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REPORTS

What is the future for smallholders in the face of expanding global agribusiness?

Miguel Pinedo-Vasquez and Kanok Rerkasem

Urban markets around the world, including those in developing countries, are increasingly being supplied with produce by large agribusiness. The marketing of fresh food by corporate giants is leading to the replacement of local open markets by large and medium sized supermarkets even in the seemingly most isolated urban areas. What are the effects of expanding global agribusiness on the livelihood of the millions of smallholder farmers and how they are dealing with such drastic change? We will attempt to come up with a few answers in this brief article. Our work in PLEC, a global programme that focuses on smallholders and their changing resource use, provides some new and encouraging information that we would like to share with the readers of ePNV.

We have observed in many communities in Africa, Southeast Asia and Latin America that poor farmers are adjusting to the changes by diversifying their economic activities. Farmers have long moved between rural and urban environments, and agricultural and off-farm activities in search of income and other resources. This phenomenon described by some experts as a process of "deagrarianization" is increasing dramatically and is challenging conventional categories of what constitutes urban and rural populations. From the highlands of Kenya to the Amazon lowlands, a great number of rural families have members living in the cities and in some cases have a house in burgeoning shanty towns. These dispersed or multi-sited households play a critical role in moving capital, knowledge and resources from the city to the village and from the village to the city. Some governmental and non-governmental agencies are responding to these new needs and patterns in innovative ways.

A pioneer programme that aims to provide temporary employment to dispersed households was established in the municipality of Santarem, Brazil, the site of long-standing PLEC activities. The programme, based partly on data provided by PLEC, offers jobs to one member of participating rural families to work for 15 days in the city while the rest of the family are working in their landholdings or protecting their lakes and forests. Other members of the same family can then substitute for their family member. The programme structure allows fathers or

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mothers to work for 15 days and sons and daughters for the other 15 days. This flexible system helps the family secure a monthly cash income while continuing to produce their own food and conserve their resources. The programme is currently expanding with the cooperation of agribusiness and supermarkets, because it is offering more temporary, flexible employment to members of dispersed households. The residents of the communities of Santarem have told us that to survive in a world that is changing constantly, access to cash, food, and their forests and lakes are all necessary. This innovative programme seems to be helping smallholders adapt to these changes.

PLEC teams have observed that in regions and situations where temporary employment is scarce, some poor farmers and their organizations have successfully identified niche markets for their special products supplied in quantities too small for supermarkets. As with many smallholders in North America, Europe and Japan, poor farmers in developing countries are increasingly producing for organic and "ethnic" markets. For instance, some farmers in Jamaica who lost their income source when banana markets collapsed, are producing organic vegetables, fruits and medicinal plants for both the urban markets and the tourism industry. In addition, Jamaican farmers are selling their produce to traders from New York, London and other cities with a large population of Jamaican migrants. The access to ethnic markets is helping them increase their household incomes as well as to restore the rich agrobiodiversity that was lost during the time of banana plantations. Similar trends were also observed by the PLEC-Ghana team where access to niche and ethnic markets is helping to restore the diversity of yams and other tuber crops that were gradually being abandoned during the cacao boom.

Finally, a strategy that has worked for some farmers including many families at the PLEC site in the Brazilian State of Amapá is to produce a diversity of products and build upon the efficiency of combining agriculture and forestry, or agriculture and fisheries. Such cross-sectoral production systems may be difficult or impossible to carry out at an industrial scale, but are prime examples of the kind of agrodiversity that has long sustained successful smallholders and that PLEC has promoted. For instance, in the estuarine area of the Amazon floodplain, farmers are responding to the loss of markets for their agricultural products by refocusing their production toward agroforestry products such as açaí (palm) fruits and fast-growing timber in fallows. While field crops are not ignored, they are destined primarily for the family table. The products of fallows which had previously been used mostly for subsistence are now being increasingly marketed. The economic benefits of this market reorientation of local agroforestry and forestry is allowing many farmer/foresters to increase incomes. Similar complex, multi-staged production techniques that combine farming and fisheries are also benefiting farmers in Brazil and other rural areas where PLEC teams are working.

