and is deliberately cultivated as an agroforestry tree for firewood, poles and to improve soil fertility (Bradley, 1991, p.181-2). The tree is intercropped with maize and used as a fallow shrub in southern Kakamega District, especially around Bunyore, and in neighbouring parts of Kisumu and Siaya districts (Bradley, 1991, Ohlsson and Swinkels, 1993). The existence of fallowing in this densely populated rural area is interesting in itself. Ohlsson and Swinkels (1993) found 52 percent of a sample of 71 farmers left land fallow. Fallowers had significantly more land, labour and income (inferred through surrogate measures such as housing materials) than non-fallowers. Land was left fallow by these farmers to improve soil fertility and/or because of labour shortages.

ICRAS is interested in the potential of this species as a component of improved fallow management and Ohlsson and Swinkels (1993) stress the importance of gaining a better understanding of the practices they describe to evaluate the adoption potential of improved *Sesbania* fallows. Since fallowing may be decided by the resources available to a household it is at this level that adoption of any improved fallowing practices would be determined.

This implies that, if a predictive modelling approach is to be taken, then at the very least there is a need for very detailed data on inter-household resource availability (over time), on social circumstances and on the priorities of land managers. Most of these variables could be assessed from existing census data. Within this range we would expect social differences to be uniformly distributed. For example, exploratory analysis of existing land use data for Western Kenya (Ecosystems Ltd. 1985) suggests that housing quality is strongly correlated with population density. Therefore the spatial element to prediction here concerns the delimitation of the biophysical limits of *Sesbania* and the range of population densities within which fallowing could be expected.

Figures 1 to 4 shows the superimposition of the biophysical limits to *Sesbania*'s range (<2250m altitude, 500-2000mm rainfall) with the range of population densities within which improved fallowing might be expected (200+ persons per km²). Potential conditions for improved fallowing with *Sesbania* (figure 4) are concentrated in the area where the practice has already been studied and in Kisii District (where agriculture is much more oriented towards perennial cash crop production than is the case in the Kisumu/Siaya/Kakamega area). Other areas are localized and scattered. From such a map it is very easy to emphasize potential impact: the area shown covers some 10 125km², and so on. It is difficult to be much more precise than this using available secondary data.

If one indulges in the creation of Figure 4 then one is really asking the question of why the management of *Sesbania* is so restricted within its geographical range. Within Kakamega, for example, it is only important in the south of the district and not in other parts that have similar farm sizes, social,
economic and environmental circumstances. Bradley (1991) suggests a combination of historical and social reasons for its use in fallows in the South. Originally it was used as a shade tree for coffee in an
area that is close to the Maseno research centre (Figure 4). Its potential for soil enrichment in an area notable for the low fertility of the soil was realised and high rates of adult outmigration led to a low-input agricultural system in which women found it feasible and desirable to leave Sesbania growing on the crop land. These reasons would also appear to explain the importance of the practice in adjacent parts of Kisumu and Siaya.

Some useful conclusions can be drawn from this exercise. The first relates to the idiosyncratic nature of management practices reflecting local circumstances and history. To attempt to extrapolate management practices from localised experiences, however positive, is to ignore the importance of local conditions in deciding their success in the first place. On the other hand, extrapolation of the conditions that caused Sesbania fallowing around Maseno (high male out-migration, low soil fertility and a long familiarity with Sesbania) would produce a very patchy map. These points highlight the limitations of trying to change resource management practices, even by building on indigenous ones, by working from a small number of research sites whereby research is automatically locked into local idiosyncrasies. This proves the necessity for the study of spatial variation as an integral part of natural resource management research and challenges the appropriateness of existing research structures and the transfer of technology model.

Secondly, the example shows that by concentrating on components or individual practices we ignore broader issues of common importance for larger areas. Fallowing (and agroforestry for wood products) is important in many parts of Western Kenya. If the intention is to improve the effectiveness of the fallow we can learn more by trying to understand where it is practised, by whom and for what reasons. This exercise will reorientate the research problem away from a focus on component technologies. We enlarge upon this in the next section.

A geographical approach to natural resource management research

To reiterate the argument stated at the end of the previous section. Spatial variation needs to be studied per se as a means to understanding better how and why resources are managed to identify appropriate interventions and innovations. The goal is not to estimate where technology will work, since often technology alone will not provide an appropriate intervention. Rather it is to find out why resources are managed in particular ways, whether and with what riders are technical interventions appropriate and what else, besides available or forthcoming technology, is required to cause a change in management that
is more acceptable to interested parties. An exploratory approach is essential because of our lack of understanding of resource management.

Analysis of resource management necessarily goes beyond the boundaries of a production/management/socio-cultural system, beyond biophysical system limits such as watersheds and moves across system levels. This contrasts somewhat with the hierarchical approach to farming systems analysis where analyses at different levels are then linked through economic or biophysical models (cf. Fresco and Kroonenberg 1992, Swift and Isaac 1993). The functional relationships between different factors and components of a rural production system transcend scale barriers, whether spatial or temporal. For example, the flux of migrant labour between town and country enlarges the system boundary beyond the immediate locality of the farm.

It is one thing to focus on a neighbourhood, village or local drainage basin concerning bio-physical processes and resources because the human labour by which these resources are tapped and utilised is very much contingent on this wider system of labour exchange. There is an obvious lack of coincidence between the physical milieu on the one hand and the social system on the other. They come together at the place of work (the farm), but they each pursue a different structural logic.

Kakamega in Western Kenya is a classic example where the pace and functioning of rural life and agricultural production are in part decided by the local physical resource base, including the dual rainy season supplemented by lake rains that makes for continuous cropping throughout the year, and in part by the problems relating to a loss of labour to cities (Nairobi in particular). Similar trends exist elsewhere in Kenya and, to a lesser extent, throughout the Eastern Highlands.

Some advances have been gained in attempting to come to grips with these scale-transparent factors. In the Kakamega agroforestry/woodfuel study (KWDP 1991, Bradley 1991) it was possible to operate at a district level by integrating both local and regional data into a crude GIS. The process is outlined in Table 1. This was later extended to Kisii and Muranga Districts such that by the end, the three areas had shown both similarities and individual characteristics. The similarities were clearly common to the Kenyan Highlands as a whole and, with suitable local modifications (checked by rapid field surveys), could provide a template for generalisation and development intervention.
The practice of tree growing on farms is one such general characteristic with locally prevalent choices dependent on the environment, local preferences and historical factors. For example, wattle in Kenya's Central Highlands, *Grevillea robusta* in Meru, Eucalyptus in western Kenya. Furthermore, the results showed that family composition and the relative importance of off-farm employment play crucial roles in the choice of production strategies on individual farms. These factors can be reached through census data, household surveys and land use surveys. All this data can be analyzed to yield surrogate indices of certain "type" situations (for example, the child-dependency ratio). The factors can be
measured at appropriate scales, collected by different means (official statistics, air-photography/remote sensing, questionnaire surveys and literature searches) and, if so wanted, integrated through appropriate statistical procedures (see Table 1).

Returning to the example of fallowing in western Kenya, if a broader perspective of fallowing is taken, it can be seen as one of several ways to try to deal with low or declining soil fertility. It may imply the existence of alternate uses of labour or capital that provides higher economic or social returns than if they were invested in attempts to improve soil fertility. Its use may also be related to the ability of households to purchase food with off-farm income.

Several questions can be asked to try to get a broader understanding of the issues. By expanding the spatial frame of reference from the area where a specific practice has been observed, a range of insights into the broad influences of historical, biophysical, demographic and economic factors on soil management can be gained. Table 2 sketches out a framework for this.

A stratification of western Kenya could be carried out based on the available secondary data listed in Table 2. Within spatial strata, differences in resource availability and quality could then be evaluated in more depth (as was suggested in Table 1). At the level of individual households or management units, the details of, and rationale behind, soil management strategies could then be pursued in greater depth drawing on the methods, insights and experience of different disciplinary specialists. This might lead to grouping of farms based on similarities in resource management strategies, for example, and to formal experimentation by researchers to answer questions of a basic nature that are essential for a better understanding of the system. From there it is possible to envisage the development of a participatory research agenda across a range of situations and from a range of households (or farm types). Figure 5 sets out the whole process from problem definition to on-farm research. Generalisation, the final stage, and agricultural research's principal concern with space, is the subject if the discussion in the next section.
The generalisation of research findings

Any attempt at generalizing research findings must be based on a prior understanding of processes and relationships in the society under study and also its biophysical environment. We argue there is an underlying order to the spatial variation that has seemed so overwhelming to some observers but we also
Figure 6  

*A hypothetical research structure for NRM*

criticise the treatment of spatial variation by models whose relevance is questionable from a social science as well a geographical perspective. Spatial variation is complex and consequently demands time to understand it. The issue for natural resource management research is, "What is the best use of available resources to enable researchers to increase their understanding?"

We argue above that the challenge of natural resource management research demands a break away from a focus on technology, supporting instead an approach steering analytical practice towards a search for patterns rather than predictions. Through pattern searching (of both spatially-defined strata and of variable associations or complexes) it is possible to define a series of spatial scales appropriate for different types of research methods. This can be seen in the district resource analysis procedures of KWDP where the programme went in a series of hierarchical steps from the nation, to the district, to sub-region to groups of households.

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Although the nature of the exercise prevented "statistical, predictive extrapolations" back up to the district and national levels, it did allow extrapolation to wider scales based on key surrogate indices, of major trends and of "forcing" factors. The result was that the cumulative experience of the programme has enabled researchers to move into new districts with a more limited, and more tractable, series of questions to ask.

The establishment of field-orientated and experienced research teams is essential if resource management is to be explored in detail. It is the creation over time of experienced research teams, knowledgeable about the problems of particular systems and places, which will lead to research having an impact on resource management. The process of selecting appropriate methods at appropriate scales, the identification of key relationships and indices and the evaluation of options for change with farmers based on these analyses, provides a base of experience that could be built upon to save time in new areas. This base would then allow the team to focus quickly on key issues and move into areas such as technical innovation, institutional changes or extension as and when appropriate. The make-up of such teams needs to be multidisciplinary and generalized rather than specialised. Often in so-called multidisciplinary programmes, different disciplines are merely aggregated and insufficiently integrated. The approach we advocate needs to go further so that the perspectives of different disciplines are synthesized. If true multi-disciplinarity is attained, it will lead to better questions and approaches and better research will result.

Resource management systems need to be investigated at different scales to see how they are linked to the outside world. This needs to be done so that the work of the teams, in specific locations, is not isolated from the generation of a comprehensive picture of the inter-relations between different places and sectors of the socio-economy under study. Field teams must be "mobile," working in different places, as time and resources allow, in order to synthesize the understanding reached under a range of contrasting situations. The knowledge thus generated is more likely to allow sensible generalizations, either through empiricist/positivist or alternate approaches. The appropriate methodologies required to instigate such a programme are available, most of them within existing private (NGO) and public research programmes. Diagnosis, stratification and focused investigation with farmers to identify more specialised research agendas are all well-developed stages. By covering several geographic areas, field teams can begin to address an explicit agenda, understanding in greater depth the similarities and differences between places and addressing the issue of generalisation from a more knowledgeable standpoint.

The nature and mobility of such teams demand the existence of, and links to, other elements. These include research structures, which generate technical, institutional and policy options at local and other levels (eg. regional, national, international), and to the managers of the land themselves. An explicitly spatial structure for research (Figure 6), by which research agendas are locally driven and integral to local processes of change, would be provide interesting alternatives to the hierarchical structure of most contemporary agricultural research. Within such a structure, what gets generalized could range from the exchange of experiences and methodologies to the promotion of changes in behavioral or social norms and of course, the testing of technical or institutional changes that have worked elsewhere. If empirical model development is to have a role in generalization, then models need to be founded upon a more sophisticated understanding of resource management systems than we currently have. Building and validating such models, through the explicit study of spatial variation in resource management, can be an integral part of this alternate approach. The nature of such models is likely to be much more sophisticated as a result.

References


Mayer, E. 1979. Land Use in the Andes: Ecology and Agriculture in the Mantaro Valley of Peru with Special Reference to Potatoes. Lima, Peru: Social Science Department, special publication. CIP.


Grassroots Indicators as a Base for Functional and Equitable Development

by

Monica Opole

Introduction

There are many indicators for change in a natural environment undisturbed by the products and by-products of man made technological development. These indicators can be found within micro and macro environments. Some of these indicators are restricted by cultures and ecosystems.

In today's development world the result of technological advancement has led to the evolution and manufacture of alternate methods of predicting changes within any given environment. At the global scale the use of satellites in bio-geography and for weather mapping is an example of methods used at a larger scale to predict on-coming changes in the environment. In many situations, however, indicators for sustainable and equitable development, used by decision makers to monitor and predict ecosystem changes, are different from those used by the indigenous inhabitants.

Decision (policy) makers operate within a geo-political environment and they base their decisions upon formulations by scientists and technocrats as exemplified in their use of data for extrapolating on-coming changes. Grassroots decision making infrastructure, on the other hand, is based upon a time-tested coexistence of the inhabitants with their surrounding environment and is derived from observation, inference and a deep understanding of the socioeconomic and cultural factors that make up their communities. Grassroots based, indigenous communities have continued to depend on their time-tested ways of predicting change because they have no access to global/national data or because their environmental changes are affected by many variables of which only they are aware.

In many situations, therefore, grassroots indicators used by decision makers to monitor and predict ecosystem changes are different from those used by indigenous peoples. Within the current development context, the successful development and maintenance of a sustainable way of life lies in bridging the gap between these two methods of measuring environmental change.

Developed versus developing indicators

In a similar vein, within the context of world development the various indicators for monitoring changes can be visualized as existing within two different spheres. The spheres can be understood as that used mainly by developed nations and that used by developing countries.

The use of different indicators by the two worlds is based upon their interpretation of local and international environments. Among developed countries, development is considered to be based upon access, by most of the population, to products of technological change. In contrast, the lifestyles of most of populations of developing nations are still decided by the traditions of the pre-industrial era. The industrialized part of the world is preeminent in their creation of materialistic products such as capital equipment, consumer goods, modern weapons and communication equipment. In comparison, developing nations are predominantly affected by hunger, famine, diseases, civil war and minimal access to the tools of science and technology.

Unwittingly politicians and decision makers often take it for granted that products and by-products designed for the developed world are suited for the developing countries of Asia, Africa and South America. It is also assumed that if the products and by-products are not suitable to the developing world then it is these societies that need to adapt their thinking and ways of doing things rather than requiring that the products require development. This perspective, with previous development trends, ignores the
role of culture as an identity and a constituent for change. The cultural differences between the developing and developed nations are what separates the relationship of developmental goals.

For many "developed" peoples, self-reliance is based upon the "internal" needs of the self or family as a unit. This self-reliance tends not to respond to natural external stimuli like the environment and therefore does not adjust its needs because its reliance is based upon "market" (economic) forces. In other words, self-reliance is based more upon "qualitative" rather than quantitative needs. Developing countries are also beginning to experience the self-reliance syndrome. This is particularly obvious among affluent urban dwellers. Rural communities on the other hand have a different outlook to development. To them, development is a way of life that is synonymous with nature. To many rural communities sustainable development implies a balanced response to natural environmental stresses. It also implies group or communal reliance/balance to and with natural forces. The group or community response to environmental stress is synonymous with the member's culture. Thus, for them self-reliance calls for continuous adjustments to natural forces. This process of continuous change illustrates and calls for qualitative and quantitative adjustment to the needs of the future and is based upon a balanced perspective of relating to nature.

**Culture and grassroots indicators**

Cultural homogeneity implies the satisfaction of meeting basic needs. This may be instinctive and among many grassroots communities, results in a natural motivation to maintain and sustain cultural systems despite external "pressures". Cultural homogeneity also implies togetherness in doing things and therefore calls for a deep knowledge of the surrounding environment, which is then time-tested. This time-tested cultural knowledge is today called indigenous knowledge.

Grassroots indicators are quite diverse. They are also not static within time and space. In many spheres these indicators are eco-culturally specific and call for specifically modified ways of sustainable co-habitation with nature. Examples of eco-specific grassroots indicators are "army worm" manifestations interpreted as a sign of impeding food scarcity between the Luo and Akamba of Kenya. Unusual flooding accompanied by migration of certain animals and insects is seen as a sign of impeding drought, which calls for adjustment and selection of resistant seed varieties by farmers. Cloud formations and the flowering of trees are other examples of indigenous knowledge systems used by grassroots communities.

