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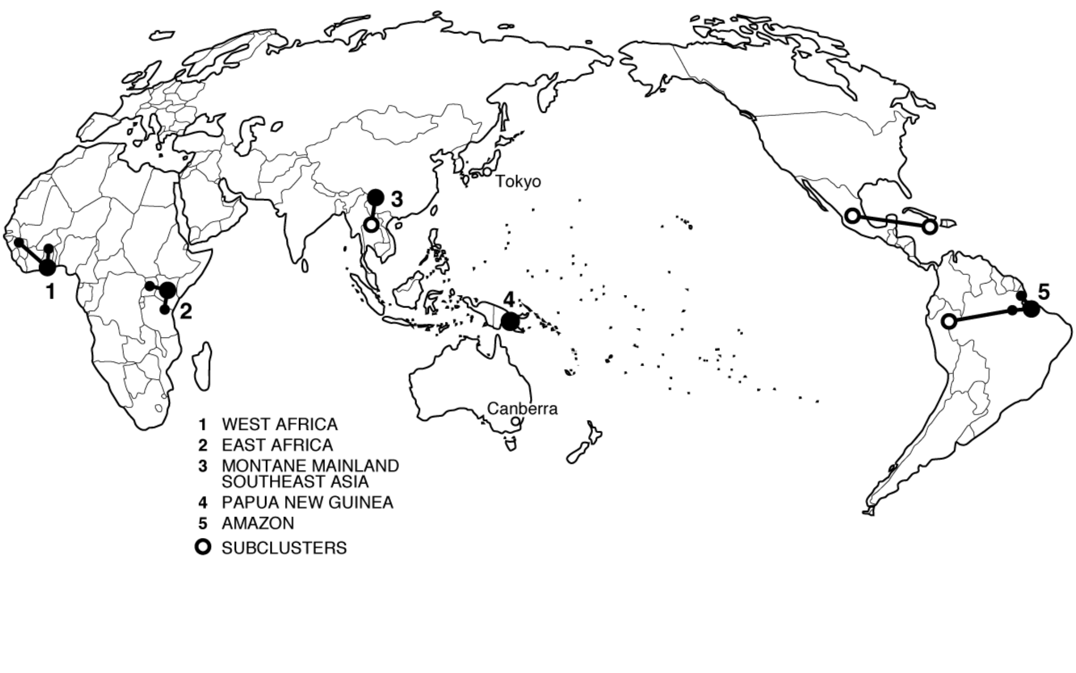

The Clusters of PLEC

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PRINCIPAL SCIENTIFIC COORDINATOR'S REPORT

MAY TO AUGUST 2000

Harold Brookfield

There is a growing volume of material suitable for inclusion in this small periodical. This issue is brought out only four months after the previous one, and the next will appear early in 2001. The Mid-Term Review (MTR) takes precedence in this issue, followed by some important papers. My report is therefore short.

The third General Meeting, Brazil, May–June 2000

The third General Meeting, and fourth Management Meeting, were held in Macapá and Belém from 27 May to 1 June. A Coordination Team meeting followed on 2 June. After a day at EMBRAPA in Belém, the meeting assembled in Macapá with 33 participants and a group of farmers and field assistants from the Macapá demonstration sites at Mazagão and Ipixuna. After a discussion of the MTR, short presentations on progress were made from each Cluster, and then by some of the Amazonian farmers, speaking to excellent posters of the activities being undertaken on their farms. There was then a session organized by the Biodiversity Advisory Group (BAG) which could not be concluded until two days later because of failure of the audio-visual equipment.

The second day was occupied by a visit to farmers at Mazagão, by road and river, starting in rain and ending in beautiful sunshine. Miguel Pinedo-Vásquez was a highly informative leader. Time and distance, together with the difficult walking conditions in the tidal swamps, limited us to only three of the farms, but what makes an 'expert farmer' was very clearly demonstrated. We saw a good deal of what had been presented in *PLEC News and Views* No. 15.

Business on the third day was serious. Kevin Coffey presented his clear and user-friendly system for biodiversity database development, now made available to all Clusters. Then there was a Demonstration Activities Advisory Team (DAT) session which covered a range of issues, among which perhaps the most important was the degree of intervention tolerable—or wise—in PLEC. The discussion showed how far PLEC scientists have come together around this theme. Lastly, there was a robust discussion about 'a life for PLEC beyond GEF'.

The management meeting in Belém covered some of these topics in greater depth, in particular the response to the MTR and follow-up actions that were necessary. A preliminary discussion about data analysis led to the decision to start an electronic debate on this topic This was initiated on 21 June and is still in progress—and beginning to get somewhere—at the time this report is written. The debate is separate from the '**Plecfutures Forum**', which is more formally handled and is concerned with the future development of PLEC work. The delayed and uneven state of formal reporting was also discussed.

The hospitality and arrangements in Brazil were excellent, and Tereza Ximenes-Ponte, Toby McGrath and their colleagues gave us all a marvellous time.

Fusing BAG and DAT to make STAT

BAG, in its original form, has now done its work. It has been decided to fuse it with DAT in a single **Scientific and Technical Advisory Team (STAT)**, to work with the Cordinators and the Clusters on all scientific and technical matters. This body will have four full members, the two former members of DAT, Miguel Pinedo-Vásquez and Edwin Gyasi, with Lewis Enu-Kwesi from the former BAG; and Kevin Coffey, consultant to BAG earlier this year in developing the database manual.

PLEC publications and prizes

A first priority is to make the **Database Manual** prepared by Kevin Coffey widely available. A revised version, including discussion of agrodiversity data, is now in preparation by Kevin. This will be published in a limited edition, with support from PLEC, by the New York Botanical Garden Press, later in 2000. The Database Manual will also be made available on the PLEC Website. Consideration is also being given to production of a CD version.

The proposed **PLEC Manual** comes next. This proposed 'Manual', still awaiting a good title, is about how PLEC has developed the agrodiversity concept, demonstrating to a wider audience how useful this can be. An outline, with *PN&V* articles for reprinting and drafts and abstracts of new papers, is now being assembled. It will be offered to a British publisher in September, and discussed in October. As earlier agreed, principal (first named) authors of all papers published in this 'Manual', other than Scientific Coordinators, will receive an honorarium of $200.

The proposed follow-up special issue of a journal including more strictly scientific papers by PLEC members, is not yet firmed up. Outlines of a number of papers have been discussed with authors, but few will be complete before 2001; most people are too busy to give them priority. However this is completed and published, its first purpose is the career advancement of PLEC scientists; an honorarium of $150 will be paid to each first-named author (other than Scientific Coordinators).

PLEC scientists who publish outside these two sponsored collections will be invited to send copies of their papers prepared up to mid-2001 for assessment by external reviewers. There will be a first prize of $250, and two second prizes of $100 for the papers judged to be best.

Forthcoming meetings

In Belém, an invitation from **Tanzania** to hold the next meeting of the **Management Group** in that country was accepted. The meeting will take place at Arusha in northern Tanzania in May 2001.

The **fourth General Meeting of PLEC** will also be the final meeting of the GEF-funded project. As agreed in Belém, it will take place towards the end of the four years in a place where wide publicity can be generated for PLEC results and outputs, probably in either the United States or western Europe. This meeting will therefore be quite different in nature from the three previous meetings, and consolidated reports will be sought from each of the Clusters. Hopefully, these presentations can form the basis of a final major publication from GEF-PLEC.

THE MID-TERM REVIEW

THE REVIEW REPORT

Stephen Brush

(The PLEC project was reviewed by Professor Stephen Brush of the University of California, Davis, in the month of April, and the report was sent to UNEP on 5 May. Reproduced below is all that part of the text which concerns the project as a whole. Almost half of the text consisted of discussion and recommendations specific to the three Clusters visited in the field, China, Ghana and Brazilian Amazonia; that text is not included. Similarly, in the Project Reply, which follows directly, Cluster-specific replies that were annexed are not reprinted here. Except for the correction of a few minor typographical errors, and deletion of the paragraph-numbering system, the project-wide sections of Professor Brush's report are reproduced exactly as written. Eds)

Executive Summary

This review is based on personal inspection of PLEC activities in China, Ghana, and Brazil, interviews there with Cluster and sub-Cluster Directors, associated researchers and administrators, community leaders, and farmers, personal communication with Scientific Coordinators, and examination of project documents and reports.

The PLEC Project has succeeded in establishing an international framework to address a novel area in biodiversity conservation—agricultural diversity comprised of ecosystem (landscape), species, and sub-species (crop genetic diversity), and management components. Scientists from different backgrounds have come together to work on a common theme that is new to many of them. Coordination has been facilitated by establishing a lean central administration at UNU, periodic visits of Scientific Coordinators, specialized teams, and meetings of participants at the national, regional and international levels. The overall PLEC project has established cross-country advisory groups on biodiversity assessment and demonstration, increasing the consistency and comparability of data and demonstration activities. The mechanisms for administration and dispersal of funds appear to be efficient and satisfactory.

The initial phase of PLEC has been highly successful in establishing active working groups in five of the eight countries funded by the GEF. [Note: The three countries with limited progress were not visited by the reviewer.] These working groups combine researchers from different institutions (universities, ministries) and different disciplines (e.g., botany, geography, agronomy). They have established demonstration sites in different regions of each country. Farmer Associations have been organized or recruited to work with PLEC researchers. Data sets on agricultural diversity and agricultural biodiversity have been assembled, including species inventories of home gardens, description of different land-use stages and field types, and floristic composition of forests managed by communities. Demonstration activities have been initiated in all of the sites visited.

Three key recommendations are made, all dealing with the need to consolidate this broad and somewhat diffuse project. PLEC will have greater value to other sites and GEF programmes if it can successfully move from its initial phase of description to a more mature stage of analysis of threats to the loss of biodiversity in agriculture, make recommendations to confront these threats, and demonstrate conservation activity.

1. The second phase of the project should include a focus on a specific biological component of agricultural diversity that

can be compared between Clusters, and be described in terms of trends and threats, and that might be the target of conservation programmes. It is this reviewer's conclusion that the landscape level is too broad to meet these criteria. Possible components for this focus are the adjacent forests managed by the communities and/or within-crop diversity of major cultivars (e.g. rice, yams, cassava). The project might take advantage of the fact that many of the countries are in world centres of crop origin and diversity.

2. Each Cluster should aim to generate specific recommendations and demonstration activities for conserving biological diversity within the participating agricultural systems. These recommend-ations and demonstrations should be linked to the focus or foci developed in response to point number 1 above.

3. The activities and budget allocations for the programmes in Kenya, Uganda and Papua New Guinea should be reduced for remainder of this phase and these programmes cut from any future phases.

The integrative aspects of PLEC as an international project have been beneficial insofar as they have helped to direct research and demonstration across different environments and social contexts to an issue that is novel to many of the participants. PLEC has succeeded in initiating organizational efforts at the country level for work on agrodiversity. Progress in the current phase is sufficient to warrant consideration of continued funding after the current GEF phase for PLEC-like research in five of the eight countries funded by GEF (China, Ghana, Guinea, Tanzania, Brazil). Nevertheless, future progress is more likely to be within individual countries rather than across them, and the added costs of international coordination are not warranted by the future benefits of such coordination. Future PLEC projects should be approached on an individual country or limited Cluster (e.g. West Africa) basis rather than as a globally integrated project.

Progress of the implementation

PLEC Management Unit (UNU – Tokyo)

PLEC has generally succeeded in establishing an effective management unit at the inter-Cluster level to carry out the work described in the PLEC Project document. In particular, PLEC has succeeded in creating a flexible structure to oversee the diverse set of Project activities, carried out in different countries, on different aspects of agricultural diversity. This structure is comprised of 1) a relatively lean central Project administration from UNU offices in Tokyo, 2) decentralized scientific direction from the three principal Scientific Coordinators, and c) two thematic teams of scientific advisers—the Demonstration Activities Advisory Team (DAT) and the Biodiversity Assessment Advisory Team (BAG). This Project involves both research and demonstration, and given the great differences between work sites, a decentralized approach is advantageous. The cost of coordination is relatively high, but this cost is partly justified by the need to hold the disparate Cluster and country and sub-country projects together and to provide coherency to the overall Project.

It is important to stress the novelty of the theme of 'agricultural diversity' as an objective of conservation, and the relatively brief period of operation of PLEC. The Project clearly has made important progress in informing local scientists and environmental administrators in some Clusters (e.g. China, Ghana), in prompting them to seek new ways to conceptualize and organize their work, and to promote new coalitions of scientists, policy makers, administrators, and farmers.

Whereas activities that are not directly connected to biodiversity conservation are appropriate to address perceived local needs, the amount of PLEC investment in terms of research should be minimized so as not to jeopardize the biodiversity aspects of the project. Examples of these activities are the soil erosion research and applied projects on soil degradation that have been carried out in several sites. In some cases, a higher proportion of project effort has gone into these than into direct biodiversity activities. For example, in the Tamale area of Ghana, it is estimated that 60% of the project effort went into filling gullies with stones to limit siltation of the village water supply. Another major activity was helping villagers to develop compost pits. While these activities were associated with limited re-forestation, they seem to have detracted from biodiversity work that is closer to the GEF mandate. The second phase of the project should be cautious to avoid allowing GEF funds to be used for a loosely defined integrated rural development project.

Scientific progress

The reviewer's opinion is that the greatest progress in implementation has been at the individual country level rather than at the Cluster or inter-Cluster level. The integrating theme of the Project, 'agrodiversity', is so broadly defined as to impede cross-country comparison for environmental conservation. The general nature of the theme lends itself more to a descriptive scientific exercise rather than one that leads to analysis across different communities, countries or Clusters. Likewise, the general nature of 'agrodiversity' makes it difficult to define threats or trends to biological diversity in agriculture or to initiate conservation activities.

The Project rightly resists reduction to a single key variable that might affect agrodiversity, partly because agrodiversity is operationally defined in different ways across countries and Clusters. Nevertheless, without better specification of a common definition of agrodiversity or key variables that affect it, there is a centrifugal tendency in the Project. That is, individual Clusters, countries, and scientists have a tendency to follow their own interests, however loosely connected to a central biodiversity theme. The result is that the Project has the danger of becoming a vaguely defined integrated rural development project rather than one with a critical focus on conserving threatened agricultural biodiversity. This reviewer's judgement is that a better balance needs to be struck between promoting the interests of individual scientists and those of the Project. Each activity should be scrutinized and justified by its specific contribution to the conservation of biological diversity in agriculture.

The expansion of Project activities, including the addition of new country programmes, should be resisted because of the tendency to dilute the scientific progress of the Clusters and teams that have well established programmes. No single team has made sufficient progress to justify using limited funds to open new projects. In fact, the existing country programmes warrant increased support in the second half of the Project.

Uneven performance seems to prevail across countries. It is reliably reported that three countries are falling seriously behind others in the Project objectives: Uganda, Kenya, Papua New Guinea. Reduction of activities in these countries might be conducive of success in other sites.