**Culture and Development**

Culture and development are not synonymous within the context of indicators for sustainable and equitable development. Cultural sustainability calls for the maintenance of ways of doing things according to environmental stress. Development on the other hand does not need culture because development as we know it today is based upon technological knowledge. This scientific knowledge has no cultural base as illustrated by the existence of high technology among developing nations. A closer look at the existence of science among nations, however, shows some disturbing results. Because science was not based upon culture, in many situations, the need for more technological products that "improve" the quality of urban lifestyles has inadvertently resulted in environmental and social degradation.

Sustainable development processes must be based upon identity and authority. Questioning the indicator that is used by decision makers to monitor the status of ecosystems and predict ecosystem changes, raises two major issues. The first examines the relevance and precision of existing monitors. The second questions the suitability, sustainability and the feasibility of merging existing grassroots indicators (if they exist) with those of the formal institutions.

**Sustainable Equitable Development**

Among indigenous people, equitable development implies a state of well-being with the environment. This implies the fulfillment of the basic needs of life such as food, water, shelter and security. Therefore,
among many indigenous rural based communities, equitable development implies that they are at peace with neighbouring cultures, have adequate food, water resources and are in some form of stability.

Change always takes place as part of existence. Within the current framework of development, change, as an indicator for equitable development, can be observed at the individual and communal level of a society. Often changes adversely affect the present and future wellbeing of people.

**Factors Contributing to non-equitable development**

Differences in the perception of development are many. Eco-cultural specificity, economic empowerment and proximity to and access to tools and products of science and technology reveal that there will always be a difference between grassroots indicators for development when compared with the indicators used by policy makers. In attempting to bridge this gap in the knowledge base, it is important for policy makers to note the following:

i. the relationship between the politics of change and natural resource management;

ii. the development of a research agenda based upon farmer indicators, management and practices;

iii. the socio-political pressures resulting from the difference in perspective of natural resource management between policy and grassroots communities;

iv. the socio-economic pressures used by external (cash-crop) market forces versus indigenous or localised food needs; and

v. the eco-cultural pressures experienced by grassroots communities because of borrowed cultural frameworks regarding the management and development of rural indigenous societies.

Changes in natural resource management from policy to grassroots levels, the lack of an appropriate farmer based research agenda, socio-economic pressures passed by market forces and the weakening of cultural norms of individual and societal development all contribute to a situation of conflict that needs resolution. These conflicts are at differing stages. There are conflicts at the levels of the individual, between genders, at the nuclear family level and within communities. Beyond the community level, the resolution of resource management conflict needs institutional intervention because of the interdisciplinary and cross-cultural aspects that are often involved.

These conflicts involve land use management systems, leadership structures from the national through the village to the household level. These conflicts often focus on such topics as who decides what indicator to use to access sustainable development. It is not possible within the scope of this paper to exhaustively discuss all aspects that need resolution to contribute to the development of sustainable and equitable indicators that can be used by indigenous communities. The following are examples of available cases for revising and structuring collaborative participatory methods of upgrading grassroots indicators into mainstream of development.

**Policies on:**

a) **Land use Management**

Indicators exist at grassroots level among people living in the different eco-cultural zones from the highland to lowlands. A state of conflict over resource management exists between central government and indigenous people. For example, the role of the policy making departments within national governments versus grassroots needs to be reviewed. The role of various actors such as the role of the official policy organising, NGO and individual/village communities also needs to be reviewed. There are examples of successful indigenous community initiatives such as with the "Lukurus" and "Atumia" whose local village elders used sustainable management methods in the exploitation of their natural resources and co-operated with national policy making organs.
b) Leadership

The question of accountability and sustainability within the context of indicators used by grassroots communities needs review and evaluation because in many situations, policies are made that conflict with natural resource management based on indigenous knowledge. Examples of the use of indicators to warn of impending famine, including the degree of seriousness, include the observations of selected village elders who can identify these situations. National planning for food security would be more meaningful if local, specific value systems were incorporated into mainstream planning.

c) Gender variation

Gender perspective, which has links with the family and the role of the formal sector, and gender based indicators for sustainable development, may be incorporated into the mainstream of development. Specific examples involve cropping system choice for economic gains versus household food security. The choice of crops for household food security within the highlands, where men have control over land use, as opposed to western Kenya or the Coastal Province, where women have a greater say in land use, contributes to opening a new research agenda into why farmers plant “what where and when” within the framework of indicators for environmental change.

Conflict/Resolution: The role of the State and NARS

The acceptance by national policy makers that grassroots indicators for change, based on indigenous knowledge, have a role to play in sustainable development is a major step to resolving parallel views of resource management. Conventional indicators used by scientists and statisticians have their role in formulating planning policies and projects. It would be more meaningful, within the context of sustainable development, to correlate grassroots indicators with those used by policy managers to have more realistically and people based sustainable and equitable development policies.

The question of where and how to begin rests within the grassroots. If a bottom-up approach to planning is to become operational, then the perspective value systems using indigenous knowledge to predict change must be incorporated into national planning. The thorny issue in this regard is how to integrate the particulars of national planning strategies with the needs of local communities while incorporating the features of grassroots planning. Also, there is the issue of how to integrate indigenous knowledge based indicators for change into existing planning frameworks.

The problem of how to use scientific knowledge, to provide more options and avenues for resource management, must be reviewed by NARS. Although it seems acceptable, with a homogeneous community and environment, to structure research, the challenge at the national level is to merge the variety of options offered by a mixture of mountain slopes and swamps found in a highland watershed. A typical scenario that presents a challenge of this type can be observed in the Lake Victoria catchment area.

For control and access to equitable development there exists a need by NARS to work towards bottom-up planning and production strategies rather than those based on statistical data. The support by policy makers of community based planning, research and the management of natural resource programmes, or projects, is important if existing community adaptation to social and environmental changes are to be incorporated into development at national levels.
Conclusion

The existence of various indicators for sustainable and equitable development needs to be recognised. The juxtaposed existence of grassroots indicators, at one level, versus those of policy makers need to be recognised and evaluated for resolving areas of conflicting perspectives. The role of different actors such as cultural variety, changing views of development, the role of the formal sectors such as the state, NGO and donor institutions, are also areas that need to be resolved for sustainable, equitable development.

The challenge inherent within the IDRC initiatives for grassroots indicators for sustainable and equitable development lies in how best to document the information in a language acceptable and usable to grassroots people. Grassroots indicator evaluation methods must be reviewed to relate them to community based, managed and driven initiatives that are sustainable and equitable.

Bibliography


AFRENA-East Africa: A Mechanism for Collaborative Research on Agroforestry in the Highland Areas of East and Central Africa

by

Kwesi Atta-Krah

Introduction

The Agroforestry Research Networks for Africa (AFRENA) are network mechanisms through which the International Centre for Research in Agroforestry (ICRAF) collaborates with national agricultural research systems (MARS) in agroforestry and natural resource management research in many of the agro-ecological regions of Africa. To date, ICRAF has successfully used the AFRENA mechanism for the definition and development of its research programmes in the major ecological regions of sub-Saharan Africa. Because of their collaborative nature, AFRENA have also provided focal points and helped to define ICRAF's training, education and dissemination activities. They are, therefore, an integral and important part of the organizational matrix through which ICRAF organizes and executes its activities (see figure 1).

Currently, there are four AFRENA covering some ecological zones within the continent. These are:

- AFRENA-S.A., covering the sub-humid tropics of the unimodal rainfall plateaux of Southern Africa;
- AFRENA-E.A., the sub-humid tropics of the bimodal rainfall highlands of East and Central Africa;

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<td>4. Systems Improvement</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DISSEMINATION</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5. Training</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6. Education</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7. Information</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Figure 1. ICRAF Programme structure, showing the position of the AFRENAS and their relationship with the ICRAF research programmes
• AFRENA-HULWA (Humid Lowlands of West Africa); and
• AFRENA-SALWA (Semi-Arid Lowlands of West Africa).

The structure and operational framework of AFRENA has been part of a dynamic process initiated in 1984 and still evolving. The various AFRENA are at different stages of development and each is growing at its own speed. This paper focuses on the East and Central Africa AFRENA (AFRENA-EA) as an example of a typical network.

The East and Central Africa AFRENA

AFRENA-EA is the central mechanism through which ICRAF conducts research on natural resource management in the highland areas of East Africa. The structure, operational mode and research objectives of this network are presented here as an illustration of a collaborative research mechanism established between ICRAF and national research institutions (NARS). The network was established in September 1986 and covers four countries: Kenya, Uganda, Rwanda and Burundi. The network's two main objectives are:

• the development and transfer of appropriate agroforestry technologies for the land use systems within the bimodal rainfall highland ecological zone; and
• the development and strengthening of the national/regional capability and capacity to plan, formulate and carry out agroforestry research.

The mandated operating zone for AFRENA-E.A. are the bimodal rainfall highlands of East and Central Africa. This area is characterized by two rainy seasons and has an elevation between 1000 and 2500m. The rainfall normally exceeds 1000 mm per year. The area covered is estimated at 207 000 km² and supports a population of about 26 million. Most of the population depends on subsistence agriculture for their livelihood. Most soils in the zone are of medium fertility, however, there are limitations because of acidity and slope. General site information for the major research sites in various countries is given in Table 1.

Developing the Research Agenda

The research agenda for AFRENA-E.A., as for the other AFRENA, was developed with a strong bottom-up perspective. At the start of the research activities, macro and micro diagnosis and design (D&D) studies were undertaken in each country to identify priority land use systems, the major constraints farmers faced in those systems and the opportunities for agroforestry to mitigate these constraints. This work was undertaken by research task forces in each country consisting of both national and ICRAF scientists.

The three main region-wide research needs identified by the diagnostic studies were:

• soil fertility maintenance/improvement and erosion control to increase productivity and sustainability of food crop production;
• the production of high quality fodder to improve the productivity of livestock; and
• the production of wood and fruit to reduce deforestation and to enhance the supply of these products for domestic use or sale.

Besides the three major zonal research objectives, listed above, other land-use specific research needs were also identified (through the micro D&D exercise) by the country research task forces. These were incorporated into the research programmes of the various countries.
<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>BURUNDI</th>
<th>KENYA</th>
<th>RWANDA</th>
<th>UGANDA</th>
<th>Type</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>Mashitsi</td>
<td>Maseno</td>
<td>Rwerere</td>
<td>Kachwekano</td>
<td>Ferralsol</td>
<td>2 - 5%</td>
</tr>
<tr>
<td></td>
<td>1620</td>
<td>1500</td>
<td>200/2300</td>
<td>1205</td>
<td>Ferralsol</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>3°22'S</td>
<td>0°O</td>
<td>1°32'S</td>
<td>0°28'S</td>
<td>Ferralsol</td>
<td>0 - 5%</td>
</tr>
<tr>
<td>Alt. (m)</td>
<td>1600</td>
<td>1490</td>
<td>2350</td>
<td>1205</td>
<td>Ferralsol</td>
<td>0 - 15%</td>
</tr>
<tr>
<td>Lat.</td>
<td>0°30'S</td>
<td>2°10'S</td>
<td>2°29'S</td>
<td>0°34'S</td>
<td>Ferralsol</td>
<td>25 - 45%</td>
</tr>
<tr>
<td>Long.</td>
<td>1°16'S</td>
<td>1°16'S</td>
<td>1°29'S</td>
<td>1°16'S</td>
<td>Ferralsol</td>
<td>0 - 2%</td>
</tr>
<tr>
<td>Rain (mm)</td>
<td>1187</td>
<td>1140</td>
<td>1230</td>
<td>1040</td>
<td>Ferralsol</td>
<td>8 - 56%</td>
</tr>
<tr>
<td>Temp:</td>
<td>28.4</td>
<td>25.8</td>
<td>20.1</td>
<td>17.2</td>
<td>Ferralsol</td>
<td>5 - 10%</td>
</tr>
<tr>
<td></td>
<td>25.0</td>
<td>20.7</td>
<td>19.5</td>
<td>22.5</td>
<td>Ferralsol</td>
<td>5 - 25%</td>
</tr>
<tr>
<td></td>
<td>14.6</td>
<td>14.1</td>
<td>15.7</td>
<td>14.5</td>
<td>Ferralsol</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>13.5</td>
<td>10.9</td>
<td>8.8</td>
<td>19.5</td>
<td>Ferralsol</td>
<td>1 - 15%</td>
</tr>
<tr>
<td>Soils:</td>
<td>10.4</td>
<td>10.9</td>
<td>13.0</td>
<td>13.3</td>
<td>Ferralsol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30.7</td>
<td>21.5</td>
<td>15.0</td>
<td>8.1</td>
<td>Ferralsol</td>
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<td></td>
<td>25.7</td>
<td>25.4</td>
<td>19.2</td>
<td>10.5</td>
<td>Ferralsol</td>
<td></td>
</tr>
</tbody>
</table>
Research activities

The major research activities undertaken within AFRENA-EA are:

i) Screening, management and improvement of multipurpose trees and shrubs (MPTS): The goal of this research is to broaden the species and provenance base of agroforestry species for the mandate region. Specific research activities undertaken within the region include:

- general MPTS screening;
- technology specific screening;
- MPTS establishment and management trials;
- genetic improvement of selected MPTS; and
- on-farm MPTS introductions and evaluation.

ii) Fodder production technologies: The goal of this research is to improve the availability and quality of fodder by integrating leguminous fodder trees into production systems using agroforestry techniques. Research activities being undertaken in this regard include the following:

- fodder tree screening and selection trials (including palatability and digestibility);
- fodder tree management in production systems (on-station);
- on-farm testing of fodder tree cultivation and management in both on-station and on-farm trials; and
- the effect of tree fodder on livestock productivity (feeding trials).

iii) Upperstorey tree systems: The goal of research in upperstorey tree (UpST) technology is to increase the supply of wood and fruit production through agroforestry. This research involves the following activities:

- upperstorey tree screening and selection;
- the development of management systems involving UpSTs in either boundary planting or interspersed within cropping fields; and
- on-farm testing of UpST technologies.

iv) Soil fertility maintenance and conservation. The goal of this research is to develop mechanisms and systems for the maintenance, conservation and improvement of soil fertility through agroforestry. This research has a broad natural resource management objective and involves the following activities:

- screening and selection of MPTS for soil fertility purposes;
- The screening and selection of MPTS for tolerance to soil acidity and aluminium toxicity;
- management of MPTS in various technologies for soil fertility enhancement and erosion control;
- the management of terraces to minimise scouring; and
- on-farm testing of soil fertility and conservation technologies.

Research support and dissemination activities

ICRAF's support of AFRENA is not only in the area of research. The AFRENA receive major support in training, education and dissemination activities within the framework of ICRAF. The major components of this support are training, education and information exchange.
Training and education

Through the AFRENA mechanism several NARS scientists and technicians have received training at various group training courses organized by ICRAF. NARS scientists are also able to obtain fellowships and scholarships to undertake higher degree courses at both local and foreign universities. This has helped to strengthen national agroforestry research systems.

Information dissemination and exchange

ICRAF provides information support services to the network by making its library services available to network members. Several technical and scientific journals, as well as agroforestry news and other information sources, are supplied through various means to network members.

Within the network, information exchange is promoted through conferences, workshops, meetings and through correspondence. Once a year there is a network research planning and review workshop at which information is shared by all the members of the network and future research activities are planned. As well, representatives from the member organizations visit other members to coordinate ongoing activities. Meetings of technical working groups are also important mechanisms for information exchange and experience-sharing.

The structure and coordination of the networks

The coordination of AFRENA networks is considered one of the principal support activities provided and coordinated through ICRAF. Each of the four AFRENA networks has a Coordinator, assigned from ICRAF's scientific staff, who is responsible for the technical and administrative management and direction of a network. The AFRENA coordinators are also regional coordinators in ICRAF's management structure. The regional mechanism, directing and overseeing the activities and affairs of AFRENA-EA is carried out through the Regional Steering Committee whose members are directors of partner NARS. ICRAF is also represented on the committee.

Technical direction and research planning for the network are executed through a Regional Technical Committee. This committee is made up of national AFRENA project research leaders and their counterpart ICRAF scientists sent to work within the various AFRENA networks, in collaboration with the NARS. All ICRAF programme coordinators (both research and dissemination programmes) are members of this committee.

Execution and management of AFRENA research programmes within each country are the joint responsibility of the AFRENA research teams. These teams are largely made up of national scientists, usually with one ICRAF scientist operating as technical advisor and/or counterpart project leader. The leadership of AFRENA research teams is usually held by national scientists. In cases where NARS scientists may not yet have the strength and capacity to provide the technical and administrative leadership required, the ICRAF counterpart takes temporary leadership of the project.

National steering committees, made up of directors of research and development institutions involved in agroforestry research and development in the various countries, provide the needed technical direction and steering of the national AFRENA research programmes. Figure 2 gives the chain of operation and direction of AFRENA-EA.

Conclusion

The AFRENA network model has proved to be an effective mechanism for collaboration between ICRAF and national agricultural research institutions. In the particular case of East and Central Africa, AFRENA-EA has become an integral part of the various national research systems and has also become the central mechanism for natural resource management research in the highlands of the region. While the strong links of AFRENA with ICRAF are expected to continue, the process of evolution is geared
towards NARS taking an increased responsibility and leadership for the management and coordination of the network. ICRAF's input and support will be concentrated in providing research support and collaborating in research on strategic issues of regional importance.

Two parallel research organization and coordination initiatives are under development for the Eastern and Central Africa region. Both are relevant to and will have implications on, linkages with AFRENA-EA.

Figure 2. Chain of operation and direction of AFRENA-East Africa

The first of these, known as the "Highlands Initiative," is an attempt to coordinate efforts of the various international agricultural research centres (IARC) interested in integrated natural resource management research for the highlands of East and Central Africa. The Initiative will promote collaboration between IARC and NARS in the region. Details on the Highlands Initiative are provided in a paper by Bruce Scott (in this publication).

The second initiative is termed "Framework for Action (FFA) on Agricultural Research in East Africa." This is a Special Programme for African Agricultural Research (SPAAR) and USAID sponsored initiative that aims at strengthening agricultural research by establishing a central mechanism for the coordination, direction and control of agricultural research across the region. The FFA will be coordinated by a committee of the Directors of the national agricultural institutions. It is envisaged that all regional research networks and other research initiatives (e.g., the Highlands Initiative) will come under this network and will be coordinated through the Directors Committee. AFRENA-EA will, therefore, be linked to this larger framework as a sub-programme. With all these on-going developments, it can be said that the region is in an evolutionary phase concerning agricultural research coordination and collaboration. Natural resource management research for the highlands of East and Central Africa will continue to be a major component of this research and AFRENA-EA continues to exist as a coordination and collaboration mechanism in this regard.
Local Knowledge and Soil Resource Management in the Highlands of Southwest Uganda
by
Cary Farley

Introduction
Throughout the densely populated highlands of Kabale and Kisoro Districts in southwestern Uganda, local farming practices are generally assumed to be inducing agricultural encroachment into the forests, altering hydrologic responses in the watersheds and damaging the long-term productivity of the soils. Government officials, researchers and development workers alike have expressed concern that the local land use practices are threatening the sustainability of the highland agricultural systems as well as the viability of the few remaining natural forest and wetland systems. Soil degradation, including erosion and fertility loss, is considered to be widespread in the region (e.g., Ngabirano 1993, Peden and Kakuru 1993).

The concern over soil degradation in the southwestern highlands exists not only among regional administrators and “outside-experts.” Many local farmers also recognize that it is occurring, and they point to a general decline in crop production as evidence of the phenomenon. While local farmers and district agricultural staff might agree that there is a need for improved resource management, commonalities in their outlook end there.

Much of the current concern over resource management in the highlands can be traced to differing responses to the “problem” of soil degradation by local farmers and district-level administrators. This divergence, however, should not be cause for accusation or recrimination but rather investigation. Neither the magnitude of the soil-related problems, nor their various causes, nor the ability of farmers to manage them are well understood. An on-going investigation to understand the constraints acting upon farmers in the highlands of southwest Uganda has proven valuable and informative. Preliminary results from the investigation are presented in this paper.

The Highland Agroecosystem
The topography of southwestern Uganda is characterized by ridges of uplifted Pre-cambrian rock striking N/NW - S/SE, with elevations ranging from 1500 to 2700 meters. The ridges are separate from one another by steep-sided valleys that often contain wetlands or swamps. In the extreme southwest of the region lies the eastern extent of the Virunga volcano. Soils in the highlands are generally considered to have poor to medium agricultural potential (e.g., oxisols and ultisols), with the exception of a few areas

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1 The highlands of southwestern Uganda include the Districts of Kabale, Kisoro and Rukungiri. During the British colonial period, together they comprised the single district of Kigezi.

2 Problems commonly cited include sheet and rill erosion, gullying, mass wasting, leaching of nutrients as well as a reduction in soil organic matter and soil organisms (e.g., Bagoera 1988, Tukahirwa 1988).

3 Few investigations have been conducted into the chemical or physical status of soils, or their inherent susceptibility to erosion. Recent research has actually found clay soils from Kabale well aggregated and stable (Magundo 1992). Preliminary results from a research project in Kabale also indicate minimal rates of soil erosion under traditional cropping systems (Tukahirwa 1994).
of more fertile volcanic soils (e.g., andisols), Chenery 1960, Yost and Eswaran 1990). The climate is equatorial yet temperate, with a mean monthly temperature range between 22.2 and 23.9 degrees Celsius. Precipitation averages just over 1000 mm/year, although year to year rainfall variation can be high (Harrop 1970, Jameson and McCallum 1970, Peden and Kakuru 1993).

The Districts of Kabale and Kisoro represent one of the most densely populated rural regions in Uganda.4 Throughout the highlands, the vast majority of the landholdings are fragmented, a result of traditional inheritance practices whereby landholdings are divided amongst a man's children, usually the sons. Most farmers cultivate from three to seven dispersed plots that can include land on both hillsides and valley bottoms. While farmers recognize that the fragmented nature of their holdings can impede efforts to improve soil management, they also note that it provides opportunities to diversify crop production and mitigate risk. In recent years, land shortages have precipitated the decline of the traditional fallow system both in terms of frequency of fallow and length of fallow period. In an attempt to accommodate population pressures, many farmers have also expanded cultivation into increasingly marginal environments such as steep slopes and papyrus swamps, as well as protected forest zones.5

More than 85 percent of the population in Kabale and Kisoro Districts (G of U 1991) are described as subsistence farmers although many farmers are also involved in a variety of semi-commercial activities such as crop marketing and sorghum-beer brewing. While men participate in the hoe-tillage of farm plots and assist with harvesting, women provide the bulk of the agricultural labour in the highlands farming system. Women are responsible for most aspects of land management and agricultural production including the provision of food crops for household consumption. Unfortunately women also most heavily bear the costs of soil degradation (e.g., declining food crop production), and given the variety of gender-based constraints to improved resource management6 in the highlands, they are often the least able to address the problem.

Throughout the highlands there are two cropping seasons per year that correspond with the short (February-May) and the long (August-December) rains. Crops cultivated include sorghum, millet, maize, wheat, peas, bush and climbing beans, Irish potatoes, sweet potatoes, pumpkins (squash), taro, bananas and a variety of vegetables. Traditionally, mixed and relay cropping were common farming practices, but they have largely been supplanted by mono cropping systems. Farmers have also modified their cropping profiles7 in an attempt to maintain or increase their agricultural productivity. Animal husbandry (cattle, goats and sheep), once an important component of the highland farming system, has declined in recent years.

The colonial soil conservation experience

The British colonial administration in southwestern Uganda (Kigezi District) first identified soil degradation as a land management problem in the 1930s (Anderson 1984). Prompted by concern over the region's rapidly expanding population, the colonial administration established stringent soil and water conservation regulations in 1939 (Tukahirwa and Veit 1992). The regulations, however, reflected little awareness of local agricultural knowledge or land use practices despite evidence that a number of effective practices such as modified terraces, trashlines, existed prior to colonial intervention in the region. Instead, the regulations prescribed soil conservation techniques including grass bunds and

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4 District level population densities average 250 people/km², while parish-level densities can reach 620 people/km² and village-level densities can exceed 1,300 people/km².

5 Encroachment into Mgahinga and Bwindi Impenetrable National Parks, located in southwestern Uganda, has been a major concern for Ugandan conservationists.

6 For example, local land tenure and cultural traditions effectively prevent women from planting trees or hedgerows.

7 The cultivation of "traditional" crops such as peas and millet have decreased while the cultivation of "newer" crops like Irish potatoes and wheat has increased. These cropping modifications have been the result of a variety of influences, including population pressures, declining yields, changing cultural preferences and market influences.
<table>
<thead>
<tr>
<th>Soil Type (Rakiga Dialect)</th>
<th>Physiographic Position</th>
<th>Soil Description</th>
<th>Land Use/Crop Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Omuchuchu (omuchuchu = dust)</td>
<td>Ridge-tops &amp; Upper-slopes</td>
<td>Red-brown; water absorbed into upper 15 - 20 cm quickly, but doesn't percolate well into sub-horizons; dusty when dry &amp; easily wind-blown; no stones or clay.</td>
<td>Trees &amp; pasture; Sweet potatoes, Irish potatoes, peas, millet, wheat</td>
</tr>
<tr>
<td>. Eryakatuku (mutuku = red)</td>
<td>Upper-slopes</td>
<td>Red &amp; brown; difficult to cultivate unless wet; some stones; exposed sub-soil.</td>
<td>Trees, Pasture, Sweet Potatoes.</td>
</tr>
<tr>
<td>3. Amabare (amabare = stones)</td>
<td>Upper-slopes &amp; Mid-slopes</td>
<td>Stones; rock; exposed parent material.</td>
<td>Trees &amp; Pasture</td>
</tr>
<tr>
<td>4. Eryorugugo (engugo = chalk)</td>
<td>Mid-slopes</td>
<td>Greyish-white; water percolates quickly; moisture held easily.</td>
<td>Trees; Sweet potatoes.</td>
</tr>
<tr>
<td>5. Orushenyi (maraam soil)</td>
<td>Mid-slopes &amp; Lower-slopes</td>
<td>Red-brown; dries out quickly; stony.</td>
<td>Sweet potatoes, maize, beans and peas.</td>
</tr>
<tr>
<td>6. Eryonombre (esombe = lump)</td>
<td>Lower-slopes</td>
<td>Dark-brown; slippery &amp; sticks to hoe when wet, hard &amp; lumpy when dry; clay-loam, no stones.</td>
<td>Sweet potatoes, beans, peas, sorghum &amp; wheat</td>
</tr>
<tr>
<td>7. Eririwikusungura (okwikusungura = black)</td>
<td>Suspended (Step) Valleys</td>
<td>Black; fertile-loam; holds moisture well.</td>
<td>All crops &amp; vegetables produce well.</td>
</tr>
<tr>
<td>8. Eryonushenyi (onushenyi = sand)</td>
<td>Foot-slopes</td>
<td>Colour varies from black to dark brown to white; sand, often with some clay.</td>
<td>Trees, house plaster; Sweet potatoes &amp; beans.</td>
</tr>
<tr>
<td>9. Eibumba (eibumba = clay)</td>
<td>Valley Bottoms &amp; Swamps</td>
<td>Black and/or grey clay soil; sticks to hoe when wet, &quot;chumps&quot; easily; readily holds water after rains, but dries-out quickly; no stones.</td>
<td>Sweet potatoes, maize, beans &amp; sorghum</td>
</tr>
<tr>
<td>10. Eryofunjo (orufunjo = swamp)</td>
<td>Valley Bottoms &amp; Swamps</td>
<td>Black; holds water well; silt with some clay; no stones.</td>
<td>Irish potatoes; maize, beans, vegetables.</td>
</tr>
</tbody>
</table>

Table 1 *Local Soil Classification (Kikumbi Parish, Kabale District)*
alternative strip-cropping that required the modification or replacement of traditional farming practices, were often labour intensive and were enforced by fines or other punitive measures. While the colonial administrations undoubtedly considered many of the measures necessary, little effort was made to understand local practices or to enlist farmers to participate in the development of the regulations imposed on them.9

The soil and water conservation regulations introduced during the colonial period continued to be updated and revised periodically.9 Since independence (1962), however, many of the prescribed technologies have been abandoned or ineffectively managed. The current generation of by-laws (see Appendix) are poorly implemented by district-level agricultural staff and rarely complied with by local farmers. Aside from the by-laws, other remnants of the colonial soil conservation programmes can be found in Kabale and Kisoro Districts. The vegetative bunds, for example, planted along the hillside contours for erosion control, are still evident throughout the region. Today, the highlands are characterized by a patchwork agricultural environment representative of both the colonial soil conservation efforts and the fragmented nature of land holdings in the region.

Local soil knowledge in Kicumbi Parish

In recent years there has been a growing movement to investigate the "ethnosciences" and consider the potential role of local ("indigenous") knowledge in rural development and resource management efforts (Pauluk 1992, Reij 1991). A wealth of research findings have revealed a variety of local soil classification systems and soil and agricultural management practices for a number of regions in Sub-Saharan Africa (e.g., Almy 1991, Carter 1993, Osunade 1992). In the highlands of southwestern Uganda, small farmers also demonstrate a well-developed knowledge of soils and a range of management practices for a diversity of local environments.

In this section, the preliminary results from an investigation into local soil knowledge, management practices and constraints in Kicumbi Parish,10 Kabale District, will be presented. Participatory research methods, including group discussions and ranking and mapping exercises, were utilized to investigate local soil knowledge and management practices. Informal interviews were also conducted with local soil "experts" who assisted with the identification of local soil types in the field.

Throughout the Parish, farmers were able to systematically describe nine discreet soil types (plus "amabare" or rocks) specific to their farming system (see table 1). Farmers "classify" the soil types according to a variety of locally important criteria such as colour, "stoniness", moisture-holding capacity, susceptibility to drought and erosion and agricultural potential. The agricultural or land use potential of a soil is one of the most important criteria in the local classification system.11 Generally there are two or three preferred crops for a given soil type, although many farmers can discuss the potential performances of a range of crops.12 The criteria utilized in the local classification system underscores the practical or functional dimension of local soil knowledge. In addition to a complex soil classification

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8 Farmers generally employed simple and practical means to manage their soils. They avoided steeply sloping areas; maintained a near-continuous vegetation cover on plots; practised minimum tillage and broadcast planting; created trash-lines and modified terraces; and rotated crops and utilized a fallow system to manage soil fertility. The traditional wooden hoe, prominent in the minimum tillage cropping system, has also been replaced by the steel hoe (e.g. Reij 1991, Rugyema 1974).

9 The soil and water conservation regulations were formally legislated as district-level by-laws in 1961.

10 In Kicumbi Parish, the population density is 406 people/km².

11 This "traditional" method of differentially managing soil types, or "farming by soil," is now promoted in the US albeit with the assistance of computer technology (e.g., Robert 1993).

12 Land shortages often dictate that farmers grow culturally important (sorghum for beer production) or marketable (Irish potatoes) crops despite the local soil classification.

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system, farmers recognize soil associations within their highland environment. They can also accurately describe the local soil catena, systematically locating local soil types on a given slope (see table 1).

Farmers also demonstrated a well-developed understanding of the fertility and erodibility status of soils in Kicumbi Parish (see table 2). Many farmers indicate an awareness of the relationship between soil erosion, fertility loss and declining crop production as well. However, as previously noted, discussions with farmers also revealed some uncommon perspectives. A number of farmers, for example, pointed out that top-soil and nutrients are not “lost” per se, but rather “transferred” elsewhere within the larger farming system: soils “erode” and move downslope, essentially from plot to plot. Given the fragmented nature of landholdings in the Parish, many farmers have both hillslopes and valley-bottom plots, the costs and benefits of erosion are distributed amongst farmers. While farmers do not suggest that any parity is actually achieved from plot-to-plot soils movement, ridgetop plots obviously experience a net loss of soil, their perspectives reveal that soil erosion is not simply perceived as a detrimental process, or a “loss”.

For many farmers, soil erosion is a complex process that does not simply result in the removal of soil and nutrients from their plots. Farmers not only reveal an understanding of soil erosion but can actually manipulate the processes to manage for fertility in their plots. A number of farmers in Kicumbi Parish for example, apply manure\(^{13}\) to the back or “up-slope” portions of their plots. They do this for two basic reasons:

1) farmers recognize the existence of soil fertility gradients in most plots (gradient runs from the fertile soil “downslope”, immediately behind the bund, to the less fertile soils “upslope”, at the back of the plot, where the soils are normally exposed sub-soil of inherently poor fertility); and

2) farmers recognize that erosional processes will distribute the manure and nutrients downslope over the plot. While the latter practice might not be the most effective means of managing manure, it again underscores farmers’ basic understanding of erosional processes.

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\(^{13}\) The application of livestock manure to farm plots is by no means universal in Kicumbi Parish. The livestock population in the area has declined in recent decades and only livestock owners are able to follow this practice.
As mentioned earlier, the grass bunds introduced during the colonial era remain a prominent feature of the landscape in the highlands though more often than not, the bunds are poorly maintained. While farmers claim they recognize the erosion control benefits of the bunds, they are generally reluctant to make significant investments to improve their management. There are two basic reasons for this unwillingness. First, the very success of the grass bund system in arresting the downslope movement of top-soil and trapping nutrients also creates a management problem: the downslope farmer is often tempted to undermine the bund, thereby inducing collapse and allowing for the "harvest" of the fertile bund soil. Secondly, wide and well-managed vegetative bunds also attract grazing livestock as grazing often leads to bund collapse and crop raiding. While farmers are generally reluctant to improve the management of the grass bunds, they have not entirely either abandoned them either. This is not simply because the soil erosion control benefits are perceived by the farmers to be greater than the other costs. Rather, farmers point out that the bunds are now an integral part of the local land tenure system and serve to demarcate farm plots.