Scientific progress of the Project would be likely if the group agreed on a minimal set of measures of site characteristics (e.g., interspecies diversity in agriculture, intraspecies diversity of major crops, diversity in adjacent forests managed by communities) and a minimal set of socio-economic factors that affect those characteristics (e.g., demographic factors, market integration, social heterogeneity). Scientific progress is likely to be greater if the Project adopts not only a minimal set of common descriptive variables but also a common analysis of the process of change between key dependent variables (e.g., interspecies diversity, intraspecific diversity, adjacent forest diversity) and independent variables (e.g. socio-economic factors, policy factors, environmental heterogeneity). The adoption of a research strategy in all Clusters and countries that stresses inter-household comparison would be very beneficial to the whole Project. Household surveys allow quantification of common dependent and independent variables and thus enable cross-site comparison and analysis rather than mere description of different sites.

The Project has given very little attention to the within-crop diversity, despite the fact that each Cluster is located in a world centre of crop diversity. By expanding activities to include within-crop genetic diversity, PLEC might make significant contributions to the development of a new GEF Operational Programme on Agricultural Biodiversity. PLEC is in a good position to expand into the area of crop genetic diversity, at least in a few sites (e.g. China, Ghana). This would be valuable both for PLEC and GEF.

Human resource capacity

The creation of an international network of scientists and environmental administrators focused on the novel theme of agricultural diversity is an important accomplishment and contribution of PLEC. Many of the participants had little direct knowledge or experience with the issues of agricultural diversity, and they are now interested and involved in understanding and working toward the maintenance of diversity. Another general accomplishment of PLEC is to bring together disparate institutions that had little experience in working in a single project. Finally, PLEC has begun to develop the capacity of environmental organizations to work with farmers and the capacity of farmers to work with environmental organizations. Examples of this are the organization of the Farmers' Association for Biodiversity Conservation in Baihauling Village in Baoshan, Yunnan, China and the Women's Biodiversity Conservation Association in Jachie, Kumasi, Ghana.

As a demonstration project, PLEC has given some thought to the processes and products of demonstration. Project support via the Biodiversity Advisory Group (BAG) and the Demonstration Activities Advisory Team (DAT) can contribute to the capacity of national participants to understand biological diversity and mount activities that conserve biological diversity in agriculture.

PLEC's long-lasting contribution can be enhanced by giving more attention to four issues:

1. Threats to agricultural biodiversity: project tends to be overly descriptive in telling us what farmers do. It needs to go beyond this, to suggest factors that are negatively affecting diversity, to demonstrate the impact, and to deduce measures to counter act them.
2. Policy: the project lacks a critical policy dimension. What can be done to address the loss of diversity and/or to promote its maintenance at the farm level. My impression is that the general nature of agricultural diversity impedes progress in imagining policy solutions. Defining critical components within diversity is needed to overcome this.
3. Recommendations: while there have been some definitive recommendations, such as the no burning policy in northern Ghana, PLEC has made limited progress in specific biodiversity recommendations that can be evaluated and then extended beyond the project sites. Moreover, the organizational and methodological framework for diffusion of recommendations has not received sufficient attention. Increased attention to defining a specific set of demonstration modalities is warranted in the second half of the Project. A limited range of demonstration modalities (e.g. field days, publications, work shops) would give flexibility to Clusters to choose appropriate ones.

4. Sustaining farmer organizations. The farmer organizations are critical to the future of PLEC work, so that attention on maintaining them post-PLEC is necessary. One possibility is to build a more permanent system of linking university researchers to the communities where PLEC has worked. Another possibility is to make better links with existing extension organizations (NAR or NGO).

Recommendations for second half of implementation phase

- Emphasis should be given to the successful completion of country projects that are well established (e.g. have assembled primary data sets and established demonstration sites). Country projects in Uganda, Kenya and Papua New Guinea have not reached this stage; and the activities and budget allocations for the programmes in these three countries should be reduced for remainder of this phase and these programmes cut from any future phases.
- Additional funding, available through normal GEF/UNEP procedures for cost overruns and special opportunities, should be made available to PLEC because of the small amount of funding that has been available to each country and because of the novelty of the project. These additional funds should be allocated among the successful country programmes (China, Ghana, Guinea, Tanzania, Brazil) on a competitive basis. This additional funding is important to responding to the issues raised in this report about identifying threats to agricultural biodiversity and conservation means to confront these threats.
- The Scientific Advisory panel, now comprised of the three senior Scientific Coordinators, should be broadened to include one representative from each Cluster. This broader panel should take a larger and more assertive role in defining a common set of key measures and quantitative analyses that will be applied across all Clusters and in preparing publications.
- Project activities that are not directly (and demonstrably) linked to agricultural diversity should be curtailed and/or eliminated. For example, work on soil degradation should be reduced, not because soil degradation is an unimportant issue, but because it is not sufficiently well connected in the Project to maintaining agricultural biodiversity.
- In at least some locations, the Project should undertake documentation of the relation between farmer management for production and the biodiversity of other species (birds, fish, insects, forest diversity). Demonstrating a general biodiversity conservation benefit would strengthen the project.
- The scheme for describing and analysing management levels used in Brazil should be applied across all sites.
- More attention should be given to the process and products of demonstration—the identification of target audiences and methods for reaching them.
- Expansion of activity relating to crop genetic (within species) diversity should be undertaken in at least two Clusters, perhaps where local experts and/or consultants are available. For example, work on rice in Yunnan (a world centre of rice diversity) could be undertaken co-operatively with the Yunnan Academy of Agricultural Sciences. Likewise work on yams (*Dioscorea*) could be undertaken in Ghana. This work better would link PLEC to the new GEF Operational Programme on agricultural biodiversity.
- Specific funds should be allocated for editorial assistance for scientific publication.

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PROJECT REPLY TO THE MID-TERM REVIEW REPORT

(This reply was drafted in May, and discussed by the Management Group at its meeting in Belém on 2/3 June. It was subsequently further modified and sent to UNEP on 16 June. For printing the reply is slightly abbreviated. Eds)

The Review Report by Professor Stephen Brush (hereafter 'the Reviewer'), is of great value to the PLEC Project. The many favourable comments are noted with appreciation. Some of the modifications suggested are in line with already-active plans for the two final years of the GEF-funded project, set out in the year 2000 contracts and the year 2001 work plan. On others we have differences in emphasis, as set out below.

This reply comes from the Project as a whole, and is concerned with whole-Project issues. It was drafted before the meeting of the Project in Brazil in May-June 2000, was discussed there in detail, and has been further revised since the end of the meeting. To simplify this reply, we focus on the three principal recommendations set out in the Executive Summary, and on wider issues that arise around them elsewhere in the Report.

Recommendation 1

Recommendation 1 is the central recommendation of the report. It deals with the need for consolidation and to move from an essentially descriptive phase to 'a more mature stage of analysis and threats to loss of biodiversity in agriculture'. We accept the need to move on to analysis, and some Clusters have begun to do so. We remark that an emphasis on description during the first two years was to a large degree mandated in the project work plan. This required inventory of biodiversity on farm land and in adjacent forests, and also inventory of the management practices used at field level by farmers. This work has proved to be complex and has taken up more time than was expected, to the extent that it is not everywhere complete.

By our mandate as a project within the GEF operational programme on biodiversity, much of this initial work was at landscape level. Recommendation 1 further proposes 'a focus on a specific biological component of agricultural diversity [which] can be compared between Clusters, that can be described in terms of trends and threats, and that might be the target of conservation programmes'. He adds that: 'it is this reviewer's conclusion that the landscape level is too broad' [for this purpose]. We disagree only in so far as comparative work at ecosystem level is required. The main purpose of landscape work has been to provide the necessary ecosystem context for more detailed work at community and farm levels, within the much narrower demonstration sites, and the sub-sites within them. This is so for all Clusters whether they are composed mainly of natural or ecological scientists, or of social scientists.

In practice, most work in all areas has by now focused on specific farms and managed areas within the demonstration-site areas, on biodiversity within these, and on differences in household practices and their consequences for biodiversity. The Project now holds a great deal of data at this level, and work is in progress to improve its organization in database form to facilitate analysis and comparison.

As a project that is staffed by scientists, we appreciate the Reviewer's generally warm evaluation of the scientific research embodied in PLEC, and his proposals for strengthening this research. But while threats to biodiversity are obviously an important dimension, our GEF funding is principally for work in the demonstration sites. In the Project Matrix which forms

Annex 1 to the Project Document, the Project goal is described as follows: '*To develop sustainable and participatory approaches to biodiversity conservation within agricultural systems, by setting up over 20 demonstration sites where sustainable and conservationist resource-use practices can be developed in participation with farmers and other stakeholders*'. We must continue to give priority to this applied work. It needs to be stressed that PLEC is not a body of scientists aiming to do only scientific research. Some of the comments on p. 5 may therefore be misplaced.

In expanding recommendation 1 at a later place, the Reviewer asks us to suggest and analyse factors that negatively (our emphasis) affect diversity, an approach found in a lot of ecological work. In addition to threats to biodiversity, we also suggest factors that affect diversity in a positive manner. We place stress on what farmers are doing, mainly at farm level, to manage their total biological and physical resources and processes. We experiment to validate or improve on this knowledge, and introduce certain variations especially from other areas, thus providing examples of method that can be more widely used in the enhancement of biological diversity.

Two focus components are advised in Recommendation 1. 'Adjacent forests managed by communities' are a part of the total managed landscape in which our major stated concern is with diversity on farmed or otherwise managed land. They are more important as a focus of work in some areas than in others. The particular emphasis on forest diversity seems to generalize from a case in China. 'Within-crop diversity of major cultivars' is an important area, one taken up substantially by other projects, and it has to a limited degree been developed spontaneously—rather than by mandate—within PLEC, especially in China, West Africa and Papua New Guinea.

These focal areas are potentially valuable, but a more exclusive concentration on them would take PLEC away from its stated objectives. We accept the proposal that we strengthen a focus on within-species diversity, which would lead to stronger linkages with other projects. Yet our original mandate concerned biodiversity as a whole, not agricultural biodiversity alone. To isolate inter-species and intra-species diversity, and adjacent forest diversity as the key dependent variables for analysis (p. 4) would be a good approach for follow-up work, but it could become central only in a project different from the one here reviewed.

In more specific relation to the recommendation that we focus attention on within-crop diversity, we remark that a basic limitation of present work on agricultural biodiversity, on the evidence of many recent publications, is its relative disregard of management, both agro-technical and through the farmers' organization of their resources. Yet a chapter in a recent book contains the following: 'What is important to preserve is not the genetic material in and of itself, but the processes that create and preserve genetic diversity' (Louette 1999: 138). The central role of PLEC in relation to the important new scientific developments going on is to stress the context of these processes. This is why we place emphasis on 'agrodiversity'. This area is not at present adequately developed by the emerging agricultural-biodiversity mainstream, and there is a place for PLEC in filling the gap.

The Reviewer regards 'agrodiversity' as too broad, in need of a common definition, and needing to be broken into component parts to become useful (p. 5). It has indeed been both defined and broken into component parts for analysis by the Project, especially in the special methodological issue of *PLEC News and Views* (No. 13 1999). This classification has been used at farm level as well as at landscape level, fairly uniformly across the project.

Analysis of 'agricultural diversity' makes possible a balanced view. It was a novel theme to PLEC scientists, but they have taken it up with enthusiasm, as the Reviewer remarks (p. 6). High praise is rightly given to one major product of our work on agrodiversity, in Amazonia. The approach through 'system, method, technique and activities' is also being developed elsewhere in the Project, and it will permit cross-regional comparison in the final analysis.

In summary, our stress is on management, distinguishing good from indifferent management at household level. Value judgements on management quality are based on both the conservation of biodiversity, and on the support given to rural livelihoods. We are concerned with differences between the practices of individual farming households, not with statistical means across the populations. In relation to the emerging mainstream in agricultural diversity, and especially the new GEF Operational Programme in this area, we see the role of PLEC as being primarily to supply an analysis of management, and a methodology for taking this important element into account. We agree that this has not yet been achieved, but it will become a major focus of effort in the balance of Project life.

In accepting the spirit of Recommendation 1, therefore, we lay emphasis on the need for more analytical work on the large body of data collected in the Clusters. This will have two main objects: to identify threats to biodiversity; and to highlight farmers' strategies that sustain and enhance biodiversity. The central focus will be on the management of diversity, and on the identification, scientific validation and improvement of management strategies that have wider application, and which can form the basis of both technical and policy recommendations. In the process we will place greater emphasis than hitherto on within-species biodiversity of selected crops, its conservation and enhancement, but with stress on the conditions that support crop diversity more than on the crop plants themselves.

Recommendation 2

PLEC welcomes the recommendation that 'each Cluster should aim to generate specific recommendations and demonstration activities for conserving biological diversity'. We also accept the criticism (p. 6) that 'the organizational and methodological framework for diffusion of recommendations has not received sufficient attention'. The degree to which our Clusters are presently in touch with decision makers at national level differs from area to area, as also does the ease with which these contacts can be established. Progress in this direction is already required in Cluster contracts for the present year, and the presentation of recommendations becomes a central activity for the fourth year in the Project workplan.

The demonstration activities now in full progress in all Clusters are already closely related to the conservation of biological diversity. The now-general practice of identifying expert farmers to provide leadership in demonstration-site work recognizes the importance of gaining wider adoption for management methods that have been validated by the accompanying scientific work.

Recommendation 2 is expanded by three recommendations under the heading of 'Human resource capacity'. In regard to these we comment:

1. Our work does isolate factors that negatively affect diversity, as well as those methods which have a positive impact. Policy recommendations arise from analysis of both.
2. Our focus on management is important in order to obtain an integrated set of recommendations. Critical components of agrodiversity are identified, but appreciation of the interactions between them is necessary for development of proposed policies.

3. The demonstration modalities proposed (field days, publications, workshops) are all in use in different areas of the Project, although not everywhere equally or in conjunction. There has also been substantial use of the media. We agree with the need to make greater efforts to communicate with decisions-makers and other experts during the remainder of Project life.

Recommendation 3

The Reviewer's remarks on delayed progress in Uganda, Kenya and Papua New Guinea are broadly correct. Our internal assessment picked up problems in these Clusters a considerable time ago, leading to vigorous remedial action. By now, there is valuable progress in at least one site in each of the three regions.

It is probably correct to say that it is now too late for these groups fully to 'catch up' with the more advanced Clusters, but there has been substantial progress in 1999, not least in capacity-building in the areas of biodiversity and agrodiversity analysis where little existed before. It is worth remarking that another Cluster (Tanzania) had difficulties in the past, but turned itself around in a limited period of time after late 1998, and is now among our leading groups. We anticipate that, before the final evaluation, much that is of relevance to the central purposes of PLEC will have arisen from the work of the three presently less-advanced groups. They are situated in key areas of biodiversity importance.

There is much that can be done within the time remaining if resources are concentrated where they can be most effective. Following the recommendation, each of these three Clusters has now been asked to propose strategies to do this. In this way the substantial investment made in their work, which has included visits by both BAG (Biodiversity Advisory Group) and DAT (Demonstration Activities Advisory Team) in recent months to assist them, will not be wasted. Our less-advanced Clusters are still capable of substantial achievements, and a more focused approach by their multi-disciplinary teams will give them the opportunity to do this.

Integration of the Project, and cross-country coordination

The report is ambiguous about the state of project integration. Efforts to achieve this, including BAG and DAT as well as scientific coordination, are praised on pages 3 and 4, but regarded as inadequate at p. 5. PLEC has always emphasized a diversity of approaches as well as of farming situations and responses, but in the course of two years major efforts have been made to strike a balance between the interests of individual groups of scientists and those of the Project. The fact that a minority among participants still have a 'tendency to follow their own interests' (p. 5) to the neglect of the central theme should not be allowed to obscure the very considerable harmonization of work that has taken place, and the degree of collaboration around the theme of agrodiversity in the demonstration sites that has been achieved.

The creation of BAG and DAT during the first two Project years has proved highly successful in Project unification. PLEC has, by now, developed an approach to work between scientists and farmers which is applicable in environments as far apart physically and socially as Amazonia and Yunnan.

The Reviewer's remarks on the benefits of cross-country coordination cut both ways. It is regarded as expensive (p. 4), but it should be further enlarged (p. 7). The 'lean' administrative apparatus in Tokyo is praised (p. 4). The Coordination team has already been greatly strengthened by creation of BAG and DAT from within PLEC developing-country membership. Together with the involvement of regional advisers in the

Management Group, this is already a response to the proposal for enlargement of coordinating personnel (p. 7).

Other specific recommendations across Clusters or to the whole Project

The desirability of assisting communities to meet local needs is recognized in the Report, but there is concern that gaining farmers' cooperation in this way can lead to PLEC becoming a 'loosely defined integrated rural development project' (p. 5). PLEC is well aware of this risk, and many steps have been taken to avoid it, while at the same time ensuring cooperation in conservation activities by offering limited and mainly technical support to local enterprises. To this end, there has been heavy concentration in all areas on support to those local activities, old or new, that generate value out of biodiversity.

Although PLEC, as a biodiversity Project, crosscuts with land degradation, work on soil erosion as such forms only a minor part of the Project work plan. It is true that is has received more than minor emphasis in some areas (p. 7). Biodiversity conservation is certainly PLEC's concern, but it includes conservation of the resource base. Some of us would argue that soil conservation is as important for the defence of biodiversity as is planting trees. Soil conservation is a major interest of several of our participants, and was initially of greater importance than it is now. Emphasis on this aspect has already been substantially reduced, and will continue to be kept at a low level. However, a PLEC-related but separately-funded initiative supported by UNEP, to prepare a set of guidelines on the field study of soil degradation, will continue. [These guidelines will soon appear, and will be reported in the next issue of *PLEC News and Views*.]

Future planning

It is a mark of success in coordination that the Reviewer recommends that progress in five of eight countries is sufficient to warrant consideration of continued funding on a national or regional basis after the current GEF phase. We recognize that follow-up activity after the termination of GEF-PLEC will have to be different in both nature and organization from the present Project. The matter is now under active discussion, and several scenarios are being explored. The Reviewer's remarks at pp. 3–4 will be taken fully into account in these deliberations. While PLEC Clusters in the five countries are already able to work independently, and/or with other partners, we urge that there is likely to be a continuing value in networking. In particular, the full international impact of collaborative work with farmers on the conservation of diversity is unlikely to be achieved without an integrated voice.

Final remarks

We note with satisfaction the proposal that additional funding should be made available for cost overruns and special opportunities. A revised 2001 budget will shortly be submitted to UNEP and GEF, taking account of the need to respond to the opportunity to create designs for strengthening biodiversity conservation, to more effectively demonstrate these designs, and for final reporting purposes. These should include the editorial support for scientific publication which is specifically mentioned in the last bulleted point at p. 7. We accept the proposal that allocation of additional funds between Clusters should be on a competitive basis.

The Reviewer pays PLEC the compliment of reviewing it largely as a scientific project, and shows a number of ways in which its scientific impact could be enhanced. This goes beyond the mandate of the present GEF-funded project, but would be much more clearly related to the new GEF Operational Programme on agricultural biodiversity, to which analysis of PLEC results could provide a valuable contribution. To do this would require time, as well as additional funds. We agree with a verbal comment made more than once by the Reviewer to those who accompanied him during his mission, but which he did not include in his report. This is that PLEC should have been designed over five years rather than four. It would be difficult, if not impossible, to complete the 'more mature stage of analysis' in a manner that would fully derive benefits for GEF as a whole from PLEC data and experience, in shorter time.

Although we take issue with some points raised in the report, we appreciate its positive tone, and praise for what the Project has managed to achieve in only two GEF-funded years. We also appreciate the praise given to the three Clusters visited, and to two of those whose efforts have been seen only on paper (Guinea, Tanzania). We wish that the reviewer could have seen more of the Project, and hope that those who finally evaluate PLEC will see more of it. In a short review it is not possible for one person to take in everything he has seen or been told, verbally or on paper, and some of our points of difference arise from this limitation. Our few dissents notwithstanding, the Reviewer has made many valuable proposals that we will take into account.

Reference

Louette, D.
1999 Traditional management of seed and genetic diversity: what is a landrace? In S.B. Brush (ed.) *Genes in the field: on-farm conservation of crop diversity*, pp. 109–142. Boca Raton: Lewis Publishers.

OBITUARIES

Charles Anane-Sakyi, Ghana

Mr. Charles Anane-Sakyi, a Ghanaian PLEC scientist, passed away at an early age on 26 July 2000. He was based at the Savanna Agricultural Research Institute (Council for Scientific and Industrial Research, CSIR) at Manga-Bawku, in the Upper East Region of Ghana. Edwin Gyasi writes of him that "PLEC remembers Charles for his gentle disposition and, above all, for his outstanding research work on *'Women in conservation of indigenous varieties of rice in northern Ghana'.* The research had registered a strong social impact, and resulted in various reports which, under the strong influence of PLEC, Charles sought to develop into publishable manuscripts. His untimely death represents a tragic loss to PLEC, particularly to his northern Ghana PLEC group which has barely recovered from the loss of Mr. Sadiq Abdulai, another illustrious colleague, who passed away only last year." All of PLEC mourns the loss of a man who served the Project so well.

Edward Kaitaba, Tanzania

Mr Edward Kaitaba, of the Agricultural Research and Development Institute at Mlingano, Tanzania, also died in early August, at the very early age of 39. He had been sick for some time. A soil scientist and land-resources surveyor, Edward Kaitaba was one of the first members of the Tanzania sub-Cluster, having earlier been a colleague of Fidelis Kaihura. He participated in all the initial work at Arusha, and in the writing of reports up to 1998. Many in PLEC will remember him at the Mbarara meeting in Uganda in March 1998. Our condolences go to all his relatives and colleagues.

PAPERS BY PROJECT MEMBERS

AGRODIVERSITY ASSESSMENT IN DIVERSE AND DYNAMIC SMALL-SCALE FARMS IN ARUMERU, ARUSHA, TANZANIA

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(This paper is derived from a longer report sent to PLEC early in 2000 as one of the three 'chapter length' reports required in the Project workplan. It has been reduced in length and detail for publication, and in Tables 2 and 3 a part only of the detail supplied is presented. The reductions, proposed by the editors, have been agreed by the principal author. The paper is presented to a wider readership as an example of comprehensive agrodiversity inventory, with a valuable discussion showing how the new is blended with the old. The full original text is available from the principal author. Eds)

Assessment methodology

Assessment of agrodiversity was conducted in two PLEC sites at Arumeru, Tanzania, covering in detail most aspects of biophysical diversity, crop, land and livestock management. Both sites are on the slopes of Mt Meru. The Olgilai/Ngiresi site is at high altitude with relatively high rainfall, and is densely populated (2,158 people), with only 0.22 ha of cultivable land per person (Murnaghan 1999). Kiserian is at lower altitude, is semi-arid and, although more populous than Olgilai/Ngiresi (3,330 people), has more cattle than people (Figure 1). Both are occupied mainly by Waarusha people, with smaller numbers of Wameru, Wapare, and some Wachaga from the nearby Kilimanjaro region.

The first task was to establish current Land-use Stages and Field Types within each land-use stage, as defined in *PLEC News and Views* No. 13, April 1999. For each land-use stage, reconnaissance traversing was done, crosscutting the entire area. In farmers' fields, current field types were identified and named. In all cases identification and assessment was done in collaboration with key informants. The checklist outlined in *PLEC News and Views* No. 13, 1999 was the main guideline for most of the data collected.[3]

Management systems were assessed in terms of crops and cropping systems, planting, tillage, livestock management, soil management of household farms and soil management of rented and/or hired farms. Crops and cropping systems found in the

[3] General surface conditions of each field type were described in terms of farm ownership, farmer category, location (geo-referenced), land form, vegetation, drainage and per cent slope of the field, fertility rating, and evidence of N, P and K deficiency symptoms on plants. To describe subsurface properties 10x50 cm^2 mini-pits were excavated. Soils were described in terms of mini-pit characteristics and named in local and scientific names. Other descriptive parameters included: topsoil depth, surface (0–20 cm) and subsurface (30–50 cm) soil properties of colour, texture, structure, consistency, pore size and distribution, and root size and abundance. For each mini-pit soil samples were taken from surface and subsurface horizons for laboratory analysis. In cases where field types did not show clear soil differences one mini-pit was described to represent similar field types in terms of soils. Each field type was also designated an identity (ID) for purposes of database development (in progress).

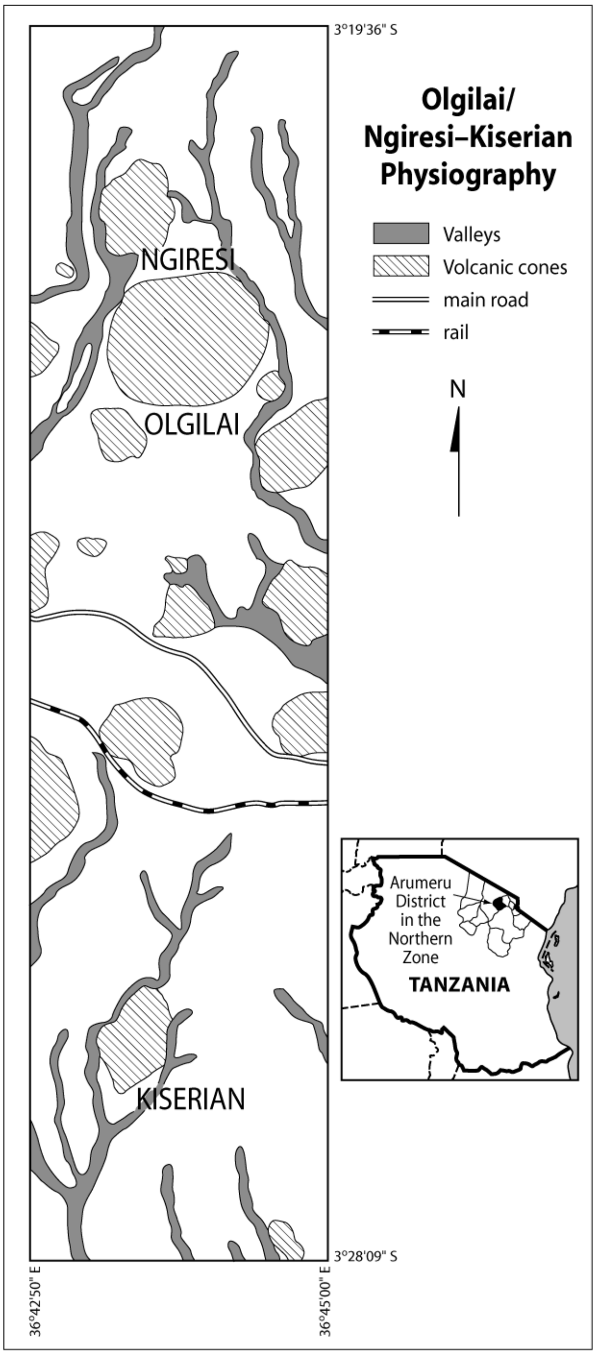

Figure 1

(based on a more detailed original by the authors)

field type, recording scientific, Kiswahili and local nomenclature, total number of varieties per field type, economic uses, characteristics of each variety, cropping systems and cropping systems strategies. Planting was characterized in terms of planting season and time, planting materials and methods, source of planting materials and existence or non-existence of volunteer crops in each field type. Tillage was assessed in terms of types of tillage and tillage tools. Livestock were described in terms of breed and nomenclature, source of the breed, purpose of the breed, feeding and housing systems. Crop management was characterized in terms of types of weeds and weed control, pests and their control, and crop storage. Soil management was addressed in terms of fertility management strategies, and erosion, drainage and moisture conservation systems.

Description of land-use stages and field types in the study area

There were five dominant land-use stages in Olgilai/Ngiresi and seven in Kiserian. For each land-use stage, field types were variable and ranged from one to four, and more in a few cases. There were nine field types on one farm in Ngiresi. These 'field types' may change frequently, especially in Olgilai/Ngiresi, where planting takes place three times a year. In Table 1 land-use stages and their corresponding field types are characterized.

General soils and fertility conditions

The soils of Arumeru are locally classified into four main types:

1. *Engulukoni narok-nagol*. Dark soils with a very well-developed surface and subsurface structure (correspond with Luvisols);

2. *Engulukoni narok-nanana*. Dark soils with weak fine and very fine structure, with many fine and medium pores and many very fine, fine and medium roots in both surface and subsurface (mainly correspond with Andosols);
3. *Engusero*. Deep black cracking clays (correspond with Vertisols);
4. *Engulukoni*. Very shallow dark brown soils.

There are also minor soils recognized locally. In scientific terms soil characterization was based on physiography and land use. There were 25 dominant soils. Fertility rating ranged from high in the high altitude, high rainfall site (Olgilai/Ngiresi), particularly in the planted forests and coffee/banana/maize/beans agroforestry systems, to low in the fallow and pasture plots in the semi-arid, low potential site (Kiserian). Based on visual assessment of the current crops in the respective land-use stages and field types, most crops/trees and shrubs indicated deficiency of N, P and K nutrients. Maize was remarkable for N and P deficiency while bananas were remarkable for K deficiency.[4]

Discussion of management diversity

Woodlots

Conservation of remnant natural forest patches is an important activity of some farmers, particularly elderly farmers. Different types of trees and shrubs are found in complex mixtures, each of which has a known economic value. Most remnant forest woodlots are found in ravine valleys and old or seasonal river valleys. Such woodlots are conserved as gene banks for traditional medicine, building poles, firewood, soil fertility improvement, and making of carvings. Understanding growth habits of each type of tree, farmers manage them differently. Trees least attacked by pests and diseases receive less attention than more vulnerable types. Other economic uses of the trees include: fruit production, dyeing materials, shade, wind breaks and drought insurance. Although in Kiserian there are communal woodlots that are less carefully managed, most woodlots are family properties, just as are crop fields. They are normally harvested once a year.