While farmers in Kicumbi Parish recognize soil erosion as a natural process which cannot be completely controlled, most farmers also acknowledge that there is a need to improve soil resource management within their farming systems. The reasons behind farmers' unwillingness to utilize many recommended soil resource management practices are diverse, however, and their biases underscore the influence of a variety of factors on local soil resource management. Farmer-cited constraints to improved soil resource management reveal social and economic, as well as technical concerns. They include land, labour and tool shortages; decline of the fallow and crop rotation system; uncontrolled cattle grazing; gender-based control of and access to resources; and timely and equal access to markets and agricultural inputs. These constraints underscore the importance of strengthening local social institutions to address land management conflicts initiating a more holistic approach to soil resource management and including farmers in future programmes.

**Conclusion**

The history of the colonial soil conservation experience in southwestern Uganda reveals the limitations of a "top-down" approach where exogenous technologies were introduced without consultation with local farmers and local soil knowledge and practices were largely ignored or disregarded. The general failure of externally-developed and directed soil conservation programmes has been overlooked, however, and few lessons have been learned from this experience. At a minimum, the failure underscores the need to consider alternative approaches to improved soil resource management in the region.

Many of the available "on the shelf" soil conservation technologies recommended for highland areas are also inappropriate for the fragmented land holdings and heterogeneous environments characteristic of Kabale and Kisoro Districts. Given the enduring importance of subsistence, hoe-based, agriculture in the region it will be important to consider practices already utilized by farmers for further promotion in the region. The local soil classification system and management practices described in this paper reveal a wealth of knowledge and experiences that should be tapped and built upon. A reliance upon local knowledge and resources has the potential to minimize vulnerability as well as reduce dependence on externally supplied inputs and experts.

While farmers and researchers have incomplete knowledge of the various social and physical elements of the highland farming systems, they both possess valuable experiences and skills that can contribute to soil resource management programmes. The expanded participation of farmers in future soils resource management initiatives can also facilitate the development of a range of technologies and recommendations reflecting local conditions. It can also encourage farmers to feel greater "ownership" of the technologies and thus improve their chance for adoption. Not only should farmers be encouraged to participate in on-station and on-farm research but their own adaptive traits and field experiments must

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14 Women are responsible for most aspects of crop production and land management, while men are the primary livestock owners and caretakers. Thus there is a strong gender-based dimension to the continual conflict between crop production and land management, on the one hand, and uncontrolled livestock grazing.
also be supported. The knowledge and skills of farmers and researchers should be considered complementary (Walker and Wortmann 1993) and a strong collaboration between the two can facilitate the development of successful soil technologies and resource management strategies reflecting local needs, resources and environments.

References


Terracing in Nyarurembo, Uganda. Washington, DC: WRI.

Appendix

Kabale District Soil and Water Conservation Bylaws*

This law shall be called the Kabale soil and water conservation law (1990). The following rules to prevent soil degradation shall be followed:

1. All land under cultivation, or cleared for cultivation, or land planted to trees shall be provided with bunds of earth/stone across the slopes and parallel to the contour at intervals not exceeding 16 yards apart on [land of moderate slope] and 12 yards on hilly areas.

2. Bunds shall have a minimum width of 3 feet and a height of not less than one foot. Each bund shall in all cases be planted with grass (the downward facing slope inclusive), such as Kikuyu grass.

3. On sloping land planted to annual crops, trash lines consisting of dead vegetation shall be laid parallel to, and half-way between the existing bunds.

4. When crops are planted in lines, the lines shall be across the slope and parallel to the contours. In the case of sweet potatoes, the ridges shall be used and planting shall be done on soil ridges across the slope and parallel to the contour. In such a case lateral bunding shall be practised.

5. No fields or lots shall be demarcated by furrows or gullies. Live hedges or shrubs or stone walls shall be used for demarcation.

6. No annual crops shall be cultivated within 9 feet of any perennial or seasonal water course or any maintained roads.

7. All paths, cattle tracks, ditches and access roads shall be protected against erosion by run-off channels, soak-way pits, or stakes to prevent erosion.

8. Paths or tracks may be closed by a Gombolola (Sub-County) Chief with the assistance of RC's (Resistance Council Members) to prevent erosion; alternative routes shall be provided.

9. Cultivation on any steep sided slopes vulnerable to erosion/landslides shall be stopped by the Gombolola Chiefs, with the help of the RC's, on the advice of the District Agricultural Officer (DAO) or his field assistants, as and when deemed necessary to prevent soil erosion. Alternative vegetation. (e.g., Black Wattle, Cypress, Leucaena, Sesbania and Erythrina abyssinica), shall be planted on such land.

10. Any form of grass burning, be it trash or on hillsides, is prohibited. Noxious weeds like couch grass (lumbugu) and comelina shall be heaped together to decay.

11. All house compounds, except the winnowing area and compounds around buildings, shall be grassed over with a low-growing grass. Stone-filled trenches shall be constructed under food caves and the trenches shall discharge into soakaway pits.

12. In the case of reclaimed swamps, the land holder shall ensure that the water channels bordering on or passing through the land allocated to him/her are kept clear of earth, rubbish and other obstructions for smooth water flow and prevention of flooding.

13. Land planted to bananas or coffee shall be covered with mulch where possible.
14. All Black wattle [and] any other trees, whether in lines or plantation shall be thinned in year of germination to 4.5 feet apart and at the age of three years to a minimum of 9 feet apart.

15. Any person disobeying the provisions of this law shall be guilty of an offence and shall on first conviction be liable to a fine not exceeding Uganda shillings 3000/=-** or imprisonment for 15 days, or both, and shall on subsequent conviction be liable to a fine not exceeding 5000/- or to imprisonment, whichever is deemed more effective.

* Considered and Passed by the Kabale District Resistance Council, May, 1990.

** 1990 Exchange Rate: US$ 1 = Ugandan shillings 950.
Introduction

Since its inception, the International Livestock Centre for Africa (ILCA) has had inter-disciplinary teams working at various sites in sub-Saharan Africa. The sites were selected based on their ecoregional relevance and proximity to other institutions with whom collaboration would be possible. The highlands are one of the major ecological zones in which ILCA has chosen to work. The Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) define cool tropical zones as those areas with a temperature range between five and twenty degrees Celsius during the growing season and includes tropical highlands in this term. However, there seems to be no consensus on the demarcation of highlands and ILCA has adopted the generally accepted definition of land lying over 1500 meters above sea level. This altitude is roughly equivalent to the boundary between crops adapted to the warm tropics and those adopted to growth in the cool tropics.

About 75 percent of the highland areas of tropical Africa are to be found in the eastern part of the continent. Countries with extensive highland areas include Uganda, Tanzania, Rwanda, and Burundi. Sixty-two percent of the East African highlands are in Ethiopia. The history of human settlement and habitation in this region ranges from very old, as in the Ethiopian highlands, to more recent. Today, African highlands face acute problems, many of which are associated with population pressure on agriculture, and show symptoms of unsustainability particularly concerning the current pattern of resource-use and agricultural production practices. Unlike in the lowlands, the land use systems in the highlands must cope with a rugged terrain, high altitudes, slopes, shallow soils, and clusters of spatially close but often dissimilar "niches." As land productivity declines, people are forced to move cultivation onto the steeper slopes, which results in deforestation, overgrazing, and land degradation.

The Ethiopian highlands cover some 490,000 km², or 40 percent of the land, and account for about 85 percent of the cultivated area, accommodate 88 percent of the total human population, 70 percent of the livestock population, and 90 percent of the economic activity of the country. Agriculturally and socioeconomically, the Ethiopian highlands have some similarities to the rest of the highlands areas in the region. Most of ILCA's highland research has been confined to Ethiopia although other countries were also included in diagnostic surveys.

The Ethiopian highlands serve as the catchment for many tributaries that ultimately feed the river Nile. The growing demand for water from the river, accompanied by deforestation and cultivation induced land degradation in Ethiopia, tends to threaten the water courses and reservoirs with siltation. This situation increases the prospects for water deficiencies and transboundary conflicts in the associated lowland countries. Protection of the Ethiopian highlands therefore is an international concern and it can only be achieved by reducing societal pressure that results in degradation-prone activities. It is within this context that ILCA's concentration of its highland's research efforts within Ethiopia should be viewed.

ILCA's highland research as an example of an ecoregional approach to agricultural research

The strategies needed to arrest and possibly reverse the trends in highland land resources are complex and require multi-institutional approaches. TAC has proposed an ecoregional approach to focus and
Table 1 Comparison of TAC’s criteria for ecoregional institutions and ILCA’s highland research

<table>
<thead>
<tr>
<th>TAC’s Criteria for an Ecoregional Programme</th>
<th>ILCA’s Considerations for Highland Vertisol Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Zone of population pressure</td>
<td>Yes. Human/Livestock population very high in East African Highlands</td>
</tr>
<tr>
<td>2. Agriculture dependent economy</td>
<td>Yes. East African region continue to depend on agricultural base</td>
</tr>
<tr>
<td>3. Faster resource degradation</td>
<td>Yes. Ethiopian highlands alone</td>
</tr>
<tr>
<td></td>
<td>- loses 2 to 3.5 billion/tons of soil annually</td>
</tr>
<tr>
<td></td>
<td>- forests depleted from 16% in 1950 to 2.7% 1992</td>
</tr>
<tr>
<td></td>
<td>- land productivity declines 3% annually</td>
</tr>
<tr>
<td>4. Less equipped national research systems</td>
<td>Yes. National institutions under-staff and poorly equipped</td>
</tr>
<tr>
<td>5. Possibilities for multi-institutional collaboration</td>
<td>Yes. Joint Vertisol Project 3 IARCs, 5 NARS, (n) NGOs</td>
</tr>
<tr>
<td>6. Research Coordination</td>
<td>Yes. Advisory Committee</td>
</tr>
<tr>
<td></td>
<td>Technical Committee</td>
</tr>
<tr>
<td>7. Special funding possibilities and donor confidence</td>
<td>Yes. 1986-1992 SDC, CARITAS, Oxfam funds</td>
</tr>
<tr>
<td></td>
<td>1994 Dutch Government funds</td>
</tr>
</tbody>
</table>

coordinate the research skills of CGIAR members in pursuit of this goal. Viewed from the position of TAC’s criteria for ecoregional programmes, ILCA had already adopted this approach to its highland research (see table 1). An example is the Joint Vertisol Project, which started in 1986, details of which are described below.

ILCA’s highland research: an update

Highlands are ecologically heterogenous with a variety of landforms: very steep slopes, moderate or gentle slopes, flat plains and valleys (Figure 1). In each of these land forms human adaptation to variable “niches” caused by diverse geology and edaphic conditions, steepness and orientation of slopes, wind and precipitation patterns had led to many land use systems. As a result, blanket recommendation of technologies even within the same altitudinal limits seems inappropriate.

ILCA used farming systems principles to guide its research. During the preliminary stages, the highland’s research team studied the following:

- traditional production systems;
- adoption by farmers of all or part of an improvement designed by ILCA;
- testing innovations under ILCA management; and
- to carry out component research focused on forages and animal traction.

Extensive interviews were conducted over several years to record what farmers did within their households, how they earned money, where they spent their time and resources, how fast they and their animals reproduced and why they did certain things and not others. When population pressure was low, there was a balance between different land use types such as cultivation, fuelwood lots and grazing lands. Customary laws helped to regulate this balance. In the highlands of Ethiopia, demographic pressure has increased, traditional land tenure arrangements and management have weakened and the productivity of
(Highlands = 1500 m asl)

1. Human-animal populations and land use exceed land capability
   2. Waterlogging and inability to fully use the valley bottom lands (e.g., Vertisols)
   3. Declining productivity on more suitable agricultural lands and exploitation of steeper slopes and fragile lands
   4. Deforestation, overgrazing, land degradation, land slips/slides, excess silting of rivers, water ways, floods in the lowlands

Solutions
1. Increased land productivity, by exploiting high potential crops in combination with land conservation measures
2. Reducing livestock numbers and increasing productivity per head
3. Increasing the vegetative cover of off-form or communal areas
4. Empowering community level resource management strategies

Figure 1 Highland land forms and development options
agriculturally more suitable lands (moderate slopes and flat lands) has declined. As a result, cultivation and grazing have moved to fragile and steeper slopes often exceeding 60 percent (see figure 1). The search for solutions to manage the highlands resources have the following objectives:

- increasing the productivity of agriculturally more suitable land by exploiting high potential crops in combination with land conservation measures;
- reducing livestock numbers and increasing productivity per head;
- increasing vegetative cover of off-farm and communal areas;
- empowering community level resource management strategies; and
- increasing the amounts of goods and services produced to satisfy the "social values" of present and future generations.

Productivity increases in agriculturally more suitable lands

It is estimated that only 24 percent of the 8 million ha of the highland vertisols in Ethiopia are sown annually with pulses like chickpeas, lentils and rough pea or with cereals like tef. The high water holding capacity of vertisols allows plant growth on residual moisture long after rains cease. But, early planting is not possible as the vertisols are waterlogged. Only in one area of the Ethiopian highlands is a unique land shaping method practised that effectively drains excess water from vertisols. Ploughed land is scooped up into broad beds and furrows (BBF) by women and children and the beds are reformed every year.

Animal traction is well developed but the traditional plough, the "Maresha," has no land shaping capability. The Joint Vertisols Project, in which ILCA is a partner, developed attachments to this tradition plough that enables land shaping using the same draught animals available to the farmer. This is called the broad bed maker (BBM). The use of broad beds enables improved drainage and allows early planting. To make use of a long growing period (rainy season plus residual moisture period) there is a continuous search for compatible crops and forages that can be grown in sequence, such as intercrops, alley crops etc. (Figure 2). There is sufficient on-station and on-farm evidence that different crop forage land systems can increase land productivity. In addition, grain and fodder can be harvested at different times of the year thus eliminating the seasonality of these products under traditional management systems. Increased productivity of vertisols can potentially compensate for the loss of grain if farmers are persuaded to refrain from cultivating steeper slopes and marginal lands.

An interesting aspect of the JVP is the process of technology transfer. When the project started land tenure arrangements were regimented. Lands were collectivised and farmers were periodically reallocated land by the peasant associations on the basis, for example, of family size. During this period, it was easier to try out new technologies on-farm by working top down through the officials of the peasant associations. With the liberalisation of land tenure in 1990, farmers voluntarily reverted to their individual land holdings. Although farmers were free from top-down direction, and therefore not obliged to continue with a new farming technique, more came forward wanting the BBM technology. The improved vertisols technologies have four components, namely land shaping attachments to the traditional implement, improved seeds, fertilizer and early planting.

Independent efforts by some NGO like OXFAM America, Global 2000, Lutheran World Federation and Agricultural Academy are now involved in the promotion of this technology. No single institution can have the disciplinary specialists (agricultural engineers, hydrologists, agronomists, crop breeders, crop physiologists, sociologists, economists, soil scientists, anthropologists and animal scientists), the infrastructure or the resources required to address the technical complexities for tapping the potentials of highland vertisols. Thus, the Joint Vertisols Research Project continues as a collaborative operation between national institutions, namely the Institute of Agricultural Research (IAR), Alemaya University of Agriculture (AUA), the Ministry of Agriculture (MoA), the Relief and Rehabilitation Commission.
(RRC) and Addis Adaba University and three international institutions: ILCA, ICRISAT and IBSRAM. When additional input is needed, other institutions such as the AFRIC Institute of Engineering Research, Silsoe, England is brought in. Tasks are allocated based on the interests and strengths of the participating institutions (table 2). To coordinate activities and maintain inter-institutional relationships, an advisory committee and technical committee were formed in 1986. This advisory committee consists of the chief executives of all the participating agencies. The technical committee is composed of subject specialists nominated by the participating agencies.
Table 2 Division of responsibilities between participating institutions

<table>
<thead>
<tr>
<th>Institution</th>
<th>Research area</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAR</td>
<td>Soil fertility: N and related micro-nutrients including BNF</td>
</tr>
<tr>
<td></td>
<td>Crop physiology/cropping systems for all crops with special emphasis on those</td>
</tr>
<tr>
<td></td>
<td>crops which IAR is running improvement programmes</td>
</tr>
<tr>
<td></td>
<td>Standardization of animal-drawn implement testing</td>
</tr>
<tr>
<td>AUA</td>
<td>Soil fertility: P and related micro-nutrients including mycorrhiza</td>
</tr>
<tr>
<td></td>
<td>Crop physiology/cropping systems for all crop with special emphasis on those</td>
</tr>
<tr>
<td></td>
<td>crops on which AUA is running improvement programmes (crop types different</td>
</tr>
<tr>
<td></td>
<td>from IAR)</td>
</tr>
<tr>
<td>LUPRD</td>
<td>Vertisol characterization</td>
</tr>
<tr>
<td>ICRISAT</td>
<td>Resource assessment and utilization (agro-climatology)</td>
</tr>
<tr>
<td></td>
<td>Land and water management (watershed-based land-use planning)</td>
</tr>
<tr>
<td>ILCA</td>
<td>Traction animal (physiology, feeding uses)</td>
</tr>
<tr>
<td></td>
<td>Implements for soil, water and crop management and water harvesting</td>
</tr>
<tr>
<td></td>
<td>Crop-livestock interactions, crop residue utilization</td>
</tr>
<tr>
<td></td>
<td>On-farm technology evaluation</td>
</tr>
</tbody>
</table>

AUA Alemaya University of Agriculture
IAR Institute of Agricultural Research
ICRISAT International Crops Research Institute for the Semi-Arid tropics
ILCA International Livestock Centre for Africa
LUPRD Land Use Planning and Regulatory Department, Ministry of Agriculture

Reducing livestock numbers and increasing per head productivity

Farmers in the Ethiopian highlands keep cattle for farm power. There are 6.5 million work oxen in Ethiopia and selection of a pair of oxen needs a herd of 12 to 14 head of cattle. This has principally contributed to a total livestock population put at 30 million tropical livestock units (TLU) in the country, of which over 80 percent are in the highlands. They primarily contribute to overgrazing of the communal lands in the country. Since 1990 ILCA, in collaboration with the Institute of Agricultural Research, has been experimenting with the use of cross-bred cows for both milk production and draught power.

On-station experimentation with F1 Friesian x Boran and Simmenthal x Boran cows has shown that both tasks (milk production and traction) were performed at optimum level when the animals were fed adequately. Very limited on-farm tests have been carried out using cows for traction. They are, however, proving that substantial increase in household incomes can be gained by the farmer because of milk sales and reductions in the use of work oxen for land preparation. Although the benefits are insufficient to overcome the social bias against using cows for work, the pressure on land for cropping and feed will make it necessary for herd reductions in the future. The use of cows for multiple tasks will be an important avenue for achieving this as has happened in similar situations in other countries. Increase of fodder productivity from more agriculturally suited land, as indicated above, can then be targeted to meet the feed requirements of the selected high-performing livestock.

Increasing vegetative cover of off-farm or communal area

In the highlands, the most important problem for raising livestock is the shortage of grazing land. Areas that traditionally served as grazing lands in Ethiopia are encroached upon by cropping and have been reallocated to other developmental activities including reforestation. Feed supply and demand ratio in the highlands have been estimated to be 0.66. Although the shift from grazing to crop lands slightly increased dry matter (DM) and metabolic energy (ME) output per hectare, it has reduced the protein supply compared to the natural pasture.

Several herbaceous forages such as *Avena sativa*, *Vigna unguiculata*, *Lablab purpureus*, *Vicia*
dasycarpa and Trifolium steudneri have shown potential in the Ethiopian highlands. There is also an interest in forage trees but only Sesbania sesban and Chamaecytisus pamensis have been critically evaluated at higher altitudes.

In a communal grazing situation, the establishment of herbaceous and tree forage plants is difficult. They can, however, be grown in small areas as fodder banks and feed gardens to supplement natural grazing. On-farm trials, establishing trees on fence lines and herbaceous feed gardens, have attracted farmers because they learn that they can adjust feed budgets for their livestock types, seasons and functions by including forages and trees in their farming system. Planting fodder trees in alleys or contours could reduce soil erosion and it is being investigated. Wide spread use of individual improved feed-patches is also being considered as a first step toward the improvement of off-farm ground cover.

One of the major reasons, if not the sole reason, why smallholder productivity lags behind in Africa are the gradual depletion of nutrients from the land even in areas where rainfall is unreliable. In most highland land use systems, the amount of nutrients leaving the soil through harvested products or through erosion and runoff exceeds the amount of nutrient inputs. ILCA is actively pursuing integrated nutrient management strategies to reduce nutrient losses from the production systems through non-useful outputs. These tactics include:

- using crop residues as livestock feed;
- recycling nutrients through manures;
- enhancing atmospheric and surface nutrient cycling through N-fixing herbaceous and tree legumes;
- reduction of soil erosion through spatial and temporal manipulation of crops and forages as companion crops; and
- the use of rotation techniques, or leys, and also monitoring the vegetation cover on communal lands for the purpose of warning against the use of ecologically unstable areas.

ILCA's future research in the highlands

ILCA's past work to improve the productivity of the lowlands (valleys) through nutrient conservation, use of livestock for multiple tasks and the introduction of feed and fodder gardens in farming systems, are essential components for the safe and sustainable exploitation of the highland resource base. However, information so far derived from plot based trials needs to be integrated to develop alternate land-use types and technologies to assess the impact of improved resource management upon people and the environment. A long-term research project to monitor the effects of new land-use types on a catchment scale is therefore envisaged. Its objective will be to improve the empirical data base for better resource management and to help development policies and programs towards achieving sustainable productivity of the East African highlands. Future research will therefore:

- study land management systems at the community level;
- assess floral and edaphic changes under voluntary and regulatory stocking rate;
- the development and transfer of farm productivity improvements through crop-livestock and commodity specialised livestock systems and soil conservation technologies; and
- investigate market forces and policies that favour alternate crop-livestock land use systems.

The study of community level land management systems

This activity will document (through structured and unstructured surveys) land history, land-based activities in historical and attitudinal gradient, indigenous knowledge of plant types their distribution and uses, forest extraction rates and methods, population migrations, traditional management practices to cope
with environmental hazards (including floods, drought and earth slips). It will also look at community
decision making processes and decision implementation at times of environmental emergencies in a
historical perspectives.

**The assessment of floral and edaphic changes under voluntary and regulated stocking rates**

This activity will attempt to quantify and monitor, at different altitude, gradients such components as
floral compositions, biomass productivity seed reserve, seed sensitivity and germination waves. It will
also investigate edaphic changes under voluntary (community participatory) and regulatory adjustment
of grazing frequencies and livestock numbers.

**Development and transfer of farm productivity improvement through crop-livestock and
specialised dairy systems and soil conservation technologies**

This activity envisages a two pronged approach.

a) Development of alternate land use options and cropping schemes by improving water
management efficiency and tillage systems using animal drawn implements for secondary and
repeated cultivations.

b) Introduction of cow traction and investigation of its impact on farm-power requirements, feed
supply and extraction rates and minimum herd size for farm needs. Simulation models to assess
environmental impact will be developed.

**The investigation of market forces and policies that favour alternate crop-livestock land
use systems**

This shall carry out exante and expost analyses of the need and implementation mechanism, incentives,
investment support service structures for safe exploitation of highland resources and establish safeguards
to ensure sustainable productivity. This will be done by comparative analyses at various time and space
horizons of activities that are more suited to sustain the natural resources base and the uses to which the
resource base is exposed due to external pressure for highland-specific commodities.

The research tasks and the scope are very ambitious for ILCA alone. For example, land tenure is a
complex issue but it is important. It is primarily a national issue. Therefore, ILCA is collaborating with
a national effort to jointly study land tenure issues in the Ethiopian highlands. Another example, can be
found in the use of development valleys. Land productivity can be improved in drained valleys and
the captured water can be used for irrigation or for fish culture. These are not within ILCA’s mandate,
but the project provides opportunities for other partners and ILCA is actively seeking those partnerships.

**Conclusions**

Highlands are a very vital but fragile land resource in the eastern part of the African continent. We have
to learn to manage these areas more efficiently. For ecological and environmental conservation, off-farm
land resources are equally important as on-farm. In this ecoregion, it is the off-farm land resources that
support the numerous cattle typically owned by farmers. Cattle, sheep, goats and horses are vital to the
smallholders typical of the region, providing milk, meat, draft power and cash income.

Nutrient flows between crop lands and grazing lands are mediated by livestock and thus are important
to smallholder production systems. Off-farm land resources are, however, communally owned and
therefore can be misused to the detriment of the entire production base. ILCA’s experience in crop-
livestock production systems in highland Ethiopia can therefore play a significant role in developing
suitable crop-livestock production systems in the highland ecoregion of Eastern Africa.
Sweetpotato: A Commodity for Sustainable Agriculture in the East African Highlands

by
Edward. E. Carey

Introduction

The sweetpotato (*Ipomoea batatas*) was domesticated in the new world, probably in central or Northwestern South America. Before the arrival of the Europeans, the crop had already spread widely within the Americas and had also been distributed to the South Pacific (Yen 1974). Following the conquest, the crop was distributed by Portuguese and Spanish seafarers. Today sweetpotato is a major world food crop and is grown in many countries.

Sweetpotato is a vegetatively propagated, perennial vining plant, which is generally grown as an annual crop according to cropping seasons. It does not tolerate frost and this limits the range of latitudes and altitude at which it is grown. In the tropics the sweetpotato is usually propagated using cuttings taken from the vines obtained from existing plantations, while in the temperate zone cuttings (slips) are obtained from storage roots stored over the winter and sprouted in beds in the spring. It is grown principally for its fleshy storage roots, which are a rich source of carbohydrates and vitamins, and which also provide moderate levels of good quality protein. The storage roots have traditionally been consumed boiled or roasted, as a vegetable or staple in the human diet. The roots may also serve as a raw material for many processed products, including human foods, animal feed and starch for industry. The foliage is also important in some places serving as a palatable and nutritious fodder for animals and also a green leafy vegetable for human consumption. Woolfe (1992) recently reviewed the literature on the nutritional value and use of sweetpotato.

The crop is broadly adapted, producing relatively well under a wide range of soil and climatic conditions and has become important in many agroecologies world wide. Most of the world's sweetpotato is produced in China in temperate and sub-tropical environments. Except for China, production may be divided about equally among the humid tropics (particularly in southeast Asia), semi-arid tropics (Asia, Africa and Latin America), tropical highlands (Asia, Oceania and Africa) and sub-tropical lowlands (CIP 1993). Production, area and yield of sweetpotatoes in 1991 for the top fifteen producing countries are presented in table 1. Except for China, eastern Africa is a major area of sweetpotato production. Uganda, Rwanda, Burundi, Kenya and Madagascar are African nations falling among the top fifteen producers (FAO 1992).

This paper examines the role and importance of sweetpotato in the highlands of East and Central Africa and describes a research and development strategy for the improvement of the crop in this region. Special attention is given to the role that sweetpotato can play as a component in the sustainable agricultural development of the region.

Sweetpotato in the East African highlands

Most of the sweetpotato produced in Sub-Saharan Africa is grown at elevations between 1000 and 1900 metres above sea level. These are generally areas with adequate rainfall and high agricultural production potential, and the greatest human population densities and growth rates. Scott and Ewell (1992) recently reviewed the literature on sweetpotato production, marketing and consumption in this region.
Table 1. Production, area and yield of sweet potato and changes of each over the last ten years, in the top fifteen producing developing countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Production (000 tonnes)</th>
<th>Area (000 ha)</th>
<th>Yield (t/ha)</th>
<th>% change between 1979-1981 and 1991</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>107,190</td>
<td>6410</td>
<td>16.7</td>
<td>-6.2</td>
</tr>
<tr>
<td>Vietnam</td>
<td>2105</td>
<td>325</td>
<td>6.5</td>
<td>-9.8</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1976</td>
<td>208</td>
<td>9.5</td>
<td>-6.9</td>
</tr>
<tr>
<td>Uganda</td>
<td>1800</td>
<td>420</td>
<td>4.3</td>
<td>43.2</td>
</tr>
<tr>
<td>India</td>
<td>1195</td>
<td>150</td>
<td>8.0</td>
<td>-19.2</td>
</tr>
<tr>
<td>Rwanda</td>
<td>850</td>
<td>150</td>
<td>5.7</td>
<td>-5.4</td>
</tr>
<tr>
<td>Brazil</td>
<td>700</td>
<td>69</td>
<td>10.1</td>
<td>-9.0</td>
</tr>
<tr>
<td>Philippines</td>
<td>662</td>
<td>137</td>
<td>4.9</td>
<td>-35.9</td>
</tr>
<tr>
<td>Burundi</td>
<td>680</td>
<td>97</td>
<td>7.0</td>
<td>39.3</td>
</tr>
<tr>
<td>Kenya</td>
<td>600</td>
<td>61</td>
<td>9.8</td>
<td>70.9</td>
</tr>
<tr>
<td>Korea DPR</td>
<td>515</td>
<td>35</td>
<td>14.7</td>
<td>37.7</td>
</tr>
<tr>
<td>Madagascar</td>
<td>487</td>
<td>92</td>
<td>5.3</td>
<td>28.5</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>470</td>
<td>104</td>
<td>4.5</td>
<td>11.6</td>
</tr>
<tr>
<td>Argentina</td>
<td>400</td>
<td>28</td>
<td>14.5</td>
<td>37.9</td>
</tr>
<tr>
<td>Haiti</td>
<td>380</td>
<td>75</td>
<td>5.1</td>
<td>37.7</td>
</tr>
</tbody>
</table>

In Eastern, Central and Southern Africa, sweetpotato plays an important role in two distinct food systems. In the first system, sweetpotato is a staple along with other non-grain starchy staples, principally bananas and cassava plus beans. This system predominates in the areas north and west of Lake Victoria in Uganda, Rwanda, Burundi, the Kivu Region of Zaire and part of Tanzania. Apart from the highlands of New Guinea, this is one of the few places in the world where sweetpotato is a staple in the diet. National per capita consumption figures of 122, 112 and 93 Kg per year in Burundi, Rwanda and Uganda reflect the importance of sweetpotato in the diets of numerous people in this region.

In the second food system, grain, usually maize, is the staple and sweetpotato serves as a secondary food crop. It is a food security crop important during the “hungry months” when other foods are not available and in years when other crops fail due to drought. Sweetpotato plays this role in most parts of Kenya, Tanzania, Ethiopia, Madagascar and southern Africa.

Table 2. Output per hectare per day of seven major crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Market Value (US$/ha)</th>
<th>Growth Period (Days)</th>
<th>Dry Matter (Kg/ha/day)</th>
<th>Edible Energy (000 Kcal/ha/day)</th>
<th>Edible Protein (Kg/ha/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet Potato</td>
<td>6.70</td>
<td>180</td>
<td>22</td>
<td>70</td>
<td>1.0</td>
</tr>
<tr>
<td>Potato</td>
<td>12.60</td>
<td>130</td>
<td>18</td>
<td>54</td>
<td>1.5</td>
</tr>
<tr>
<td>Yam</td>
<td>8.80</td>
<td>180</td>
<td>14</td>
<td>47</td>
<td>1.0</td>
</tr>
<tr>
<td>Cassava</td>
<td>2.20</td>
<td>272</td>
<td>13</td>
<td>27</td>
<td>0.1</td>
</tr>
<tr>
<td>Groundnut</td>
<td>2.60</td>
<td>115</td>
<td>8</td>
<td>36</td>
<td>1.7</td>
</tr>
<tr>
<td>Rice</td>
<td>3.40</td>
<td>145</td>
<td>18</td>
<td>49</td>
<td>0.9</td>
</tr>
<tr>
<td>Wheat</td>
<td>2.30</td>
<td>115</td>
<td>14</td>
<td>40</td>
<td>1.6</td>
</tr>
</tbody>
</table>
Sub-Saharan Africa is a region of the world where the sweetpotato crop has been increasing in importance in recent years. During this century the crop has become important in the region around Lake Victoria replacing grains, principally sorghum, as the dietary staple. Recent trends in production, area and yield between 1991 and 1979-81, for the world's top fifteen countries are presented in table 1. Production increases were reported in four out of five of the African countries and there were increases in area planted in each of these countries.