Pastures

Pastures constitute both land-use stages and field types according to the way they are used. *Mbuga*, typical in Kiserian, is mainly for grazing, where livestock graze in extended areas of natural pastures. In Olgilai/Ngiresi pastures are component cropping systems constituting field types in complex diverse cropping systems. They may be natural, or planted for tethering or cut and carry. Farmers without livestock may have pasture grass for sale. Pastures are also planted as fodder on physical conservation structures like contour bunds, for their strengthening. Such fodder is cut and sold, or given to livestock at home. Some grass is also used for roofing, and provision of surface cover through high biomass production properties. Most farmers mix grasses with legumes to improve nutritional quality and palatability, and to improve soil fertility through nitrogen fixation. Both woodlots and pastures are mainly found as complex mixtures of different species, either natural or planted.

Crops

Major crops include: maize, beans, banana, coffee, round potatoes and sweet potatoes. Most are grown as mixed crops, together with grass and vegetables. Table 2 illustrates some crops and crop varieties found from splits and cuttings obtained on-farm, and also from neighbours and friends. Farmers also buy seed and prepare their own nurseries. Individual shops are often reliable sources of agricultural seeds. Planted forests are the only field type for

4 A discussion of the soils characteristics of each of ten field types is excluded from this paper.

which seedlings are obtained from the forestry unit of the district or region. Others obtain their planting materials either from neighbours, friends, private shops or farmer organizations. Although farmers are encouraged by expert farmers to plant improved germplasm, it takes some time before a new seed is adopted. Local seeds are always planted because they are sure crops to harvest in case of bad weather.

Livestock

Arumeru is a cattle-keeping district, but while there are many cattle at Kiserian, there are relatively few in Olgilai/Ngiresi. Most Kiserian farmers keep the local breed, the Tanzania Shorthorn Zebu, and a few introduced breeds for crossbreeding. Visited households had from 40 to zero cattle. Major sources of improved breeds include Heifer Project International, while local breeds are either bought from local markets or inherited. Livestock production purposes include income generation through milk, meat and cattle sales, milk and meat production for home consumption, manure production and draft oxen, especially with local breeds. Other purposes include celebrations and prestige. Most of the local breeds (cattle, sheep and goats) are freely grazed while improved breeds are zero grazed. Local breeds are generally kept in open kraals while improved breeds are kept indoors. A few farmers keep their livestock in their own houses.

Cattle breeds found in Olgilai/Ngiresi include Friesian and Ayrshire and their crosses, together with the local Tanzania Shorthorn Zebu. Goats are dominantly of the local types with a few hybrids. Sheep are mainly local. The number ranged from five to zero. Most farmers buy cattle, sheep and goats from local markets. Some obtain them through dowry payments, while others inherit them from parents. Both NGOs and religious groups provide improved bulls for cross-breeding. As at Kiserian, livestock are kept for income generation, through meat, milk and animal sales; production of manure; prestige; and security as a banking system. Sheep are used for traditional sacrifices and prestige. Livestock at Olgilai/Ngiresi are either zero grazed, or more rarely tethered and grazed in small fenced plots. All are kept indoors in separate sheds or in a few cases kept in farmers own houses.

Tillage management

In this area of management there are major differences between the two communities. At cattle-rich Kiserian, with its larger farms, primary tillage of most annual crops e.g. maize, beans, cowpeas, pigeon peas and sweet potatoes is by ox-ploughing. This is normally preceded by spot application of manure, spread as oxen are drawn so that it gets incorporated together with crop residues. Weeds also are overturned at the same time. Secondary tillage is re-ploughing using the same tools but this time breaking the clods and making furrows for planting. In areas where the farms are along steep slopes, soil clods are left rough to reduce water erosion. Pre-application of farmyard manure is also done for vegetable farms. For grass planting (e.g. *Desmodium* and *Chloris gayana*), primary tillage clods are smoothed and a fine seedbed is made by hand hoes before seeds are broadcast and covered. For farmers without oxen, primary and secondary tillage is done by hand hoes, also used on small plots and on physical structures: but many farmers with oxen do not even possess a hand hoe.

Farms in Olgilai/Ngiresi are smaller and local cattle are few. Most farms have steep slopes. Ox-ploughing is almost non-existent. Primary tillage for most annual crops is done by forked hoes, and also includes incorporation of crop residues and weeds from the previous season. Secondary tillage is not normally done, as seed preparation is completed during primary tillage. Slashers are used on farmers' fields, mainly in Kiserian. In some farms more than five varieties of the same plant (e.g. bananas or beans) may be found.

Table 1 Description of land-use stages and field types at Olgilai/Ngiresi and Kiserian

Olgilai/Ngiresi

Land-use stage	Field types	Description	Area characteristics
1. Natural forest	FT1	Primary forest on the upper parts of the footslopes of Mount Meru. The area is inaccessible due to steepness, and is left to natural growth	Very steep with very deep incised valleys. Slopes range from 50–85%. Humid tropical climate with some wild animals (buffalo, gazelles, etc.); rainy for at least 8 out of 12 months a year. Area is gazetted for protection and is the least disturbed
	FT2	Secondary and slightly disturbed forest on the upper parts of the footslopes of Mount Meru. Minimum tree cutting and collection of firewood, root and tree barks and leaves for medicine at the homestead	Steep with deeply incised valleys. Slopes range from 15–35%. Humid tropical climate with some wild life (gazelles). Rains as above. Area gazetted but is slightly disturbed
	FT3	Secondary and highly disturbed forest mainly on volcanic cone tops	Cone shaped hilltops with greater disturbance, mainly due to intensive tree harvesting; in some cases used for recreation (picnic places). Area usually under controlled harvesting but due to close proximity to farms, all economic trees and shrubs have been removed
2. Planted forest	FT1	*Pinus* dominated forest with various crops. Forest trees cleared and commercial trees planted. After planting trees farmers are allocated land for crop production for 5 years or until it is no longer feasible to continue cropping (70% or more canopy cover). Crops include maize and beans in rotation with cabbages and round potatoes	Slightly steep to gentle hill slopes with slopes ranging from 15–20%. Farmers continue using the ground until full tree canopy development (Taungya system). *Pinus* forest later harvested
	FT2	*Cupressus* dominated forest admixed with maize, beans in rotation with other crops e.g. cabbage and potatoes	As above
	FT3	*Eucalyptus* planted in isolation	As above
3. Agroforestry	FT1	A complex admixture of crops in different combinations. These crop combinations also differ between the three seasons of the year. Only perennial crops remain unchanged across seasons. The system is characterized by 3 planting seasons where different crop combinations are planted	As above
	FT2	Coffee/banana/tree cropping based system with maize and beans planted in rotation with taro, yams, etc.	Depending on the market situation and relative importance of the intercrops, one of the two has a higher plant stand than the other
	FT3	Maize and beans planted as intercrops where trees constitute part of contour hedges	
	FT4	Fields planted with commercial round potatoes in rotation with cabbage and fallow during one year	

Table 1 continued

Land-use stage	**Field types**	**Description**	**Area characteristics**
	FT5	Maize planted as monocrop	
	FT6	Round potatoes only	
	FT7	Boundary fences with trees, shrubs and climbers	Partitioning structures between neighbouring farms. Diverse trees shrubs and climbers are planted. Characteristic is the presence of thorny plants to restrict trespassing
	FT8	Plot partitioning fences	Structure separating field types in one farm. They are less vegetative and range from crop residue and weed piles along boundaries to creepers and shrubs of economic value. These boundaries may be destroyed and spread for fertilizer improvement when field types are changed
	FT9	House gardens	Vegetable production field types in farms of expert vegetable producers. Common vegetables include cabbage, onions, tomatoes, spinach, amaranthus, egg plants
4. Water source micro-catchments		-	Delineated patches of land of less than 30 m^2 protecting water sources at seepage points. In the catchment perennial trees and bananas are planted. No harvesting is allowed. Entry is limited to fetching water
5. Fallows	FT1	Areas left for regeneration	Communal or individual plots for those with more land who leave areas uncultivated for fertility recovery
	FT2	Pastures and recreation	Parts of household land left in fallow but also used as recreation places by family and neighbours. Animals like goats may also graze in these fields
	FT3	Tethering/cut and carry plots	Plots allocated with certain types of pastures. Cows are tethered for grazing or grass is cut and brought to animals under zero grazing

Kiserian

Land-use stage	**Field types**	**Description**	**Area characteristics**
1. *Mbuga*	FT1	Overgrazed land with deep gullies	In lowlands and valley bottoms of Kiserian villages. Cattle are often freely grazed. The soils are deep and widely cracking when dry and very sticky and plastic when wet. Due to gullies free grazing is now shifting to distant places
	FT2	Averagely grazed land	In toe slopes and valley bottom of Kiserian villages where gullies have not developed but there are clear signs of sheet and rill erosion with pockets of depositional materials in the lower slopes of the area
2. Fallows	FT1	Neglected fallows	Patches of land owned by farmers from the high and middle altitude areas. They are cultivated seasonally, but both grain and straw are transported to the homesteads after harvest. Due to poor management these areas are declining in productivity with rapid reduction in surface cover

Table 1 continued

Land-use stage	Field types	Description	Area characteristics
	FT2	Slaughter areas	Plots separated for cattle slaughtering by farmers with big land areas. They are semi-permanent
	FT3	Grave yards	Land separated by farmers with big areas for burial of clan members and other relatives. Similar separations of land are made by villages as communal burial centres. This stage of land use lasts only a short time in communal grounds and longer for clan grounds
	FT4	Toilet areas	Typical plots for rich farmers with a lot of land, but with a culture of not constructing toilets. An area ranging from 0.5–1 ha and normally bushy is set aside for toilet purposes. The head of the family visits a specified area while others go elsewhere in the same plot. This may later be changed to other uses e.g. grazing of young or sick heifers
3. Mixed cropping	FT1	Maize + beans intercrops	Typical cropping system for most farmers in the semi-arid zone. In most cases the beans plant stand is higher than that of maize
	FT2	Maize + beans + trees	As above but with trees interplanted or as border trees on the contour or on edges that separate plots of the same cropping system
	FT3	Trees + pigeon peas	Beans in FT2 replaced with pigeon peas
	FT4	Chickpeas	Post harvest crop, planted to make use of residual moisture in vertisols (clay soils)
	FT5	Maize monocrop	Cropping system mostly typical for poor resource category farmers
4. Agroforestry	FT1	Mango based hedges	Combination of mango trees with other trees and shrubs that constitute the farm boundary of the agroforestry complex in the semi-arid zone
	FT2	House gardening	A combination of traditional and introduced vegetables
	FT3	Fallow	Separated part of the farmland for tethering of a few animals possessed by the farmer
	FT4	Maize, beans, bananas, medicinal plant complex	Both common crops and also endangered species collected and planted in the farm for various purposes including their conservation
	FT5	Hedges/fences	Used as boundaries between farms separating field types and used as cattle tracks and sometimes indirectly acting as cut-off drains
5. Woodlots		Both *in situ* conserved traditional forest trees and those introduced from elsewhere and planted for economic/social purposes	Characteristic in stream beds and valleys. Farmers on their own protect and increase the diversity in these woodlots by inclusion of other species either endangered, extinct or newly introduced for various purposes
6. Stone dominated hilltops		Portions of land being used for grazing that have degraded to leave stones exposed and most soil removed by erosion	Commonly found on hill tops with traces of shrubs and scattered grass patches. Most of the topsoil has been removed leaving mostly gravel or ironstone on surface. Depending on the extent of degradation they are either left as fallow or grazing
7. Land used for quarrying		Completely degraded pieces of land	More than 80% of land being rock outcrops and greatly used to make stone bricks from such mouldable stones. Quarries are the last land-use stage in the study area where both livestock keeping and agriculture are no longer possible and topography limits other uses

Planting time, methods and materials

At Kiserian, maize is usually planted just before the beginning of the rainy season, which starts between 15 February and early March. Beans are planted at the same time with maize, although a few farmers plant beans after maize germination. During the middle of the season sweet potato cuttings are planted, mainly on outlying fields; this late planting is to avoid tuber rot caused by heavy rains. Other crops include onions, amaranthus (local) as vegetables, and sisal planted from its bulbils as boundary vegetation.

Maize is sown in rows and intercropped with beans, the latter being generally two or three times more numerous than maize rows. This is because beans stand a greater chance of survival in case of inadequate rains, and fetch a much higher price at local and commercial markets. In some farms pigeon peas and/or cowpeas are broadcast before maize and beans are planted in rows. Seeds of local varieties are obtained from farmers' previous crops, while improved seeds are obtained from commercial farmers, and the Agricultural Research Institute. Vegetable seedlings are obtained by first preparing nurseries after buying seed from farmers' association shops, retail shops and agricultural institutions. Wild amaranth is propagated by seedlings from farmers' own farms. Other materials obtained from farmers' own farms include fodder, sweet potatoes and sisal.

There are very many crops and crop combinations in the high altitude, high rainfall site of Olgilai/Ngiresi. The long rains start in April. During this season, crops grown include round potatoes, tomatoes, coffee, fodder (both grass and trees). Selected forest trees are also planted. The crops that are planted during the short rains that start in July/August include maize, bananas, sugarcane, beans and sweet potatoes. The crops that are planted during both seasons include vegetables (e.g. cabbage) and fodder. Planting is done throughout the year for boundary trees and shrubs, and also yams.

Most vegetables are planted using seedlings raised in their own or commercial nurseries. Several farmers buy seed for nursery preparation. Round potato growers use tubers from the previous crop or bought from local markets. Coffee and bananas are planted from seedlings and suckers respectively, obtained from own nurseries or farms. Other sources of coffee seedlings are commercial nurseries. Fodder is planted and forked hoes are the tools used in preparing land for pasture and fodder production. For round potatoes, tomatoes, amaranthus and the like, forked hoes or hand hoes are used. In planted forests, machetes and axes clear bushes while hand hoes are used for primary cultivation. Similarly slashers and forked hoes or hand hoes are used in management of coffee/banana farms, where use of mulching systems avoids the need for frequent tillage except at planting.

Soil fertility and water management

There are both traditional soil management practices and others which incorporate modern changes, chemical, physical, biological, and biophysical. At Kiserian, physical structures are few and are mostly reinforced with trees and or grass materials. They include: contour ridges in maize/beans cropping systems for soil erosion control; deep trenches of 0.2 m deep x 0.7 m wide covering 100 m for soil moisture conservation in natural pastures, and shift grazing in improved and fenced pastures. Stone-lines are used to control soil erosion in woodlots and maize fields, and deep tillage is used for soil moisture conservation in maize/bean cropping systems. In *mbuga* pastures, prohibition of cultivation and burning are important for erosion control.