In each case expansion of the area planted played a bigger role in increasing production than did improvements in the yield of individual plants. In both Uganda and Rwanda there was a reported decline in yields, perhaps reflecting declines in soil fertility. This contrasts markedly with the situation in Asia, where yields generally increased as area declined.1

One reason for the increasing importance of sweetpotato in the densely populated East and Central African highlands may be its high productivity per area per unit of time compared with most other crops. A comparison of sweetpotato productivity with several other crops is presented in table 2. The data presented in table 2 do not include production of foliage, which may also be high and be used as a nutritious source of fodder.2

Another reason for the increasing popularity of sweetpotato in the East and Central African highlands may be its ability to reliably produce food on a broad range of soils including the acid, infertile soils that are common in parts of Rwanda and Burundi. The crop also responds well to improved fertility, is relatively tolerant to drought and is flexible with respect to time of harvest and planting. This allows it to fit easily into a variety of cropping systems and to provide a secure source of food if other crops fail. Following planting, the foliage grows quickly, covering the soil and controlling growth of weeds and preventing erosion.

In contrast to some countries in Asia, in Sub-Saharan Africa there is little variation in the way sweetpotato is used; fresh roots are generally used as food, eaten either boiled or roasted (Woolf 1992). Leaves are consumed as a vegetable in some countries including Tanzania, Zambia and Malawi but usually not in countries where the roots are consumed as a staple. Sweetpotato foliage is also increasingly used as fodder for animals, such as cows and goats, particularly in densely populated areas where grazing is limited.

In East and Central Africa, sweetpotato is usually a subsistence crop produced principally by women and consumed within the farm household. Excess production is mostly marketed in rural markets and serves as a source of income covering small household expenses. A relatively small proportion of total production goes to urban markets (Scott and Ewell 1992, Tardiff-Douglin 1991, Bashaasha and Mwanga 1992, Fowler and Stabrawa 1992).

**Sweetpotato and the research and development agenda in the East African Highlands**

Some of the characteristics of sweetpotato already mentioned, including its high productivity, relatively low requirement for external inputs and increasing importance, combine to suggest an important role for the crop in the sustainable agricultural development of the region. Until relatively recently, however, sweetpotato has received little attention from regional researchers compared with its importance and relative to the potential payoffs of research on the crop.

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1 Because root crops are generally grown in small plots for home consumption, and are not usually marketed through formal channels, official statistics are not reliable. However, they may be useful for providing "ball park" figures for general comparisons.

2 The use of foliage for fodder or as a vegetable varies by country. The use of foliage for fodder, especially as a weaning food for goats and calves is increasing in Kenya. The eating of leaves as vegetables is widely practised in some countries, notably Tanzania, Malawi, Zambia and Mozambique. It is practically unheard of, however, in Rwanda, Burundi, Kenya and Uganda. The reasons for this are not clearly understood but are certainly cultural.
In recent years the potential benefits from increased research on sweetpotato have been recognized by several national agricultural research systems, international agriculture research centres and donor agencies. IDRC, and other donors, have supported both national and international tropical root crop research efforts for several years and there are now a number of national programs, such as the Rwandan, with researchers having more than ten years of experience with the crop (Ndamage et al. 1992). Sweetpotato improvement has been given a high priority by most countries in the East and Central African highlands during recent research priority setting exercises.

In Eastern and Southern Africa, two research networks include researchers from the national programmes of most of the countries where sweetpotato is important. These networks, the Programme Regional d'Amélioration de la Culture de la Pomme de Terre et de la Patate Douce en Afrique Centrale et de l'Est (PRAPACE) and the Southern African Root Crops Research Network (SARRNET), help national programmes to divide research responsibilities and share results efficiently.

International centres, initially the Asian Vegetable Research and Development Centre (AVRDC) and International Institute for Tropical Agriculture (IITA) and more recently the Centro Internacional de la Papa (CIP), have conducted international research and development programmes working in close partnership with national agricultural research systems, regional networks and NGO to support and stimulate the improvement of sweetpotatoes for sustainable agriculture and improved human welfare (CIP 1991).

A multidisciplinary, inter-institutional programme for integrated research on the management of natural resources in the highlands of East and Central Africa was recently initiated by ICRAF (ICRAF 1993). Several commodity-oriented international agriculture research centres (including CIP) and centres concerned with natural resource management will work with NARS and others for the development and improvement of sustainable agricultural systems in this region. Areas to receive attention include:

a) diagnosis of natural resource management issues;

b) maintenance of soil productivity;

c) improved management of highland valleys;

d) increasing the diversity of crop varieties to better fit farmers' conditions;

e) pest management strategies from an agroecological perspective; and

f) natural resources policy.

Multi-disciplinary commodity research for sweetpotato can make a contribution to increasing the productivity and value of the crop. However, some constraints, such as soil conservation and declining soil fertility, cannot be efficiently addressed through commodity research. Because of the importance of the crop in eastern Africa, it should not be neglected by natural resource managers in the region. The low input requirements of the crop and its ability to rapidly cover the soil, controlling weeds and erosion (Eke et al. 1990), are valuable characteristics for sustainable agriculture in this region. The high nutritional value and productivity of sweetpotato as an animal feed can also help to support increased on-farm animal production, which can provide manure to help maintain soil fertility.

The role of sweetpotato in the maintenance of soil fertility has not been well studied. Farmers often consider the sweetpotato to be a crop that helps in some way to improve soil fertility. The role of associated nitrogen-fixing bacteria in sweetpotato nutrition in the region is worthy of investigation (Hill et al. 1988). Preliminary reports of foliage yields of up to 20 tons of dry matter and 5 tons of protein per hectare per year merit further investigation (CIP 1993). Throughout the region, national agricultural extension services and other governmental and non-governmental development organizations are very interested in obtaining and promoting improved and viable technologies for the benefit of their constituents. These may include small farmers or poor urban consumers. These organizations are essential for the efficient and wide-spread distribution of research results.
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Assessment of needs for sweetpotato research and development

In recent years several organizations, including IITA, CIP and NRI, working in collaboration with NARS in the highlands of East and Central Africa, have conducted a series of exercises to help to assess needs and set priorities for sweetpotato research. These activities included a regional workshop (CIP 1988), a survey of researchers (see Scott and Ewell 1993), rapid field surveys (Lenne 1991, Alvarez and Ndamage 1985) and in-depth farm level and market studies (Bashaasha et al. 1993, Ngunjiri et al. 1993, Tardiff-Douglin and Rwalinda 1993, Tardiff-Douglin 1991).

The principal findings of these studies reveal some constraints to increased production of sweetpotato in the region. These include several diseases and pests, mostly important only in Sub-Saharan Africa:

- a complex of virus diseases (Wambugu 1991);
- Alternaria stem blight (at high altitudes and on poor soils); and
- weevils (Cylas puncticollis and Cylas brunneus).

Principal abiotic constraints were:

- low soil fertility;
- drought; and
- low temperatures, principally at higher elevations.

A series of post-harvest constraints was also identified including:

- bulkiness and perishability, leading to limited marketing;
- limited demand and markets; and
- a very limited range of forms of use and little processing.

Farmers also identified a lack of timely availability of healthy planting materials and a lack of improved varieties as constraints to production. Characteristics widely wanted in new varieties were earliness, high yields, good culinary quality. Varieties with light coloured flesh, sweet taste and dry texture when cooked are preferred.

Based on needs assessment studies, a consensus on research priorities for sweetpotato in the highlands of East and Central Africa has been built. Current priorities for sweetpotato commodity research fall into four categories:

- selection of varieties with characteristics required by farmers;
- dissemination to farmers of clean planting materials from new and traditional varieties;
- post-harvest research to reduce losses and promote alternate forms of use that increase the value of sweetpotato and;
- integrated pest management to control the sweetpotato weevil particularly in the drier areas.

VARIETAL SELECTION

Improved varieties of sweetpotato are an appropriate low input way to increase productivity and control the principal diseases of the crop: viruses and Alternaria stem blight. Selected varieties can have a long-lasting influence, if they have the characteristics required by farmers.

Varietal selection activities are underway in each country in East and Central African highlands. These activities include the collection and evaluation of locally available germplasm, the introduction and evaluation of germplasm (either as seed or clones) from elsewhere in the region or from outside the
region and the hybridization and selection of new cultivars from progenies of selected parents. Uganda and Rwanda, because of the great importance of the crop in those countries, conduct full programmes involving each activity mentioned including hybridization. The remaining programmes conduct selection using local and introduced clonal germplasm in a few cases relying on others for introduced seed.

Selection criteria are similar across countries in the region. These include good establishment of planting materials, vigorous growth of foliage, earliness, high yields, yield stability, resistance to viruses and Alternaria stem blight (based on symptoms) and good eating quality. Throughout the region, the inhabitants prefer varieties having light coloured flesh, relatively dry, floury texture and sweet taste. These taste characteristics are generally associated with a high root dry matter content.

In the highlands of East and Central Africa many cultivars are grown by farmers, frequently in complex mixtures. Many of these cultivars have probably arisen from the selection of volunteer seedlings by farmers and through various plant introduction and selection efforts by researchers during this century. Due to the prevalence of informal farmers' systems for the distribution of planting materials, and the large number of cultivars, little is known about the origin of most varieties grown by farmers in the region.

Given the many cultivars grown by farmers, and the wide range of variation that these exhibit both with respect to morphology and in adaptation to environmental stresses including regionally important diseases, the existing regional germplasm bank serves as an important base for variety selection activities. In fact the region has been identified as a secondary centre of genetic diversity (IBPGR 1981) and germplasm from this region may make a contribution to sweetpotato improvement in highland and other agroecologies elsewhere in the world.

As already mentioned, the collection and evaluation of local germplasm are an important initial activity for national programmes in areas of high genetic diversity. Identification of the most productive clones from the local germplasm speeds up and systematizes the process by which excellent clones can come to predominate in a region through informal farmer-managed systems of seed exchange and variety selection. National programmes in Kenya, Uganda, Tanzania and Zaire are conducting these evaluations. In Burundi and Rwanda, extensive programmes of evaluation and selection of local germplasm have been conducted. With Rwanda, superior varieties, such as Rusenya and Magande have been identified and distributed to farmers (Ndamage at al. 1992).

The introduction of elite germplasm, either as seed or clones, from elsewhere is another approach. The performance of germplasm from the highlands of the Philippines or New Guinea for example, might be expected to be adapted to African highlands and to make a valuable contribution, either as new varieties or as parents, in hybridization programs. CIP has developed an extensive collection of pathogen-tested in-vitro clones including important varieties and experimental cultivars from many sources. Initial screening of this collection for adaptation to the African highlands, and for resistance to diseases, is conducted in Rwanda (where Alternaria stem blight is important) in Uganda (where virus diseases are important) and in Kenya, where materials can be screened for tolerance to drought.

The potential for consumer acceptance of cultivars, with quality characteristics distinct from the types generally consumed in the region now, will receive attention. For example, will children, a group not normally consulted by researchers about taste preferences, accept cultivars with deep orange flesh colour (high in provitamin A)? The processing potential of introduced cultivars will also be evaluated by linking variety evaluation efforts with regional efforts to develop and promote new forms of sweetpotato use. The potential for adoption in the region of cultivars with very high foliage production, for use as animal fodder, will also be investigated. As information is obtained on the acceptability of these new cultivars, selection criteria for them will be incorporated into national variety selection programmes.

Variety selection programmes in the region increasingly involve farmers in the process by encouraging participation in on-station and on-farm trials. This has the benefit of increasing the thoroughness of evaluations by including the farmers' perspectives in the selection process. It may also help to maintain a greater diversity of varieties on farms through the selection of varieties with adaptation to specific environments. Researchers in the region must also look increasingly to a range of partners for the evaluation and selection of new varieties. These include farming systems research programs, rural
development projects run by GOs or NGOs and, where appropriate, should also include the evaluation of sweetpotato varieties as a crop component in agroforestry research programmes.

**Systems for the distribution of planting materials**

For new varieties to be widely adopted, efficient systems for the distribution of planting materials are required. These systems might also serve to supply healthy planting materials, free of virus diseases, to farmers on a continuous basis. Such systems would also be valuable in drier areas where the availability of planting materials is a constraint to production at the beginning of the rains. Systems for the rapid multiplication and distribution of planting materials can also help with famine relief and with emergency efforts to feed refugees.

For the routine distribution of new varieties, low cost systems are required that allow the sustained, routine distribution of planting materials to farmers. This probably requires a range of approaches including effective linkages between researchers, extension services, rural development projects and farmers' groups. Special projects, such as one recently ended in Rwanda, can supply large quantities of planting material during the project but they can be difficult to sustain without continued outside support after initial funding ceases. In this regard, the organization of farmers and institutions at the community level is critical.

Farmers in the region generally grow a mixture of varieties. The precise reasons for this are not known but a varietal mixture may provide some degree of yield stability from season to season across farms. Mixtures may also be planted because of a general lack of planting material at planting time. Variety selection and distribution programmes usually distribute material from a few clones. The process of farmer adoption and incorporation of improved varieties into their current mixtures, the influence of distribution of improved materials on mixtures and the stability of yields is worthy of study (Wood and Lenne 1993).

While the sweetpotato viruses are generally considered a serious constraint to production, the potential for using healthy planting materials to improve yields of sweetpotato has not been investigated in the region. Collaborative studies involving CIP, NRI and the Ugandan national programme are underway in Uganda to compare yield gains through the clean up of locally important varieties and the study of rates of reinfection by viruses in various agroecologies. Results of these studies will help to guide future efforts with respect to resistance breeding versus use of clean planting materials.

**Post-harvest research**

While there is now almost no processing of sweetpotato in sub-Saharan Africa, many products can be made from sweetpotato (Woolfe 1992). Identification and promotion of appropriate products for the highlands of East and Central Africa could stimulate the development of rural-based processing activities leading to increased incomes for producers. A few preliminary experiences in the region have produced promising results. These include an investigation in Kenya into consumer acceptance of fried crisps and products with varying amounts of sweetpotato flour in recipes for traditional foods such as ugali, the staple food made from maize (Gakonyo 1993). In Burundi and Cameroon, initial experiences using fresh grated sweetpotato as a partial substitute for wheat flour in bread has been promising (Berrios and Beavogui 1992, Odaga and Wanzie 1992).

In the coming years the regional effort on post-harvest research for sweetpotato will grow. Within PRAPACE countries, Uganda and Kenya have been designated as lead countries for post-harvest research. In Uganda, an NRI initiative to support post-harvest research on the non-grain starchy staples will include sweetpotato among the commodities that it addresses in collaboration with the Ugandan national program. In collaboration with CIP, NRI will also post a regional sweetpotato post-harvest specialist to the CIP regional office in Kenya to work in selected countries of the region. Areas that receive increased attention as part of this regional effort includes the following:
market assessment to find out products with the highest likelihood of successful adoption in the region;

development, adaptation and promotion of new forms of use;

evaluation of varieties for post-harvest characteristics together with processing and storage work;

promotion of the use of sweetpotato vines as fodder and investigation of appropriate processing methods for vines; and

investigation of storage problems (to reduce post harvest losses during transportation and marketing).

The major challenge in this work is to identify appropriate products and processes that will have the potential for viable expansion beyond the level of pilot scale operations.

Integrated Pest Management of Weevil

Infestation of sweetpotato by weevils is worse in drier environments and tends to become increasingly severe when harvest is delayed. The problem can also be aggravated by the sequential cropping of sweetpotato on adjacent plots on the small, intensively worked farms of the region.

In recent years international organizations, including CIP, International Institute of Biological Control (IIBC) and ODA, working in collaboration with national programmes in the region, have conducted and supported research aimed at controlling the sweetpotato weevil. This has included research on the use of biological control agents, such as the fungus Beauveria bassiana, researches to understand and enhance the effectiveness of cultural practices and the demonstration of the existence of and isolation of the sex pheromones of \textit{Cylas puncticollis} and \textit{Cylas brunneus} (Smit and Magenya 1993).

High levels of host plant resistance to the weevil are not known to exist in sweetpotato so resistant varieties are not an important component of weevil control. Some varieties are, however, more susceptible to weevil attack than others principally because of their tendency to produce storage roots very near the soil surface. These roots are easily exposed to weevil attack. Promotion of a package of good cultural practices by crop protection and extension workers is likely to be the most effective method for controlling the weevil. These cultural practices include crop sanitation, avoidance of adjacent planting, piecemeal harvesting, time of planting and crop rotation (Smit and Matengo in review).

Integrating sweetpotato commodity research and development with natural resources, management research.

Multidisciplinary commodity research on sweet potato can make a contribution toward increasing the productivity and value of the crop. Some constraints, such as soil conservation and declining soil fertility cannot, however, be efficiently addressed through commodity research.

Because of the importance of the crop in eastern Africa, it should not be neglected by those involved in natural resource management in the region. The low input requirements of the crop, and its ability to rapidly cover the soil thereby controlling weeds and erosion, are valuable characteristics for sustainable agriculture in this region (Elke et al. 1990). The high nutritional value of sweet potato as an animal feed can also help to support increased on-farm animal production, which can provide manure to help maintain soil fertility.