At Olgilai/Ngiresi (Table 3) there is a similar mixture of methods, but there is more use of chemical fertilizers by better-off farmers,

Table 2 Crop types in Arumeru

Crop varieties	Economic uses	Plant characteristics
***Zea mays* (Maize)**		
Kienyeji	Food, income, crop residues fed to animals	Not very sweet, tolerant to storage pests, good milling quality, low yielding, drought susceptible
Katumani	Food, income, crop residues fed to animals	Drought tolerant, early maturing, low yielding, good milling quality, tolerant to storage pests
CG4141 (Lowlands)	Food, income, crop residues fed to animals	Good milling quality, drought tolerant
UCA (Highlands)	Food, income, crop residues fed to animals	Good milling quality, drought tolerant
Kilima	Food, income, crop residues fed to animals	High yielding, susceptible to storage pests, good milling quality, high water demand, high quality flour
***Phaseolus spp* (Beans)**		
Soya kijivu	Food, income, crop residues fed to animals	'No gases after eating', early maturing, good taste, climbing type, sweet, high price, grey
Kachina	Food, income, crop residues fed to animals	High market price, early maturing, spoils quickly after cooking
Lovirondo	Food, crop residues fed to animals	Climbing type, 'causes bloating and gases after eating', laborious to harvest, low market price
Bwanashamba	Food, crop residues fed to animals	Most popular in Kiserian, high yielding, good taste, susceptible to diseases and aphids
Masai red ndogo (*namira*)	Food, crop residues fed to animals	High yielding, good tasting, 'no gases after eating', needs wide spacing for high production
Karanga	Food, crop residues fed to animals	High yielding, good tasting when cooked (flavours food)
Masai-red kubwa (*namriri*)	Food, crop residues fed to animals	High market price, bush type, early maturing, good tasting and flavours food, susceptible to diseases
Lyamungu 90	Food and income	Good tasting and flavours food, early maturing, drought tolerant, high yielding, high market price
Kiburu	Food, crop residues fed to animals	Drought tolerant, grows well on soils with poor fertility
Engichumba	Food and income	Very high yielding, violet bean
Engichumba-ng'iro	**Loshoro* (traditional food)	High yielding, sweet, grey bean
Engichumba-narok	Food and income	Similar to *Engichumba-ng'iro*, black bean
Moshi	Food and income	Very high yielding, sweetest, yellow bean
Kibumulu	Food and income	Fast cooking, high price, dark red bean
***Musa spp* (Bananas)**		
Kisimiti	Income, brewing, animal feed (stem)	Early maturing, drought tolerant, good milling quality
Ng'ombe	**Loshoro*, brewing, income, roofing, fodder to animals	Hard when cooked
Mshale	***Matendela* (traditional food), income	Good for roasting, long and thick banana fingers
Uganda fupi	Banana soup (*mtori*), fruit, income, peels fed to animals	Early maturing, small with mainly fingers, susceptible to pests and diseases
Uganda ndefu	Banana soup, fruit, peels fed to animals	Large with few fingers, susceptible to pests and diseases
Kisukari	Fruit, income, animal feed (stems)	Very sweet, drought and disease tolerant, low nutrient demand
Mzuzu	Roasting for tea	Tolerant to drought and disease

Table 2 continued

Crop varieties	Economic uses	Plant characteristics
Malindi	Food (*Matendela*), animal feed	Drought tolerant
Mnanambu	Soup, roasting	Shade
Mkonosi	Roasting	Disease tolerant
Mkono wa tembo	Roasting	Disease tolerant
Ndishi	*Loshoro*, income	Susceptible to diseases
Olmuririko	*Loshoro*, brewing	Modest tolerance to diseases

* *Loshoro*: traditional Waarusha/Wameru/Wamasai food made of a cocktail of maize, beans and milk

***Matendela*: traditional Waarusha/Wameru food made of a cocktail of vegetables, milk, banana and beans

especially for round potatoes,cabbage, maize and beans, sugarcane, and bananas. Physical structures are not common, but they include fences and raised beds along boundaries for soil erosion control; *fanya juu* (thrown-up terraces) for maize and sweet potatoes; cut-off ditches in pasture and maize/beans plots. Ditches combine the purposes of erosion and drainage control. *Fanya chini* (narrow, cut-down terraces) are usually 0.3–0.6 m deep and l m wide, with lengths that vary greatly depending on field size.

There are also irrigation channels, using forest catchment stream water, for irrigation of round potatoes, maize and beans, and house-garden vegetables in some farms. The irrigation channel at Ngiresi is mainly used for household water supply, with only some watering of commercially-grown horticultural crops, but irrigation is used for all kinds of crops at Kiserian (Murnaghan 1999). In the larger Nduruma basin to the east is an elaborate management system with committees for each furrow, careful and well monitored regulation of supply, and penalties for infringement of quite precise bye-laws. There is also careful local regulation at Kiserian and Olgilai/Ngiresi. Water Use Associations manage use of the indispensable water resources, especially through the dry season.

Sunken beds around coffee trees have dual purposes. They collect surface litter for soil fertility improvement; and provide *in-situ* moisture conservation and soil erosion control by reducing surface runoff. In the sunken beds manure and/or compost are quite heavily applied. Crop remains are used by direct application in the field or to feed live-stock. In most cases trashlines are made along the slopes and sometimes on contour ridges. The manure that is produced on tethering pastures is also collected and applied in fields. The remaining part is directly used to fertilize the fallow. In the coffee/banana/maize/beans fields, weeds are collected together and left to decompose before incorporation. Materials difficult to decompose are mulched under the coffee/banana/trees complex.

There are local regulations in both communities for protection of forests and woodlots. In forests, they include prohibition of free cutting of trees, cultivation in conserved forests, fire burning and collecting firewood. For planted forests, firebreaks of bare land are also made. The *Pinus* planted forest in Ngiresi was protected by fire breaks 6.5 m wide and more than 1 km long.

Weed and pest control

Occurrence of different types of weeds depends on landform, soil type and management regime. Different weed populations characterize the two sites. At Kiserian, weeding is done at least twice during the growing season, using forked

Table 3 Some of the major management practices for soil fertility improvement, erosion and drainage control in Olgilai/Ngiresi

Soil fertility management		
Cropping system	**Traditional method**	**Modern biological and biophysical methods**
Irish potato, cabbage, maize, sweet potato	Incorporation of crop residues, application of farmyard manure, trash lines, ashing	Decomposition of *Grevillea* leaves
Coffee/banana/maize/beans rotation with Irish potatoes	Farmyard manure (FYM) application, incorporation of crop residues, house refuse, and weeds, application of ashes	Planting of *Grevillea, Sesbania sesban*; some composting
Maize/beans	Incorporation of *Grevillea* biomass and crop residues, green manuring, trash lines, FYM	Planting of *Grevillea*
Pastures	Weed incorporation, use of trash lines, *in situ* decomposition of pasture biomass	
Boundary	Deposition of trash in lines, decomposition of biomass	Planting *Grevillea, Caliandra*
Irish potato rotated with maize/beans	FYM application, incorporation of crop residues	Planting of *Sesbania sesban*
Vegetables	FYM application, crop residues, ashes	-
Micro-catchment	Natural regeneration. Incorporation of crop residues	-
Primary forest, slightly disturbed forest and heavily disturbed forest	Decomposition of biomass from trees	Maintenance of N_2 fixing trees. Soil fertility improvement trees (natural); green manuring, planting *Sesbania* and *Leucaena*
Planted forests	Dry pine litter, planting pines. Green manuring, trash lines, decomposition of biomass	-
Coffee/banana/maize/beans/fruit trees	Application of FYM and crop residues	-
Fallows	Decomposition of tree litter especially *grevillea*, grass residues, FYM	
Irish potatoes/maize/cocoyam	FYM; trash lines	-
Fodder grass/fodder trees/banana/maize/sweet potatoes	*In situ* decomposition of surface litter from crop and grass residues	Decomposition of *Grevillea* leaves, planting of *Sesbania sesban*, jacaranda, *mruka* and *Oloiyabyab*
Maize/beans/cocoyam and leucaena	Incoporation of crop weeds, trash lines, FYM application	-
Coffee/banana	FYM application	Application of *Sesbania sesban* leaves
Soil erosion control		
Irish potato, cabbage, maize, sweet potatoes	Incorporation of crop residues, trash lines, application of ashes	Fodder grass. Trash lines on terraces plus natural vegetation. Contour ridging (*fanya chini*), with elephant grass or sugarcane, *fanya juu* with fodder grass or cypress or banana trees; *fanya chini* with *S. sesban* and Elephant grass, *mandela*

Table 3 continued

Soil erosion control		
Cropping system	**Traditional method**	**Modern biological and biophysical methods**
Coffee/banana/maize/beans/rotation with Irish potatoes/trees	Rain interception by coffee/banana canopy	Flower hedges, coffee/banana canopy interception; planting of *Sesbania sesban*. Contour ridges (*fanya chini*) with elephant grass; *Sesbania*
Maize/beans	Trash lines	Contour ridges (*fanya chini*) with elephant grass; *fanya chini* with *Leucaena, Sesbania, Grevillea* or *Seteria*.
Pastures	Trash lines	Planting sugarcane/Elephant grass/*Desmodium (osangari*) and other fodder; *fanya chini* with elephant grass or cypress trees or *Sesbania*
Boundary		Line thorny fence; line fence of *Grevillea, Calliandra* and *mandela*
Irish potatoes rotation maize/beans		*Seteria* line fencing; *fanya chini* with *Seteria*
Vegetables		Live fencing of *Seteria*; line fencing with *mchongoma*; *fanya chini* with *Seteria*
Micro-catchment		Trees, grass and shrubs regeneration
Primary, slightly disturbed and heavily disturbed forest	Permanent surface cover and forest canopy interception	-
Planted forests	Permanent surface cover and forest canopy interception; trash lines	
Coffee/bananas/maize/beans/fruit trees	Biomass decomposition; trash lines, mulching, incorporation of crop residues	Coffee/tree/banana canopy interception; planting *Seteria* as boundary
Fallows		Permanent grass cover of star grass; live fence of *mchongoma*
Round potatoes/maize/cocoyam	Trash lines	*fanya chini* and fodder trees
Fodder grass/trees/banana/ maize/sweet potatoes		Fodder grass, shrubs and sweet potatoes
Maize/beans/cocoyam/lucaena/banana	Trash lines	*Leucaena/*banana canopy cover; *fanya chini* with *Chloris gayana*; *fanya juu* with elephant grass
Coffee/banana		Live fence, *Sesbania*; *fanya juu* with elephant grass
Soil moisture management		
Irish potato, cabbage/ maize/ sweet potato	Trash lines, *in situ* surface cover from stovers	Sweet potato cover
Coffee/ bananas/beans/trees, with Irish potato as relay crop	Incorporation of crop residues, mulching, trash lines	Trash lines, *in situ* surface cover from stovers
Maize/ beans	Self mulching, incorporation of crop residues, trash lines	
Pastures	Trash lines, decomposition of litter	Grass cover from pastures, planting of *Sesbania*

Table 3 continued

Soil fertility management		
Cropping system	**Traditional method**	**Modern biological and biophysical methods**
Boundary		Live fences of *Grevillea, mandela*
Cabbage/ Irish potato	Trash lines	
Micro-catchment		Shade from traditional trees; *Orngaboli,* natural vegetation regeneration or surface cover
Primary forest, slightly disturbed and highly disturbed forest	Biomass accumulation.	Shade from forest canopy
Planted forests	Trash lines, biomass accumulation	
Coffee/ banana/ maize/ beans/ fruit trees	Mulching, incorporating crop residues	Coffee/banana canopy cover
Fallows	Decomposition of crop residues	Grass cover
Irish potatoes/ maize/ cocoyams	Trash lines	
Fodder grass/fodder trees/ banana/ maize/ sweet potatoes		Sweet potato cover, canopy from shrubs and decomposition of grass litter
Maize/ beans/ cocoyam and lucaena	Trash lines	Coffee/banana canopy
Coffee/ banana	Canopy cover, mulching of litter weeds	*Sesbania*

hoes. Other practices include slashing or uprooting manually, the latter being the commonest method in both areas. Some weeds like couch grass can be burnt after weeding, and some can be fed to livestock. In maize/beans farms, pests include armyworms, bollworms, pod bores and caterpillars. Chemical spraying is common, but a wide variety of other methods is used, including applications of cattle dung and urine, and ashes. Early planting is also useful in the control of some pests. There is great diversity between farmers in pest management. Pesticides are mainly used to control pest attacks, not for prevention. There is no evidence of serious pest attacks in pastures. Some farmers keep cats or use rat poison to reduce rats in fields. Grasshoppers are seasonal pests that are reduced by hand picking. Weevils are common in sweet potatoes and are commonly managed by changing planting materials.

Storage of maize, coffee and beans is important. Most other crops are quickly marketed. Bagged maize is now usually treated with a chemical, but airtight jars and external structures of traditional type are also used. Seed material is dried and then either hung above the cooking place or spread in the shade.[5]

There is great variation between individual farmers, and some experts have developed elaborate systems of crop and land management. These variations, of particular interest to PLEC, are described by Kaihura, Stocking and Murnaghan in a paper that was presented at the Global Biodiversity Forum in Nairobi in May 2000, and will be published elsewhere.

5 This discussion of weeds and pests is greatly abbreviated from the original. A discussion of disease control, among both crops and livestock, is not reproduced in this paper.

Management of bought, borrowed and rented support farms

Because of land scarcity most farmers in Arumeru have additional, distant, support farms away from home. The farms may be as near as 1 km away, but some are as far as 100 km away. Because of big herds of cattle for milk and manure production in Kiserian, several farmers keep at home only improved breeds, and local oxen for ploughing, and send the rest of the local free-grazing animals away to distant places, sometimes in a different district. Discussions with farmers indicated that most farmers grow maize and beans in support farms. Crop residues from rented and/or borrowed farms are transported home to feed livestock or sold to farmers in need. Only on personal plots obtained through purchase are some residues left to be incorporated in the soil for fertility and moisture improvement.

The same practice is common also for Olgilai/Ngiresi. Most farmers have plots in the regulated taungya systems where pines, cypress and eucalyptus trees are planted together with various crop combinations, for five years. Others have additional farms outside the taungya system. In all cases, fertility is supported by *in situ* decomposition of forest litter. While the reporters did not inspect many of the outlying sites, it seems improbable that agriculture on them is sustainable.

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Ugandan farmer demonstrates medicinal plants

HOUSEHOLD LEVEL AGRO-BIODIVERSITY ASSESSMENT (HH-ABA)

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Introduction

China is one of the richest countries in biological diversity in the world. Scientific estimates have registered 32500 species of vascular plants, 800 species of freshwater fish, 226 species of amphibians, 313 species of reptiles, 2286 species of birds, and 372 species of mammals in China (Zhang and Wu 1996). China is also recognized as a centre of origin of numerous cultivated crops including rice (O*ryza sp.*), peach (*Prunus persica*), soy bean (*Glycine max*), tea (*Camellia sinensis*), lychee (*Litchi chinensis*), kiwi (*Actinidia chinensis*), Chinese water chestnut (*Eleocharis tuberosa*), sweet orange (*Citris sinensis*), and many other species important to agriculture (Wang and Yang 1995).

Within this country of enormous variety Yunnan stands out as the most diverse of all of China's provinces and is one of the world's biodiversity 'hot spots' for conservation priorities (Myers et al. 2000). In the tropical regions of Yunnan it is estimated that there are 120 species of wild or semi-domesticated relatives of cultivated crops. Studies in the Xishuangbanna Dai Autonomous region in southern Yunnan have revealed over 1000 species of plants with high economic potential (Wang and Yang 1995). Astonishingly, Xishuangbanna covers just 0.2 per cent of China's land area, but contains 25 per cent of the country's plant species (Xu et al. 1999). Yunnan's vast richness of genetic resources, both agrobiological and biological, makes its conservation a matter of global importance. Furthermore, the preservation of Yunnan's agricultural biodiversity is not merely important for the conservation of local livelihoods and land-use systems, but on a global scale, it is essential to food and economic security.

A history of diversity

The astounding richness of wild biodiversity, semi-cultivated plants, semi-domesticated animals, peculiar agroecosystems, and local varieties can be linked to Yunnan's unique geographical and cultural history. Yunnan's numerous minority groups, each with a distinctive tradition of resource management, are the originators, transformers, and conservators of much of Yunnan's biological richness. There are currently 27 distinctive ethnicities in Yunnan, all of which employ unique techniques to manipulate the countless ecosystems located in Yunnan. For example, the Tibetan minority maximize the limited resources of the magnificent snowcapped mountains in the northwest of the province, while the Hani minority practise swidden fallow agriculture in the tropical southeastern region. Yunnan owes its wealth of ecosystems to its position at the junction of three geological plates and six floristic regions.

While the geographical and cultural histories of Yunnan province have clearly fostered its diversity, the political turmoil of the past century has been a major factor in the reduction of biological diversity. Following Liberation, one of the early socialist policies implemented in rural China was the equitable distribution of land among the peasants in 1949. By the late 1950's the national government adopted more radical land and resource policies, which shifted the control of agricultural decision-making from the household level to an administrative community level. The crucial connection between household decision-making and the maintenance of agrodiversity was endangered. Variation in agricultural land use practices from one household to another, which supports the agricultural innovation that sustains agrodiversity, was jeopardized by policies that promoted uniformity. Control of land tenure and decision-making changed to a top-down approach with regional administrators determining land uses. The result was not only a loss of agrodiversity, but a drastic decrease in efficiency of agricultural production.

In response to the sharp declines in output, the government of China enacted the Household Responsibility System in the late 1970s. The policy restored the household as the basic unit of production and gave farmers an incentive to increase efficiency. The land still remained the property of the state, but a contract gave the farmers the right to profit from yields above a specified quota. Though the contract stipulated the crops the farmer must provide for the state, the farmer made the decisions regarding the maintenance and intensity of management. From the agrodiversity standpoint, considerable variation in farming practices among households soon developed. In time the rules became increasingly lenient as the efficiency of household level decision-making became more and more apparent.

Today, while the influences of past and present policies that threaten agrodiversity are observable, a great variety of land-use systems, technologies, crops, and many other factors related to agriculture, which were strictly controlled by the state in the recent past, are now again evident. Communal labor in agriculture has long existed in China, especially among the minority groups of Yunnan. The changes resulting from the strict collectivization laws of the sixties and seventies radically changed traditional community production patterns, and, as mentioned above, decision-making was transferred to multi-village level administrators. The recent return of household decision-making through the Household Responsibility System creates a unique opportunity to observe how households, previously constrained by uniform production system policies, diverge in new directions, inventing management schemes that both incorporate pre-socialist (traditional) ideas and address the current ecological and socio-economic environment.

Household level assessment

Yunnan's rich history and diversity have drawn the attention of numerous studies by government and non-government research institutes that have contributed toward the conservation of both biodiversity and agro-biodiversity. Though these studies have made promising advances, the biodiversity of the province, and especially its agro-biodiversity, continue to erode at alarming rates. PLEC, as one of the global leaders in agro-biodiversity conservation, has made the agrodiversity of Yunnan a conservation priority. Previous research and activities carried out by PLEC in this region include invaluable agro-biodiversity (ABA) landscape level assessments (for a detailed discussion of ABA see Guo, Dao and Brookfield 1996; Guo et al. 1998). The results of these surveys have provided new and innovative findings that can be of use in the formulation of local and global conservation strategies. This article attempts to expand and build upon the knowledge acquired from ABA activities, and to further PLEC's progressive insights into the field of agrodiversity conservation by presenting a new assessment method called **HH-ABA** (household level agro-biodiversity assessment). This phase of agrodiversity assessment in Yunnan will focus upon the household, the true and traditional locus of creation and conservation of agrodiversity, and promises to look deeper into the processes that threaten or conserve agrodiversity.

The previous ABA landscape level analysis studied the diversity within agricultural landscapes on the community level. There was a major effort from the people who maintain and profit from the management of plant diversity, to involve the local people in the assessment and documentation of the usage and evaluation of plants. The ABA also attempted to document the complex land tenure systems that were enforced in the sample areas. The abundance of existing state-level land tenure policies, which interact with and sometimes conflict with strong traditional regulations, create a variable and complex land tenure system that resists documentation and clear understanding by those from outside the community.

Observation of agrodiversity at the household level during this pivotal era in Chinese agriculture is a rare opportunity to study the processes that lead to variation in farming practices, and to enhance agrodiversity throughout Yunnan as well as the rest of the country. The incremental divergence of farming activities from the conformity of the past exposes the small changes that gradually lead to agrodiversity on a unique temporal scale. It is extremely rare to find such a transparent view of both the factors promoting agrodiversity and the rate at which households become increasingly distinct. Household level analysis is clearly one of the most useful tools for capturing the dynamics of these changes.

There are **five primary goals** of the HH-ABA that the PLEC China Cluster has embarked upon: **(i)** to promote agricultural systems rich in diversity by documenting and conserving the plant genetic resources, technologies, and knowledge associated with such systems; **(ii)** to explore connections between biodiversity conservation and economic development; **(iii)** to document ***particularly productive and conservationist*** agricultural technologies and management techniques developed by local households; **(iv)** to select the finest and most innovative farmers for demonstration activities; **(v)** to observe and promote the exchange of experiences and innovations among households.

A central objective of the PLEC programme is to identify and work with the innovative and productive farmers in the community, particularly those who employ biodiversity to solve problems of production, land management, and pest control. By working on the household level PLEC-China researchers gain a better understanding of variation in individual household activities, enabling them to identify the exceptional farmers in the community and work with them in setting up and carrying out demonstration activities.

An example from Tao Yuan

The story of an expert forester from the Baihualing valley in western Yunnan provides an excellent example of the type of individual PLEC seeks and HH-ABA reveals.

Since 1982 government extension workers have promoted the planting of *Cunninghamia lanceolata*, introduced from elsewhere in southwestern China, into this valley. The government's purpose in this promotion is to encourage afforestation and increase timber resources. The tree must grow approximately 15 years before it can be sold as a middle-value construction timber.

Today, on the steep slopes of the valley, patches of this species are found adjacent to some of the most intensive cropping systems in the world. The maintenance of these complex and elaborate agricultural systems in the valley requires the harmonization of carefully constructed micro-environments for the production of a tremendous diversity of crops including, but certainly not limited to, maize, rice, coffee, sugar cane, pumpkin, squash and passionfruit. The spirit of innovation and experimentation that created these remarkable and unique systems has also affected this imported prescription for timber production. In such cases, HH-ABA's focus on the household provides an opportunity to increase understanding of the processes that facilitate agrodiversity and locate the individuals responsible for it. The birth of variation takes place not on the community level, but on the individual or household level where an innovative smallholder combines an introduced idea with local knowledge in his/her living laboratory and, after experimentation, adds a new technology to the intricate web of land uses in the valley.

Community level analysis of the village of Tao Yuan may have overlooked the importance of two species in the land-holdings of Li Da-yi. After interviewing the farmer and visiting his most prized landholdings the significance of this deviation from the proposed monoculture becomes apparent. Along with *C. lanceolata*, two other species are dominant in his forest, *Phoebe puwenensis* and *Toona ciliata*. By adding these two timber species Li Da-yi has increased the value and diversity of his forest. He has also staggered the harvesting time of his timber, which can encourage regeneration, increase production, and stabilize his yearly earnings.

He collects the seeds of *P. puwenensis* from a nearby nature reserve in Gaoligong Mountain. Through the processes of experimentation he has learned to dry the seeds and plant them in a semi-shaded area beside a stream close to his house, where he is able to provide a constant supply of water. The seedlings are transplanted into the forest after one or two years. He has had tremendous success and now rents land from his neighbors and manages a total of three hectares of forest. Besides transplanting the seedlings to his own land, Li Da-yi sells seedlings to other households in the valley. He is able to do so because *P. puwenensis* is a valuable timber species that until now was only grown in small numbers around the house or extracted from an area that is now a nature reserve. This and other stories of individuals profiting from experimentation and diversification is an important part of PLEC and one of the main outputs of HH-ABA.

Variation within communities

Another benefit of household level analysis is that it offers the opportunity to compare the techniques and technologies employed by the farmers within a community. Community level analysis must average the variation within a community to come up with a single set of observations that purports to represent an entire community. While these observations are important to agrodiversity analysis, they average out the extremes and obscure the variation. It is most often in the extremes that one finds the more interesting and revealing discoveries. Examining unusual farming practices will not only help to locate the innovative farmers, but offers other insights as well. For instance, such observations may help to point out directions in which agricultural systems might develop in the future.

Agro-biodiversity research done by the PLEC China Cluster over the past several years investigated and analysed agro-diversity in selected villages. The next phase of research will use these findings as a building block. Household level analysis fits well into the PLEC programme because it integrates the concerns of the biological and social sciences. Of course, such interdisciplinary approaches also pose problems. PLEC-BAG was assembled to address some of these problems and created sampling techniques for the landscape level analysis that borrowed methods from both the ecological and social sciences. Some adjustments must now be made for the implementation of HH-ABA, which will further integrate these two areas of research. For instance, ecological approaches to plot size and selection must incorporate what is known of the current and rapidly-changing social reality of land-holding in Yunnan villages. The differences in the plot sizes of the many land-use stages found within a single community in PLEC-China's sites may lead to loss of pertinent information or confusion if a BAG-type survey, uninformed by household-level research, is performed. We further address this and other technical issues below.

The stages of household agro-biodiversity assessment have been carefully planned to incorporate the best insights of the social and ecological sciences to achieve the five gaols of HH-ABA. The process begins with the selection of sampling methods. We have considered four different approaches to the sampling of households in a community. First, an attempt could be made to sample every household in the village. This type of sampling is both time and capital consuming and limits the depth of information that can be collected. Another method is to select only the 'important households'. This can be done by speaking with members of the community and asking them to identify the unique or innovative households in the community. This technique is valuable in achieving some of the goals of HH-ABA, but it also has some shortcomings. For instance, unique and strange systems are often the most intriguing in the community; however, a sampling of purely unorthodox management practices cannot be extrapolated for the whole community. Also, this type of sampling can miss 'hidden' or undervalued details that are an important part of the PLEC initiative. Perhaps the opposite of this method attempts to locate and sample the typical plots in the community. This method is a quick way to gain a basic idea about the major land-use systems in a village, but it obviously does not meet the needs of HH-ABA because it avoids the exceptions. Finally, random sampling can be used. Predetermined percentages of households within a village can be sampled and then compared and contrasted. This type of analysis is popular in ecological and sociological sampling and is a good way to get an idea of the situation in the village as a whole. Still, this falls sort of the goals of HH-ABA because it is possible that the 'best' or 'worst' household may be skipped.

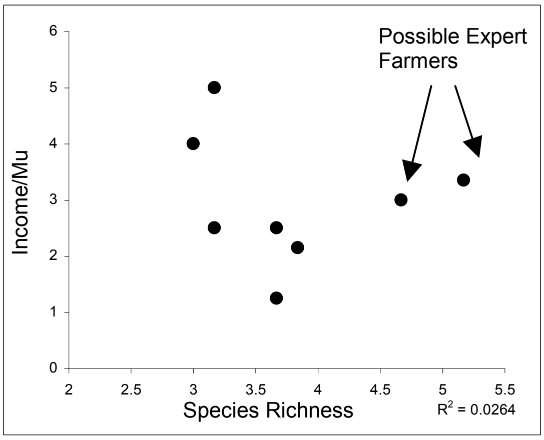
After careful consideration of the benefits and drawbacks of each option, those employing HH-ABA have chosen to adopt more than one sampling method to ensure that all the goals of HH-ABA are effectively and efficiently met. Some households will be selected randomly. Others will be selected by talking to a village leader or specialist. HH-ABA will also use preference ranking through short questionnaires. Finally, households will be selected through direct observation by researchers. By using aspects of all these four techniques in combination HH-ABA can achieve all five aims of the assessment.

HH-ABA is more than counting species

Researchers, government officials and village residents all play important roles in the assessments. Local government officials can be helpful in filling gaps in data or obtaining information that is not available to villagers. Also, the involvement of government officials, particularly policy makers, is an important tool for promoting agrodiversity-friendly policies. The purpose of the HH-ABA research group is not limited to the recording and analysis of data, but it also provides an important link between the village households, government officials, and extension agents in the promotion of both agricultural and forestry development as well as conservation. The benefits of continuous discourse among households, researchers, and government functionaries are crucial for the success of HH-ABA and of the PLEC initiative as a whole.

Household sampling techniques can be divided into socio-economic and agro-biodiversity assessments. Socio-economic assessment can be and in the PLEC China case is done using questionnaires, while agro-biodiversity assessments concentrate primarily on the plot inventory. The investigator doing these assessments should ensure the direct participation of the owner and manager of the plot, while neighbours or other villagers may provide useful information, the focus of the assessment should be on the primary manager. Both methods should include oral communication with the primary manager of the particular land use, especially for recording management activities. Also, to maintain consistency, one person should be responsible for all investigations performed on a household's activities. Households should be classified according to their land management stages before they are compared.

The graph opposite provides a simplified example of one type of output from HH-ABA data analysis. Eight households from the village of Daka in Xishuangbanna are represented as plots on the graph according to two variables, Income/mu (15 mu = 1 hectare) and Species Richness (S/lnA). Three general conclusions can be drawn from this type of analysis. First, the graph shows the wide variation in both Income/mu (σ =1.16) and Species Richness (σ =0.77) between households. Intra-community variation can be a valuable measurement, especially when observed through time, describing the divergence of households within the community. Such analysis is difficult with community level assessment; however, data from HH-ABA lead towards the description of variation among households. Secondly, a correlation can be performed to test the relationship between these two variables among the eight households. The randomness of plots suggests no correlation (R^2=0.026) between income and species richness. Finally, while this graph shows no correlation between income/mu and species richness, it should be noted that some exceptional farmers maintain a high species richness and above average income, as marked on the graph. Although expert farmers cannot be selected solely on the basis of two variables, this style of observation can aid in the selection of expert farmers.