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References


IBPGR. 1981. *Genetic Resources of Sweetpotato.* Rome, Italy: IBPGR.


Summary and Conclusions

by

Hugo Li Pun

The following is a summary of the presentations and the issues raised in the various discussions. It highlights the major points raised by the workshop participants, which have been organized into five sections, as well as the progress achieved in the implementation of research on sustainable highland agriculture, the recommendations for research approaches and methodologies, outstanding research issues, institutional issues and follow-up proposals.

I Progress in the Implementation of research on sustainable highland agriculture

Participants recognized the key role that agriculture plays in natural resource management on the hillsides and the mountains of the developing world. Its importance can be assessed for natural resource utilization, employment generation, food production and water and energy balance, among others. Agriculture can be considered an engine for development in rural areas, and also a key activity to ensure the preservation of the natural resource base in mountain ecosystems.

Evidently there is now a much better understanding of causes and effects within the vicious circle of poverty and the degradation of natural resources. Based on that understanding, realistic policies and actions need to be implemented to ensure sustainable development. For example, policies to protect the environment would not be applicable unless they would also consider alternatives for people whose livelihood depends upon the use of natural resources. The importance of local communities participating in the diagnosis of the problems and in the design, implementation and evaluation of alternatives, was stressed by all participants to the workshop. Alternatives should consider the resources, needs, skills and aspirations of the local communities and society at large.

A recognition of the value of indigenous knowledge was also made. Often it has been neglected in research and development efforts that has been due to a lack of understanding. However, a careful analysis of the situation in rural areas in the developing world would show that many traditional practices, technologies and products contribute to sustainability in the use of natural resources. Specific examples were presented such as the raised-bed techniques ("ware-wares") used in the Peruvian highlands to protect crops against frost and to manage water.

Similarities and differences between regions have been identified regarding environmental and socio-economic characteristics and sustainable agricultural problems, practices, and opportunities. Similarities outweighed differences showing the potential benefits of interregional collaboration. Although the concept of ecoregional approaches for natural resource management is relatively new, progress in their implementation can be seen in some cases. This is made possible through the analysis of problems and opportunities from higher to lower levels by:

- the use of existing knowledge about farming systems;

- the build-up from on-going R&D experiences such as the ones pursued in the Andean ecological region;

- the use of guiding principles to promote interinstitutional collaboration, which have been based on lessons derived from previous experiences such as the ones proposed for the collaboration in Eastern and Central Africa by ICRAF and the ones proposed by the Sustainable Andean
Development Consortium; and

- the use of novel mechanisms to promote farmers' decision-making in the setting of the research agenda such as the proposal by CIAT for the ecoregional initiative in the highlands of Colombia and the mechanisms to promote interinstitutional collaboration used by the Sustainable Andean Development Consortium proposed by CIP and IDRC.

Constraints and limitations to the implementation of ecoregional approaches were also identified. They include the need to develop or fine tune methodologies, institutional structures, prevailing research approaches and financial limitations among others. They have led to the use of pragmatic approaches including strategies of "learning by doing." Trade-offs have also been identified in several cases, including productivity and sustainability objectives and short-term versus long-term perspectives.

II Research approaches and methodologies

Systems research approaches are recommended to address natural resource management and environmental problems including sustainable agriculture in highland ecosystems. This is due to:

a) the characteristics of systems research: holistic, multidisciplinary and participatory;

b) it allows a systematic analysis of causes and problems, linking bio-physical, socio-economic and political perspectives;

c) it allows the understanding of problems at different hierarchies (ecoregion, country, watershed/location, communities, farms and agroecosystems) and their relationships. This is made possible through the analysis of problems and opportunities from higher to lower levels and also through a process of synthesis of results obtained from lower to higher hierarchies; and

d) it also allows the analysis of specific agricultural commodities along the chain from production, marketing and transformation to their utilization to identify bottlenecks and also opportunities for intervention.

One of the main interests in the study of mountain ecosystems is that the effects of management of resources uphill have bio-physical and socio-economic consequences downhill and vice versa. Thus, wide geographical areas can be affected by highland agriculture. Therefore, it was recommended that these relationships be studied along transects in specific locations to better understand causes, effects and to propose possible solutions.

Mechanisms and approaches for participatory research were discussed including the novel approaches to be utilized by CIAT in the Cauca valley of Colombia with support from IDRC. The usefulness of research tools such as GIS and conflict resolution approaches in ecoregional initiatives for natural resource management was discussed. The latter could be especially useful as several cases of conflict over the use of natural resources were identified in the presentations. Both methods should be included within the expanded approach to farming systems research methods.

III Research Issues

Critical indicators of sustainability both "indigenous" and "modern" should be identified. With the former, their scientific basis must be researched and validated. In the case of the latter, the applicable critical socio-economic and bio-physical indicators needs to be defined. By doing this one would avoid the gathering of excessive data and the difficulties of its management and analysis.

Research on integrated resource management needs to be conducted. At the watershed level, it was apparent that while attention is being given to land management and community issues, the key role that forests play in water balance is not being given enough recognition. This was evident in the case of the Eastern African highlands.
At the farming system level, in several presentations household and crop production systems were given strong emphasis. However, not enough attention was given to other farm agroecosystems such as animal production or tree production. Therefore a more integrated perspective that considers the interaction of the different components of the farm (household, crops, animals and trees) and off-farm activities are required. Based on that understanding the comparative advantages of interventions in the different activities could be identified and their impact on total farm activity.

The migration of small farmers and peasants is quite common in mountain ecosystems. This has social and economic implications and also environmental effects. Therefore, the impact of alternate livelihoods is another important research subject.

It was recognized that inappropriate policies have often led to inequities and the deterioration of livelihoods in the rural sector and also natural resource deterioration. Therefore, there is a need for research on policies including their formulation, implementation and evaluation. The real value of natural resources is another research area. Often mismanagement of natural resources is due to the inappropriate value assigned to natural resources. Governance that includes the decentralization of decision making, accountability as well as traditional and formal mechanisms, should be given a high priority as a research topic.

IV Institutional issues

At the national level, the need for both a central and location-specific research effort was recognized. Better collaboration should be promoted between the different institutions involved in the various aspects of sustainable agriculture, natural resource management, policy formulation and environmental management. Formation of consortia or local networking should be promoted as a mechanism to ensure the flow of information and to promote better collaboration.

Regarding ecoregional initiatives, increased attention should be given to the following issues:

- Governance: The discovery of suitable methods to promote effective management and participation by the different stakeholders is the challenge.

- Research Agenda: Who defines it and how?

- Linkages of ecoregional efforts with commodity research: How are they established, and how effective are they?

- Short-term and long-term outputs: While everybody recognized that research on sustainability is of long-term nature, the need to use existing knowledge to ameliorate the present situation is essential. Therefore, short-term outputs need to be obtained in projects addressing sustainable agriculture and natural resource management.

As mentioned previously, similarities in ecological and socio-economic characteristics and agricultural practices in highland ecosystems offer great opportunities for global collaboration. They could include the exchange of R&D experience including methodologies, germplasm, technologies and knowledge. Collaboration could also lead to global initiatives creating further awareness of the key role of mountain ecosystems and also supporting an agenda addressing key issues.

V Follow-up

The following was agreed:

1. Formal and informal activities will be organized to continue the exchange of experiences and promote further collaboration in research on sustainable agriculture in highland ecosystems. Electronic mail offers possibilities for continuous interaction among participants.
2. It was decided that, for the time being, IDRC will continue to play a coordinating role. This will include the organization of the next meeting that will take place in Latin America in December of 1994. The location would be either in Ecuador or Peru with a major role assumed by NGOs in the organization. The topics for discussion would be agreed upon during 1994. A balance of social and biological scientists, and representatives of the different type of research organizations will be looked for.
Workshop Participants

The following are the names and addresses of the participants of the Workshop who presented papers. Participants should be contacted directly for the addresses of their co-authors.

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Sub-Saharan Africa is a region of the world where the sweetpotato crop has been increasing in importance in recent years. During this century the crop has become important in the region around Lake Victoria replacing grains, principally sorghum, as the dietary staple. Recent trends in production, area and yield between 1991 and 1979-81, for the world’s top fifteen countries are presented in table 1. Production increases were reported in four out of five of the African countries and there were increases in area planted in each of these countries.

In each case expansion of the area planted played a bigger role in increasing production than did improvements in the yield of individual plants. In both Uganda and Rwanda there was a reported decline in yields, perhaps reflecting declines in soil fertility. This contrasts markedly with the situation in Asia, where yields generally increased as area declined.1

One reason for the increasing importance of sweetpotato in the densely populated East and Central African highlands may be its high productivity per area per unit of time compared with most other crops. A comparison of sweetpotato productivity with several other crops is presented in table 2. The data presented in table 2 do not include production of foliage, which may also be high and be used as a nutritious source of fodder.2

Another reason for the increasing popularity of sweetpotato in the East and Central African highlands may be its ability to reliably produce food on a broad range of soils including the acid, infertile soils that are common in parts of Rwanda and Burundi. The crop also responds well to improved fertility, is relatively tolerant to drought and is flexible with respect to time of harvest and planting. This allows it to fit easily into a variety of cropping systems and to provide a secure source of food if other crops fail. Following planting, the foliage grows quickly, covering the soil and controlling growth of weeds and preventing erosion.

In contrast to some countries in Asia, in Sub-Saharan Africa there is little variation in the way sweetpotato is used; fresh roots are generally used as food, eaten either boiled or roasted (Woolfe 1992). Leaves are consumed as a vegetable in some countries including Tanzania, Zambia and Malawi but usually not in countries where the roots are consumed as a staple. Sweetpotato foliage is also increasingly used as fodder for animals, such as cows and goats, particularly in densely populated areas where grazing is limited.

In East and Central Africa, sweetpotato is usually a subsistence crop produced principally by women and consumed within the farm household. Excess production is mostly marketed in rural markets and serves as a source of income covering small household expenses. A relatively small proportion of total production goes to urban markets (Scott and Ewell 1992, Tardiff-Douglin 1991, Bashaasha and Mwanga 1992, Fowler and Stabrawa 1992).

Sweetpotato and the research and development agenda in the East African Highlands

Some of the characteristics of sweetpotato already mentioned, including its high productivity, relatively low requirement for external inputs and increasing importance, combine to suggest an important role for the crop in the sustainable agricultural development of the region. Until relatively recently, however, sweetpotato has received little attention from regional researchers compared with its importance and relative to the potential payoffs of research on the crop.

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1 Because root crops are generally grown in small plots for home consumption, and are not usually marketed through formal channels, official statistics are not reliable. However, they may be useful for providing “ball park” figures for general comparisons.

2 The use of foliage for fodder or as a vegetable varies by country. The use of foliage for fodder, especially as a weaning food for goats and calves is increasing in Kenya. The eating of leaves as vegetables is widely practised in some countries, notably Tanzania, Malawi, Zambia and Mozambique. It is practically unheard of, however, in Rwanda, Burundi, Kenya and Uganda. The reasons for this are not clearly understood but are certainly cultural.

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In recent years the potential benefits from increased research on sweetpotato have been recognized by several national agricultural research systems, international agriculture research centres and donor agencies. IDRC, and other donors, have supported both national and international tropical root crop research efforts for several years and there are now a number of national programs, such as the Rwandan, with researchers having more than ten years of experience with the crop (Ndamage et al. 1992). Sweetpotato improvement has been given a high priority by most countries in the East and Central African highlands during recent research priority setting exercises.

In Eastern and Southern Africa, two research networks include researchers from the national programmes of most of the countries where sweetpotato is important. These networks, the Programme Regional d'Amélioration de la Culture de la Pomme de Terre et de la Patate Douce en Afrique Centrale et de l'Est (PRAPACE) and the Southern African Root Crops Research Network (SARRNET), help national programmes to divide research responsibilities and share results efficiently.

International centres, initially the Asian Vegetable Research and Development Centre (AVRDC) and International Institute for Tropical Agriculture (IITA) and more recently the Centro Internacional de la Papa (CIP), have conducted international research and development programmes working in close partnership with national agricultural research systems, regional networks and NGO to support and stimulate the improvement of sweetpotatoes for sustainable agriculture and improved human welfare (CIP 1991).

A multidisciplinary, inter-institutional programme for integrated research on the management of natural resources in the highlands of East and Central Africa was recently initiated by ICRAF (ICRAF 1993). Several commodity-oriented international agriculture research centres (including CIP) and centres concerned with natural resource management will work with NARS and others for the development and improvement of sustainable agricultural systems in this region. Areas to receive attention include:

a) diagnosis of natural resource management issues;
b) maintenance of soil productivity;
c) improved management of highland valleys;
d) increasing the diversity of crop varieties to better fit farmers' conditions;
e) pest management strategies from an agroecological perspective; and
f) natural resources policy.

Multi-disciplinary commodity research for sweetpotato can make a contribution to increasing the productivity and value of the crop. However, some constraints, such as soil conservation and declining soil fertility, cannot be efficiently addressed through commodity research. Because of the importance of the crop in eastern Africa, it should not be neglected by natural resource managers in the region. The low input requirements of the crop and its ability to rapidly cover the soil, controlling weeds and erosion (Eke et al. 1990), are valuable characteristics for sustainable agriculture in this region. The high nutritional value and productivity of sweetpotato as an animal feed can also help to support increased on-farm animal production, which can provide manure to help maintain soil fertility.

The role of sweetpotato in the maintenance of soil fertility has not been well studied. Farmers often consider the sweetpotato to be a crop that helps in some way to improve soil fertility. The role of associated nitrogen-fixing bacteria in sweetpotato nutrition in the region is worthy of investigation (Hill et al. 1988). Preliminary reports of foliage yields of up to 20 tons of dry matter and 5 tons of protein per hectare per year merit further investigation (CIP 1993). Throughout the region, national agricultural extension services and other governmental and non-governmental development organizations are very interested in obtaining and promoting improved and viable technologies for the benefit of their constituents. These may include small farmers or poor urban consumers. These organizations are essential for the efficient and wide-spread distribution of research results.
Assessment of needs for sweetpotato research and development

In recent years several organizations, including IITA, CIP and NRI, working in collaboration with NARS in the highlands of East and Central Africa, have conducted a series of exercises to help to assess needs and set priorities for sweetpotato research. These activities included a regional workshop (CIP 1988), a survey of researchers (see Scott and Ewell 1993), rapid field surveys (Lenne 1991, Alvarez and Ndamage 1985) and in-depth farm level and market studies (Bashaasha et al. 1993, Ngunjiri et al. 1993, Tardiff-Douglin and Rwinda 1993, Tardiff-Douglin 1991).

The principal findings of these studies reveal some constraints to increased production of sweetpotato in the region. These include several diseases and pests, mostly important only in Sub-Saharan Africa:

- a complex of virus diseases (Wambugu 1991);
- Alternaria stem blight (at high altitudes and on poor soils); and
- weevils (Cylas puncticollis and Cylas brunneus).

Principal abiotic constraints were:

- low soil fertility;
- drought; and
- low temperatures, principally at higher elevations.

A series of post-harvest constraints was also identified including:

- bulkiness and perishability, leading to limited marketing;
- limited demand and markets; and
- a very limited range of forms of use and little processing.

Farmers also identified a lack of timely availability of healthy planting materials and a lack of improved varieties as constraints to production. Characteristics widely wanted in new varieties were earliness, high yields, good culinary quality. Varieties with light coloured flesh, sweet taste and dry texture when cooked are preferred.

Based on needs assessment studies, a consensus on research priorities for sweetpotato in the highlands of East and Central Africa has been built. Current priorities for sweetpotato commodity research fall into four categories:

- selection of varieties with characteristics required by farmers;
- dissemination to farmers of clean planting materials from new and traditional varieties;
- post-harvest research to reduce losses and promote alternate forms of use that increase the value of sweetpotato and;
- integrated pest management to control the sweetpotato weevil particularly in the drier areas.

Varietal selection

Improved varieties of sweetpotato are an appropriate low input way to increase productivity and control the principal diseases of the crop: viruses and Alternaria stem blight. Selected varieties can have a long-lasting influence, if they have the characteristics required by farmers.

Variety selection activities are underway in each country in East and Central African highlands. These activities include the collection and evaluation of locally available germplasm, the introduction and evaluation of germplasm (either as seed or clones) from elsewhere in the region or from outside the
region and the hybridization and selection of new cultivars from progenies of selected parents. Uganda and Rwanda, because of the great importance of the crop in those countries, conduct full programmes involving each activity mentioned including hybridization. The remaining programmes conduct selection using local and introduced clonal germplasm in a few cases relying on others for introduced seed.