Conclusion

Immediately after the implementation of the Household Responsibility System, China's agricultural production systems began to diversify in 900 million directions. Almost twenty years later, the product of this mass deviation diminishes the compatibility of landscape or community level assessment with the goals of the PLEC project. It is the great degree of variation amongst farmers in this short period that calls for HH-ABA. Our method provides an accurate means to measure and analyse the process of household diversification during this most fascinating time in China's rich agricultural history, and in the region richest in agro-biological diversity.

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SMALLHOLDER AGRICULTURE ALONG THE LOWER AMAZON FLOODPLAIN, BRAZIL

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Introduction

Two adjacent environments of the Amazon basin, the forested uplands or *terra firme* and the floodplain or *varzea*, differ in their agricultural potential and settlement history. While public attention has concentrated on the forests of the uplands, it is the varzea which has traditionally been the focus of human settlement in the basin. In contrast to the relatively impoverished soils of the uplands, the fertility of the varzea soils is widely recognized. Furthermore, while the large scale colonization of the uplands is a fairly recent phenomenon, the varzea has been occupied by people of mixed Amerindian, European and African descent for centuries. Subsisting through combinations of extractive and productive activities, these people have developed crop varieties and sophisticated techniques for addressing the complex management problems posed by farming the floodplain.

Because of the great regional diversity in floodplain ecology and settlement histories, generalizations about the varzea can be misleading, and at least three major regions, upper, lower and delta/estuary, can be distinguished, each with distinct ecological conditions and patterns of land use. The PLEC Amazon Cluster consists of research groups working in each of these three regions.

This paper describes smallholder agricultural systems in the lower Amazon where the Santarém sub-Cluster is based. Here, despite the fertility of floodplain soils and a long tradition of floodplain farming, smallholder agriculture is stagnating. Once the basis of the floodplain economy, its role in smallholder subsistence has now been taken over by commercial fishing and extensive cattle ranching (Instituto do Meio-Ambiente 1997; Smith 1999; McGrath et al. 1999).

Study area

Physical environment

Research presented in this article was conducted in two smallholder communities, Aracampina and São Benedito, located on Ituqui, a 21,000 hectare floodplain island on the right margin of the main-stem Amazon River 30 kilometres downstream from Santarém, the fourth largest city in the Brazilian Amazon (Figure 1). Ituqui is a lenticular island in an east-west orientation aligned with the flow of the Amazon River. Along the periphery of the island is a ‘ring’ of higher land (levees). On the inland side the levee slopes gently downward to form a network of shallow lake basins which occupy the interior of the island. Seasonally inundated grasslands occupy the transition zone between the forested levees and permanent lakes. Habitation and agriculture occur on the higher ground of the levee ring, with communities strung along the river front, sometimes for several kilometres. Property boundaries are aligned perpendicular to the river front so that each household has access to each of the main environmental zones of the varzea, river, levee, grassland and lake (McGrath et al. 1999).

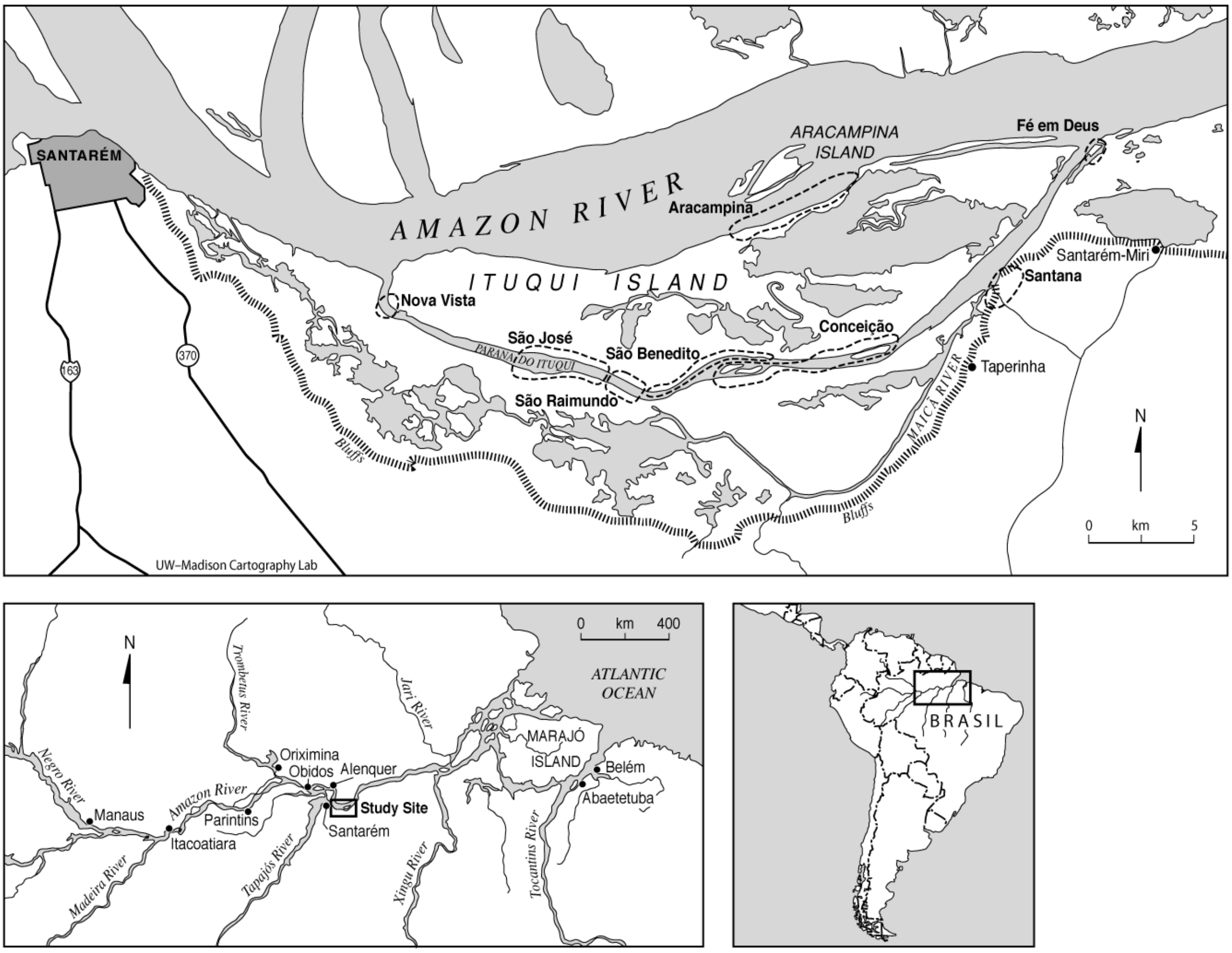

Figure 1 Ituqui and region

The climate of the region is tropical monsoon (Köppen's Amw). There are two distinct seasons on Ituqui, locally referred to as *verão* (summer) and *inverno* (winter). 'Summer' is a distinct dry period which coincides with the flood free period. Only 20% of the annual 1973 mm precipitation falls during this time of year which is also the cropping season (WinklerPrins 1999). During 'winter' much of the land on Ituqui is under water, the result of the annual flood of the Amazon River, which also overlaps with the rainy season.

While the planting season nominally coincides with the low water season when the levees are free of flood waters, a period of intense drought during the month of October often cuts the growing season into two periods, one beginning with the exposure of the levee and extending to October, and the other beginning with the onset of the rains and extending until the flood waters reach the levee. The interaction between flood and precipitation regimes is the main source of uncertainty for floodplain farmers, for while the rise and fall of the annual flood is quite predictable, the dry season in the middle of the low water season means that even slight variations in when a given site is exposed and then flooded once again can be disastrous for farmers. It is possible, for example, for a farmer to lose his first crop to drought and, if the rains are delayed or the flood rises faster than usual, his second to flooding, all in the same season (WinklerPrins 1999).

Agriculture on the floodplain is closely tied to topography and soil type, which are themselves related. Topography, especially elevation, is a critical factor in varzea agricultural strategies since it determines both the length of the growing season and the frequency and duration of flooding. Unlike the upper Amazon varzea with its parallel rows of levees and backswamps, floodplain topography of the lower Amazon is quite simple so that virtually all agricultural activities are concentrated on the main levee. Three main zones are recognized by farmers, the top of the levee, and its upper and lower backslopes. In addition to variations in topography on a transect inland from the river, the height of the levee also varies along the river, so that there are significant differences between levee sites in both the frequency and duration of flooding, with important implications for local agricultural potential.

Soils on Ituqui are of alluvial origin forming in nutrient rich (Andean derived) fluvially deposited sediments. They are classified as Typic Topofluvents in the USDA system and Eutric Fluvisols in the FAO system. The soils are fertile, with cation exchange values of 12–14 $cmol_c/kg$ (WinklerPrins 1999:149). Organic carbon and potassium values are relatively low, however, and could benefit from improvement if increased agricultural production is desired (Table 1). Additionally, silt aggregates render the soil functionally coarse so that soil moisture retention can be a problem during the growing season.

Locals divide their soil realm into three components linked to a soil geomorphological and moisture gradient. ‘Sandy soils’ predominate on the levee tops resulting in relatively dry conditions, ‘mixed soils’ are found on the upper backslopes, and relatively moist ‘clayey soils’ on the lower backslopes closest to the low-lying interior lakes. These soil classes are not discrete units, but form a continuum. Agriculture is preferentially practised on the ‘mixed soils,’ although manioc and other crops requiring a longer flood free period are always planted on the ‘sandy soils’ of the levees. ‘Clayey soils’ are used as a common pasture for cattle and water buffalo.

The vegetation of Ituqui is a highly humanized mixture of floodplain forest, natural grasslands, fruit trees, ornamentals and annual crops. Natural vegetation

Table 1 Organic carbon, potassium, and cation exchange capacity values on Ituqui smallholder farms (standard deviation in parentheses)

	Organic carbon **gm/100gm**	**Potassium** **(meq/100ml)**	**Cation exchange capacity** **$cmol_c/kg$**
Acceptable levels (Landon 1991)	4–10	0.2–0.6	0.9–26.5
Aracampina soils	1.05 (0.24)	0.14 (0.05)	14.12 (2.54)
São Benedito soils	2.46 (3.08)	0.12 (0.06)	12.07 (1.04)

patterns reflect both the frequency and duration of flooding and/or successional stage. Extensive areas of flooded forest once occupied the levees but have been progressively reduced, first for cacao and later jute. With the demise of jute cultivation forest regrowth is occurring, but this process is often set back by burning and clearing associated with the expansion of cattle and water-buffalo ranching (Smith et al. 1995; Goulding , Smith and Mahar 1996).

Local people

The smallholder inhabitants of Ituqui are descendants of Amerindians, Europeans and Africans. They are Portuguese speaking and call themselves *varzeiros*, people of the *varzea,* which is Portuguese for white-water floodplain. Varzeiros can be conceptualized as a subgroup of the population known as *ribeirinhos*, which itself is a subgroup of the Brazilian peasantry known as *caboclos* (WinklerPrins 1999). Ribeirinhos are considered to be the indigenous peasantry of the Amazon Basin since they have inhabited the region for several centuries.

Varzeiro families employ diversified land-use strategies integrating farming, small animal husbandry (chickens and ducks), fishing and cattle raising. The degree of subsistence and market orientation varies (Cleary 1993; Parker 1989). Average annual household incomes are around $950.00 (McGrath et al. 1999: 68). The limited importance of agriculture is evident from the small cultivated area, 0.23–0.32 hectare per household, a fourth the size of fields on the adjacent uplands (Câmera and McGrath 1995: 106).

Smallholder agriculture

Over the last fifty years, floodplain agriculture in the lower Amazon has undergone major changes resulting from the rise and fall of jute farming and its replacement by commercial fishing and extensive ranching on a range of scales. During the jute era, cropping was a balanced system including the cultivation of jute during the 'winter' and of subsistence dry-land crops during the 'summer' (Figure 2). This balance has now disappeared, as only the 'summer' dryland crops are cultivated. Dominant crops are manioc (cassava), maize, beans, cucurbits and bananas.

Crops are typically planted in a patchwork of monocrops. Land preparation includes the removal of the previous year's crop residue, either as the flood is rising or as it recedes. Fields are typically used annually, with the flood period as the fallow. If land is deemed to be 'tired,' as indicated by the growth of a low shrub called *gramma (Axonopus compressus* [Sw.] Beauv.)*,* the land will be fallowed for 2–3 years with a grass known as *capim-murim* (*Paspalum fasciculatum*). Burning is sometimes used to remove unwanted vegetation (weeds, old crop residue) but not as a fertilizer *per se*. The soil is loosened using a hoe; planting is done manually or with a planting stick.

Manioc cultivation on the varzea is very different from that on the terra firme, because it cannot be stored in the ground and small quantities of tubers dug up as needed, but must be harvested and processed into *farinha* (a coarse meal) all at once. As a result, the labour demand for manioc harvest can be intense. Three varieties of manioc are grown by smallholders at Ituqui. These are *duruteia*, *flor de boi*, and *abacatinha*. The first two are locally identified as floodplain varieties, the third is also grown on the uplands. All three mature in six months. Because of the relatively long period required to mature, cultivating manioc on the floodplain is a risky business. If the flood is slow to recede one season and arrives early the next, manioc tubers are threatened. Locals therefore plant at least both *duruteia* and *flor de boi* varieties. *Flor de boi* is preferred for taste, but *duruteia* is able to tolerate some moisture. Manioc tubers are processed into coarse flour (*farinha*) for household consumption, barter, and possible sale.

Manioc cultivation is limited to the higher levees, and as a result cannot be cultivated everywhere on Ituqui. Communities on the Paraná do Ituqui side of the island, such as São Benedito, are able to plant this crop because the levee on this side is relatively high; there is a fairly reliable six month growing period. In contrast, the levee where Aracampina is located, on the opposite side of the island, is much lower and a six month flood-free period is much less reliable. Consequently, manioc is cultivated less frequently in this community.

Maize is grown primarily as chicken feed. Sustaining chickens as a protein source during the winter is important as an alternative to fish; lake fisheries are less productive during this season. The main variety grown on Ituqui is *quarenta*, but *baixinho* is also grown. *Quarenta* is an improved variety that matures in 40 days. This rapid maturation makes it possible to cultivate two maize crops a year, one as flood waters recede during August/ September, and one after the rains begin in late December/ early January (Figure 2). Maize is preferentially grown in 'mixed soils' which retain moisture better than do the 'sandy soils,' but in Aracampina where the levee is lower, it is grown on the sandier soils of the levee tops.

Beans grow easily on Ituqui and are grown primarily for the market. Several varieties are grown, *manteiginha* and *leite* being the most popular. Beans are mostly grown on 'mixed soils,' but again, are grown on 'sandy soils' in those parts of the island where the levee is lower.