Selection criteria are similar across countries in the region. These include good establishment of planting materials, vigorous growth of foliage, earliness, high yields, yield stability, resistance to viruses and Alternaria stem blight (based on symptoms) and good eating quality. Throughout the region, the inhabitants prefer varieties having light coloured flesh, relatively dry, floury texture and sweet taste. These taste characteristics are generally associated with a high root dry matter content.

In the highlands of East and Central Africa many cultivars are grown by farmers, frequently in complex mixtures. Many of these cultivars have probably arisen from the selection of volunteer seedlings by farmers and through various plant introduction and selection efforts by researchers during this century. Due to the prevalence of informal farmers' systems for the distribution of planting materials, and the large number of cultivars, little is known about the origin of most varieties grown by farmers in the region.

Given the many cultivars grown by farmers, and the wide range of variation that these exhibit both with respect to morphology and in adaptation to environmental stresses including regionally important diseases, the existing regional germplasm bank serves as an important base for variety selection activities. In fact the region has been identified as a secondary centre of genetic diversity (IBPGR 1981) and germplasm from this region may make a contribution to sweetpotato improvement in highland and other agroecologies elsewhere in the world.

As already mentioned, the collection and evaluation of local germplasm are an important initial activity for national programmes in areas of high genetic diversity. Identification of the most productive clones from the local germplasm speeds up and systematizes the process by which excellent clones can come to predominate in a region through informal farmer-managed systems of seed exchange and variety selection. National programmes in Kenya, Uganda, Tanzania and Zaire are conducting these evaluations. In Burundi and Rwanda, extensive programmes of evaluation and selection of local germplasm have been conducted. With Rwanda, superior varieties, such as Rusenya and Magande, have been identified and distributed to farmers (Ndamage at al. 1992).

The introduction of elite germplasm, either as seed or clones, from elsewhere is another approach. The performance of germplasm from the highlands of the Philippines or New Guinea for example, might be expected to be adapted to African highlands and to make a valuable contribution, either as new varieties or as parents, in hybridization programs. CIP has developed an extensive collection of pathogen-tested in-vitro clones including important varieties and experimental cultivars from many sources. Initial screening of this collection for adaptation to the African highlands, and for resistance to diseases, is conducted in Rwanda (where Alternaria stem blight is important) in Uganda (where virus diseases are important) and in Kenya, where materials can be screened for tolerance to drought.

The potential for consumer acceptance of cultivars, with quality characteristics distinct from the types generally consumed in the region now, will receive attention. For example, will children, a group not normally consulted by researchers about taste preferences, accept cultivars with deep orange flesh colour (high in provitamin A)? The processing potential of introduced cultivars will also be evaluated by linking variety evaluation efforts with regional efforts to develop and promote new forms of sweetpotato use. The potential for adoption in the region of cultivars with very high foliage production, for use as animal fodder, will also be investigated. As information is obtained on the acceptability of these new cultivars, selection criteria for them will be incorporated into national variety selection programmes.

Variety selection programmes in the region increasingly involve farmers in the process by encouraging participation in on-station and on-farm trials. This has the benefit of increasing the thoroughness of evaluations by including the farmers' perspectives in the selection process. It may also help to maintain a greater diversity of varieties on farms through the selection of varieties with adaptation to specific environments. Researchers in the region must also look increasingly to a range of partners for the evaluation and selection of new varieties. These include farming systems research programs, rural
development projects run by GOs or NGOs and, where appropriate, should also include the evaluation of sweetpotato varieties as a crop component in agroforestry research programmes.

**Systems for the distribution of planting materials**

For new varieties to be widely adopted, efficient systems for the distribution of planting materials are required. These systems might also serve to supply healthy planting materials, free of virus diseases, to farmers on a continuous basis. Such systems would also be valuable in drier areas where the availability of planting materials is a constraint to production at the beginning of the rains. Systems for the rapid multiplication and distribution of planting materials can also help with famine relief and with emergency efforts to feed refugees.

For the routine distribution of new varieties, low cost systems are required that allow the sustained, routine distribution of planting materials to farmers. This probably requires a range of approaches including effective linkages between researchers, extension services, rural development projects and farmers' groups. Special projects, such as one recently ended in Rwanda, can supply large quantities of planting material during the project but they can be difficult to sustain without continued outside support after initial funding ceases. In this regard, the organization of farmers and institutions at the community level is critical.

Farmers in the region generally grow a mixture of varieties. The precise reasons for this are not known but a varietal mixture may provide some degree of yield stability from season to season across farms. Mixtures may also be planted because of a general lack of planting material at planting time. Variety selection and distribution programmes usually distribute material from a few clones. The process of farmer adoption and incorporation of improved varieties into their current mixtures, the influence of distribution of improved materials on mixtures and the stability of yields is worthy of study (Wood and Lenne 1993).

While the sweetpotato viruses are generally considered a serious constraint to production, the potential for using healthy planting materials to improve yields of sweetpotato has not been investigated in the region. Collaborative studies involving CIP, NRI and the Ugandan national programme are underway in Uganda to compare yield gains through the clean up of locally important varieties and the study of rates of reinfection by viruses in various agroecologies. Results of these studies will help to guide future efforts with respect to resistance breeding versus use of clean planting materials.

**Post-harvest research**

While there is now almost no processing of sweetpotato in sub-Saharan Africa, many products can be made from sweetpotato (Woolfe 1992). Identification and promotion of appropriate products for the highlands of East and Central Africa could stimulate the development of rural-based processing activities leading to increased incomes for producers. A few preliminary experiences in the region have produced promising results. These include an investigation in Kenya into consumer acceptance of fried crisps and products with varying amounts of sweetpotato flour in recipes for traditional foods such as ugali, the staple food made from maize (Gakonyo 1993). In Burundi and Cameroon, initial experiences using fresh grated sweetpotato as a partial substitute for wheat flour in bread has been promising (Berrios and Beavogui 1992, Odaga and Wanzie 1992).

In the coming years the regional effort on post-harvest research for sweetpotato will grow. Within PRAPACE countries, Uganda and Kenya have been designated as lead countries for post-harvest research. In Uganda, an NRI initiative to support post-harvest research on the non-grain starchy staples will include sweetpotato among the commodities that it addresses in collaboration with the Ugandan national program. In collaboration with CIP, NRI will also post a regional sweetpotato post-harvest specialist to the CIP regional office in Kenya to work in selected countries of the region. Areas that receive increased attention as part of this regional effort includes the following:
market assessment to find out products with the highest likelihood of successful adoption in the region;

development, adaptation and promotion of new forms of use;

evaluation of varieties for post-harvest characteristics together with processing and storage work;

promotion of the use of sweetpotato vines as fodder and investigation of appropriate processing methods for vines; and

investigation of storage problems (to reduce post harvest losses during transportation and marketing).

The major challenge in this work is to identify appropriate products and processes that will have the potential for viable expansion beyond the level of pilot scale operations.

Integrated Pest Management of Weevil

Infestation of sweetpotato by weevils is worse in drier environments and tends to become increasingly severe when harvest is delayed. The problem can also be aggravated by the sequential cropping of sweetpotato on adjacent plots on the small, intensively worked farms of the region.

In recent years international organizations, including CIP, International Institute of Biological Control (IIBC) and ODA, working in collaboration with national programmes in the region, have conducted and supported research aimed at controlling the sweetpotato weevil. This has included research on the use of biological control agents, such as the fungus *Beauveria bassiana*, researches to understand and enhance the effectiveness of cultural practices and the demonstration of the existence of and isolation of the sex pheromones of *Cylas puncticollis* and *Cylas brunneus* (Smit and Magenya 1993).

High levels of host plant resistance to the weevil are not known to exist in sweetpotato so resistant varieties are not an important component of weevil control. Some varieties are, however, more susceptible to weevil attack than others principally because of their tendency to produce storage roots very near the soil surface. These roots are easily exposed to weevil attack. Promotion of a package of good cultural practices by crop protection and extension workers is likely to be the most effective method for controlling the weevil. These cultural practices include crop sanitation, avoidance of adjacent planting, piecemeal harvesting, time of planting and crop rotation (Smit and Matengo in review).

Integrating sweetpotato commodity research and development with natural resources, management research.

Multidisciplinary commodity research on sweet potato can make a contribution toward increasing the productivity and value of the crop. Some constraints, such as soil conservation and declining soil fertility cannot, however, be efficiently addressed through commodity research.

Because of the importance of the crop in eastern Africa, it should not be neglected by those involved in natural resource management in the region. The low input requirements of the crop, and its ability to rapidly cover the soil thereby controlling weeds and erosion, are valuable characteristics for sustainable agriculture in this region (Eke et al. 1990). The high nutritional value of sweet potato as an animal feed can also help to support increased on-farm animal production, which can provide manure to help maintain soil fertility.

The role of the sweet potato in the maintenance of soil fertility has not been well studied. Farmers often consider the sweet potato to be a crop that helps in some way to improve soil fertility. The role of associated nitrogen-fixing bacteria in sweet potato nutrition in the region is worthy of investigation (Hill et al. 1988). Preliminary reports of foliage yields of up to 20 tons of dry matter and five tons of protein per hectare per year encourage further research efforts (CIP 1993).
References


IBPGR. 1981. *Genetic Resources of Sweetpotato.* Rome, Italy: IBPGR.


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Summary and Conclusions

by

Hugo Li Pun

The following is a summary of the presentations and the issues raised in the various discussions. It highlights the major points raised by the workshop participants, which have been organized into five sections, as well as the progress achieved in the implementation of research on sustainable highland agriculture, the recommendations for research approaches and methodologies, outstanding research issues, institutional issues and follow-up proposals.

I Progress in the implementation of research on sustainable highland agriculture

Participants recognized the key role that agriculture plays in natural resource management on the hillsides and the mountains of the developing world. Its importance can be assessed for natural resource utilization, employment generation, food production and water and energy balance, among others. Agriculture can be considered an engine for development in rural areas, and also a key activity to ensure the preservation of the natural resource base in mountain ecosystems.

Evidently there is now a much better understanding of causes and effects within the vicious circle of poverty and the degradation of natural resources. Based on that understanding, realistic policies and actions need to be implemented to ensure sustainable development. For example, policies to protect the environment would not be applicable unless they would also consider alternatives for people whose livelihood depends upon the use of natural resources. The importance of local communities participating in the diagnosis of the problems and in the design, implementation and evaluation of alternatives, was stressed by all participants to the workshop. Alternatives should consider the resources, needs, skills and aspirations of the local communities and society at large.

A recognition of the value of indigenous knowledge was also made. Often it has been neglected in research and development efforts that has been due to a lack of understanding. However, a careful analysis of the situation in rural areas in the developing world would show that many traditional practices, technologies and products contribute to sustainability in the use of natural resources. Specific examples were presented such as the raised-bed techniques ("ware-wares") used in the Peruvian highlands to protect crops against frost and to manage water.

Similarities and differences between regions have been identified regarding environmental and socio-economic characteristics and sustainable agricultural problems, practices, and opportunities. Similarities outweighed differences showing the potential benefits of interregional collaboration. Although the concept of ecoregional approaches for natural resource management is relatively new, progress in their implementation can be seen in some cases. This is made possible through the analysis of problems and opportunities from higher to lower levels by:

- the use of existing knowledge about farming systems;
- the build-up from on-going R&D experiences such as the ones pursued in the Andean ecological region;
- the use of guiding principles to promote interinstitutional collaboration, which have been based on lessons derived from previous experiences such as the ones proposed for the collaboration in Eastern and Central Africa by ICRAF and the ones proposed by the Sustainable Andean
Development Consortium; and
- the use of novel mechanisms to promote farmers' decision-making in the setting of the research agenda such as the proposal by CIAT for the ecoregional initiative in the highlands of Colombia and the mechanisms to promote interinstitutional collaboration used by the Sustainable Andean Development Consortium proposed by CIP and IDRC.

Constraints and limitations to the implementation of ecoregional approaches were also identified. They include the need to develop or fine tune methodologies, institutional structures, prevailing research approaches and financial limitations among others. They have led to the use of pragmatic approaches including strategies of "learning by doing." Trade-offs have also been identified in several cases, including productivity and sustainability objectives and short-term versus long-term perspectives.

II Research approaches and methodologies

Systems research approaches are recommended to address natural resource management and environmental problems including sustainable agriculture in highland ecosystems. This is due to:

a) the characteristics of systems research: holistic, multidisciplinary and participatory;

b) it allows a systematic analysis of causes and problems, linking bio-physical, socio-economic and political perspectives;

c) it allows the understanding of problems at different hierarchies (ecoregion, country, watershed/location, communities, farms and agroecosystems) and their relationships. This is made possible through the analysis of problems and opportunities from higher to lower levels and also through a process of synthesis of results obtained from lower to higher hierarchies; and

d) it also allows the analysis of specific agricultural commodities along the chain from production, marketing and transformation to their utilization to identify bottlenecks and also opportunities for intervention.

One of the main interests in the study of mountain ecosystems is that the effects of management of resources uphill have bio-physical and socio-economic consequences downhill and vice versa. Thus, wide geographical areas can be affected by highland agriculture. Therefore, it was recommended that these relationships be studied along transects in specific locations to better understand causes, effects and to propose possible solutions.

Mechanisms and approaches for participatory research were discussed including the novel approaches to be utilized by CIAT in the Cauca valley of Colombia with support from IDRC. The usefulness of research tools such as GIS and conflict resolution approaches in ecoregional initiatives for natural resource management was discussed. The latter could be especially useful as several cases of conflict over the use of natural resources were identified in the presentations. Both methods should be included within the expanded approach to farming systems research methods.

III Research issues

Critical indicators of sustainability both "indigenous" and "modern" should be identified. With the former, their scientific basis must be researched and validated. In the case of the later, the applicable critical socio-economic and bio-physical indicators needs to be defined. By doing this one would avoid the gathering of excessive data and the difficulties of its management and analysis.

Research on integrated resource management needs to be conducted. At the watershed level, it was apparent that while attention is being given to land management and community issues, the key role that forests play in water balance is not being given enough recognition. This was evident in the case of the Eastern African highlands.
At the farming system level, in several presentations household and crop production systems were given strong emphasis. However, not enough attention was given to other farm agroecosystems such as animal production or tree production. Therefore, a more integrated perspective that considers the interaction of the different components of the farm (household, crops, animals and trees) and off-farm activities are required. Based on that understanding the comparative advantages of interventions in the different activities could be identified and their impact on total farm activity.

The migration of small farmers and peasants is quite common in mountain ecosystems. This has social and economic implications and also environmental effects. Therefore, the impact of alternate livelihoods is another important research subject.

It was recognized that inappropriate policies have often led to inequities and the deterioration of livelihoods in the rural sector and also natural resource deterioration. Therefore, there is a need for research on policies including their formulation, implementation and evaluation. The real value of natural resources is another research area. Often mismanagement of natural resources is due to the inappropriate value assigned to natural resources. Governance that includes the decentralization of decision making, accountability as well as traditional and formal mechanisms, should be given a high priority as a research topic.

IV Institutional Issues

At the national level, the need for both a central and location-specific research effort was recognized. Better collaboration should be promoted between the different institutions involved in the various aspects of sustainable agriculture, natural resource management, policy formulation and environmental management. Formation of consortia or local networking should be promoted as a mechanism to ensure the flow of information and to promote better collaboration.

Regarding ecoregional initiatives, increased attention should be given to the following issues:

- Governance: The discovery of suitable methods to promote effective management and participation by the different stakeholders is the challenge.

- Research Agenda: Who defines it and how?

- Linkages of ecoregional efforts with commodity research: How are they established, and how effective are they?

- Short-term and long-term outputs: While everybody recognized that research on sustainability is of long-term nature, the need to use existing knowledge to ameliorate the present situation is essential. Therefore, short-term outputs need to be obtained in projects addressing sustainable agriculture and natural resource management.

As mentioned previously, similarities in ecological and socio-economic characteristics and agricultural practices in highland ecosystems offer great opportunities for global collaboration. They could include the exchange of R&D experience including methodologies, germplasm, technologies and knowledge. Collaboration could also lead to global initiatives creating further awareness of the key role of mountain ecosystems and also supporting an agenda addressing key issues.

V Follow-up

The following was agreed:

1. Formal and informal activities will be organized to continue the exchange of experiences and promote further collaboration in research on sustainable agriculture in highland ecosystems. Electronic mail offers possibilities for continuous interaction among participants.
2. It was decided that, for the time being, IDRC will continue to play a coordinating role. This will include the organization of the next meeting that will take place in Latin America in December of 1994. The location would be either in Ecuador or Peru with a major role assumed by NGOs in the organization. The topics for discussion would be agreed upon during 1994. A balance of social and biological scientists, and representatives of the different type of research organizations will be looked for.
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