Several species of cucurbits are cultivated on Ituqui island, including watermelon, various squashes (including pumpkins), and sometimes melon and cucumber. These crops are usually grown on 'mixed soils,' but can also be found on levee tops, especially in Aracampina. In order to produce quality cucurbits, irrigation is needed during the main period of crop growth, since it coincides with the peak of the dry season on Ituqui. Smallholder irrigation is limited to calabashes filled with river water: irrigating this crop can involve a considerable outlay of labour.

Most households grow bananas in house-lot gardens or as a 'crop' in an association with other crops, usually manioc. Bananas are always grown on the highest available land since the time to maturity is 7–8 months, and they are always at risk of being flooded out. Consequently, as with manioc, only areas where the levee is exceptionally high are suited to banana cropping. Production is limited and destined mainly for household consumption; any surplus is bartered or sold. For several years a banana disease called 'moko' raged through smallholder banana plots, but this appears to be under control at present. Dominant banana varieties grown are *Banana branca* and *Banana prata*, but other less common varieties can be found in house-lot gardens.

Future prospects

Given the existing threats to smallholder agriculture on Ituqui, several aspects of their agricultural system need to be considered. From a local perspective, agricultural production as it is today is not sufficient to maintain households without significant alternative income sources or activities. These may be commercial fishing, ranching, or migration (seasonal or permanent) to nearby uplands or urban areas. If the goal is to assist smallholders to persist on Ituqui without undue pressure on any one resource, then creative ideas need to be utilized and implemented involving both annual and perennial cropping systems.

Agricultural production can be augmented by implementing several extension efforts that involve the exchange of existing local agricultural knowledge following the expert farmer model described by Pinedo-Vásquez (1996). Encouraging local exchange of ideas and land management strategies is a low-cost and potentially more effective way of increasing agricultural production in the long run (Chambers, Pacey and Thrupp 1989).

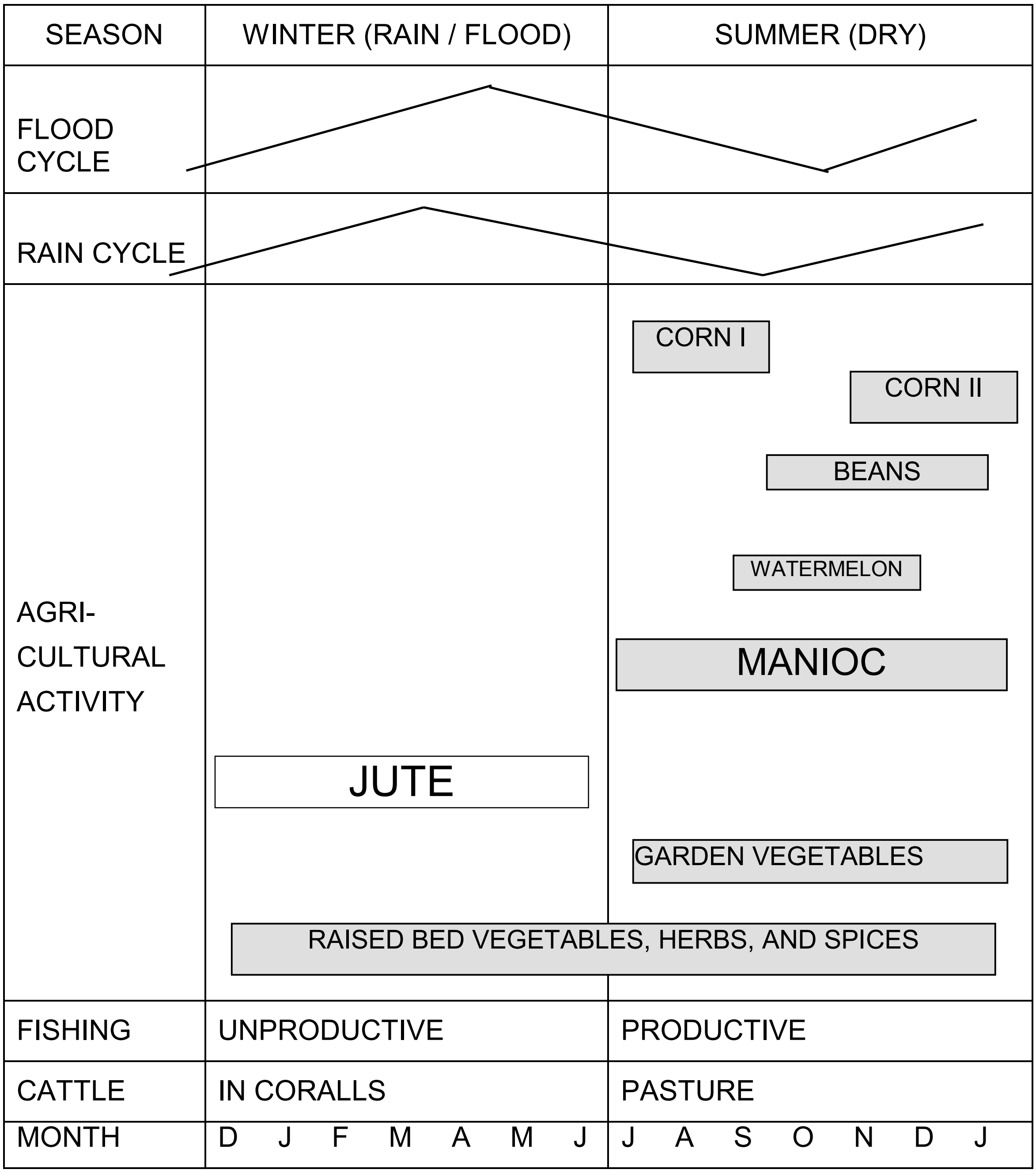

Figure 2 Seasonal calendar for Ituqui Island

With regard to annual crops, several local land management strategies can be further encouraged and developed. These include the use of the *funil,* a seed starter cup used by some to get a head-start in the growth of the cucurbit (especially watermelon) crop. A *funil* is made from a cacao leaf filled with a mixture of composted manure and the rotting bark of the Munguba tree (*Pseudobombax munguba*). Watermelon seeds are planted in these cups while the flood is still high. Seedlings are then ready for planting as soon as the land is ready to be cropped. Cups are planted *in toto*, adding valuable organic material to the soil. The plant will then grow better, and faster, and be ready for marketing before the glut. It may also require less irrigation since Munguba bark is spongy and retains moisture well. Participatory experimentation could improve the understanding of how best to use a *funil*.

Another local resource and skill is the use of green manure. Most smallholder farmers prefer the aesthetic of a 'clean' field (i.e. one without any old crop residue). This may be to prevent plagues of leaf-cutter ants and to remove serpent hideouts, but reasons for the adherence to clean fields beyond the aesthetic are not well understood at present. The use of green manure could assist greatly to conserve soil moisture and to add valuable organic material to the soil.

Despite the number of cows, buffalo, and horses on Ituqui, their dung is not extensively used as manure, except in the seed-starter cups and in raised-bed gardens (*hortas)* which women maintain as part of their house-lot gardens. The encouragement of the use of this resource could benefit the fertility of the soil, and its ability to maintain moisture. Participatory research and development of methods of composting and utilizing manure would help make better use of this resource.

A major issue with the removal of jute cultivation from the seasonal activity and income cycle is the lack of an income source to sustain families through the flood season. Seasonal migration to upland areas is an option that many are taking, encouraged by government sponsored settlement programmes, access to formal credit, and the security of producing on non-inundated land. It is possible that smallholders will be tempted not to return to the floodplain once infrastructure is in place in the upland areas. Lack of smallholder occupancy on the floodplain could open the door to complete take-over by largeholders, with their large-scale cattle and farming operations. From a conservation perspective, expansion of largeholders on the floodplain is not desirable because deforestation of the remaining flooded forest is extensive (Smith 1999). Similarly, permanent migration to upland areas by smallholders is not desired since deforestation in the upland areas is increasing, and will continue since the soil resource is not adequate for permanent non-shifting cultivation systems.

One important recent trend is the production of vegetables using pump irrigation and varying degrees of chemical fertilizers and pesticides. This trend is especially evident in zones surrounding the main urban centres in the region, including Santarém. A variant of this system involves the use of raised beds to extend cultivation through the flood season. (Smith 1996, 1999). Unfortunately both raised bed and increased dryland vegetable production suffer from significant marketing constraints, such as slow river transport and competition from more developed agricultural centres in the northeast and south. These constraints need to be addressed before either of these options can be expanded significantly. The ecological and human health consequences of increased use of chemical inputs is also a problem, and alternative methods for controlling pests need to be explored.

An alternative agricultural option for annual crops is encouragement and assistance with increasing the production of what already grows well on Ituqui. Manioc, maize, squash and beans are all crops currently produced: they have the added advantage that they can be dried and are therefore easy to store. Although their market value is not high, there is always a demand for these crops. Methods could be developed to improve their production and processing. Households could then rely on the sale of these commodities during the 'winter' season.

One striking feature of agricultural systems on the lower Amazon floodplain is the limited role of perennials, especially when compared with the agricultural systems of the upper Amazon and the estuary. While perennials are more common where levees are higher, even in these areas they are of little commercial significance. Their limited cultivation is particularly striking when one considers that up to the introduction of jute in the 1930s the dominant cash crop of the lower Amazon was cacao. Older residents, even in lower-lying areas, speak of the great diversity of perennials which were cultivated on the varzea in the past. They often attribute the loss of perennials to a greater frequency of large floods beginning in the 1950s and to the expansion of jute. Whatever the reasons, the importance of perennials in the lower Amazonian varzea economy has declined considerably over the last half century. Much local knowledge and many crop varieties have undoubtedly been lost as smallholders turned first to jute and later to commercial fishing and cattle raising. More emphasis on flood resistant perennial crops constitutes another strategy for strengthening smallholder production systems.

Conclusion

In conclusion, the kind of approach that PLEC is developing, with its emphasis on the exchange of existing local knowledge, can be especially effective for restoring smallholder agrodiversity in the lower Amazon. Two aspects of this work are relevant, building on local knowledge and promoting exchange of knowledge between regions. First, members of the Santarém sub-Cluster are seeking out local expert farmers and working with them to identify and test crop varieties especially adapted to local conditions; then to identify the techniques these farmers have developed for increasing survival and growth of annual and perennial species. A second aspect of the Amazon Cluster's work involves exchanges between the sub-Clusters of the upper, middle and estuary regions. Activities involved include visits by researchers to each other's sites, exchange of promising crop varieties between regions, and regional meetings bringing together expert farmers from the different sub-Clusters. Through these efforts the Amazon Cluster seeks to take advantage of the diversity of crop varieties, farming techniques and experience of the various regions of the Amazon varzea, to develop strategies of agricultural development which build on existing smallholder agrodiversity.

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NEW BOOKS

Helen Parsons

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Mazzucato, V. and D. Niemeijer 2000 *Rethinking soil and water conservation in a changing society: a case study in eastern Burkina Faso*. Wageningen: Wageningen University and Research Centre. ISBN 90-6754-596-1

Soil and water conservation projects are often viewed as a way of improving agricultural productivity and environmental sustainability, but they have had limited success in Africa despite a variety of interventions. The authors use an integrated approach to look at indigenous soil and water conservation in the east of Burkina Faso, and their findings are of wider interest.

The approach, analytical framework and methods are presented and discussed in a detailed and thorough way in part 1. The theories of Malthus and Boserup, with the emphasis on the importance of population pressure, have strongly influenced current land degradation narratives. This study instead focuses on the interaction of social and environmental histories to understand the dynamic landscapes that emerge. The three main research questions: what evidence is there for land degradation?; How are soils and water conserved?; and why do people do it the way they do? are analysed against the current narratives.

Results are presented and evaluated in part 2. The study took place in two villages. Presentation of the social history of the area and villages since the late nineteenth century allowed the analyses to be placed within a broader historical picture. Changes have significantly affected livelihoods, and at the same time, market integration and population and livestock densities have increased.

Analysing agricultural productivity, biodiversity, and soil, at national, regional and village levels, the authors found no evidence to indicate that land degradation had occurred. Food production has grown along with population, without the use of external inputs and increased mechanization. The authors studied local theories about soil and reasons behind the use of soil and water conservation practices. Farmers are aware of land degradation processes. They have extensive knowledge of their natural environment and use it to adapt their land use practices to the possibilities of the environment and the soils.

Farmers are able to maintain soil fertility despite long periods of cultivation. They practise adaptive management during the course of each growing season and through the cultivation cycle of each field, attaining a balance between labour investment, soil fertility maintenance and good crop production. Crop sequences are flexible, and timing and placement of inputs judicious: "adjustments Yabre [a farmer] made … were not part of some master plan, but the outcome of an interplay between agronomic knowledge, observations of crop performance, experimentation, timing and amount of labour available, availability of material to construct barriers, rainfall dynamics and other chance events" (p. 213).

The researchers found social networks important for many reasons. For example they enabled farmers to borrow land in response to need and labour availability, giving them flexibility to open up new land and to fallow their own. With monetization and changing agricultural conditions, there has been an increasing need and new uses for women's networks and maintenance of their natal ties. Networking allows greater access to resources such as equipment and inputs, increased access to cash through non-kin ties and self-help groups, and enables rearing of livestock. Social networks have adjusted and adapted with the changing context in which agriculture is practised.

Dynamic management is supported by an adaptable social organization that mediates access to resources–'people dispose of a repertoire of both social and technical ways of conserving land' (p. 305). The findings of the study will be of interest to other researchers of land husbandry, particularly in Africa. The study proposes that production systems can best be understood using analytical frameworks that focus on the interplay of social and environmental histories, revealing the complex and dynamic trends that can be present at different places and times.

The approach and methodology used offer an alternative that may be useful for others to adapt to their particular context in the study of soil and water conservation.

Almekinders, C and Walter de Boef (eds) 2000
***Encouraging diversity: crop development and conservation in plant genetic resources*. London: Intermediate Technology Publications. ISBN: 1853395102. Price: US$ 25.00**

Sustaining global plant genetic diversity is the subject of this new book. It consists of a compilation of around 80 brief articles by a number of authors with very different backgrounds, and includes case studies from over twenty countries in Africa, Asia, Europe and America. The contributions by local and international institutes, non-governmental organizations, and the private sector present the experiences and insights on the science, ethics, economics, politics, dynamics and significance of crop genetic resources.

Agro-biodiversity, a major strategic natural resource, is crucial to sustainable food security, but its use and development are subject to strong economic interests. The diversity of interests this reflects is presented in six sections and range from farmers' use of diversity, plant breeding methodologies, seed supply systems, to policy strategies to promote diversity. Each section is usefully followed by a synthesis chapter.

The final section of the book suggests guidelines for the future development in plant genetic resource management. Conservation is dependent on using a variety of strategies (*ex situ* and *in situ*, formal and informal). It has to take into account heterogeneous social and cultural systems, and resilient agroecosystems that are supported by integrated, dynamic management. This needs to be promoted by institutional cooperation and flexibility.

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