These examples illustrate only a few of the emerging production strategies that farmers have successfully employed to cope with the loss of markets to agribusinesses and the supermarkets they supply. These are strategies that give smallholders an edge over large-scale industrial level producers. Unfortunately many of the products and processes that are still being promoted by development agencies purport to be scale neutral, but privilege those farmers who have adequate access to credit, fertilizers and other benefits often unreliable or in short supply. PLEC researchers however continue to identify and promote a variety of production systems that allow smallholders to make a living in dynamic and difficult times.

Launching the SLaM project

Edwin A. Gyasi

The "Sustainable Land Management for mitigating land degradation, enhancing agricultural biodiversity and reducing poverty (SLaM) in Ghana" project was launched on 1 June 2005 in Accra with 62 people attending. The main events were a statement by Dr Stephen Duah-Yentumi, representing the Resident Representative of UNDP, an overview of the project by Prof Edwin A. Gyasi, the Project Co-ordinator, and a keynote address and launch by Dr G.A. Agambila, Deputy Minister of Environment and Science, of the executing Ministry on behalf of the Ghana Government. The Minister noted that a lack of effective policy guidelines on issues related to land and other natural resources and protection of indigenous knowledge served as a barrier to sustainable land management, and that the National Biodiversity Strategy upheld the SLaM objectives of mitigating the effects of land degradation, enhancing agricultural biodiversity, and reducing poverty.

Professor Gyasi related that five sites located in Ghana's major agroecological zones have been chosen for the initial phase of the project, and it is hoped the project would be extended to other areas subsequently. The project will be carried out by multidisciplinary teams of scientists in a participatory manner with farmers and other stakeholders. In southern Ghana, the team would be drawn mainly from the University of Ghana, Legon; in central Ghana, mainly from the Kwame Nkrumah University of Science and Technology, Kumasi; and, in northern Ghana, mainly from the University for Development Studies, with Prof. Gyasi, Dr. Oduro and Dr. Kranjac-Berisavljevic as the leaders. Scientists from the Council for Scientific and Industrial Research and the UNU Institute for Natural Resources in Africa would support them. Mainly the project is funded by the GEF. It is supported by the UNU, which provided the initial project development fund, and various Ghana Government Ministries including the Ministry of Environment and Science.

Papers

Banana emcapoeirada in Amapá, Brazil: management diversity in the face of an epidemic

Andrew S. Roberts[1] and Miguel Pinedo-Vasquez

Caboclos, smallholders who live along the Amazon River in Brazil, are refusing to follow government demands that they burn their banana fields in order to control outbreaks of Moko, the bacterial wilt disease, which has ravaged the region since the 1970s. Rather, they have improvised an alternative arrangement of their production system which allows them to continue to produce bananas despite the disease. This relatively new agroforestry system is known as "banana emcapoeirada". We describe and analyze the role of banana emcapoeirada in the control of Moko and in the rebuilding of local household economies in the Brazilian state of Amapá.[2] Our aim is to use the banana emcapoeirada system to illustrate the importance of agrodiversity in understanding how the diversification of agricultural systems allows smallholders to weather crises, be they devastating market shifts or disease epidemics.

Most experts agree that plant disease outbreaks can be difficult to control, and that they often have a crippling effect on rural households. These views can be tainted with inaccuracies. For instance, in January 2003, newspapers worldwide picked up an article published in *New Scientist* which sounded the death knell of the banana (Pearce 2003). The author hailed the impending doom of Cavendish clones, grown in monoculture for export across the tropics and subtropics. This was claimed to be due to a paucity of genetic diversity, leaving plant breeders powerless to address new, widespread outbreaks of especially virulent strains of Black Sigatoka and Panama Disease. The report was misconstrued in the popular media, as many writers focused on the complete disappearance of bananas as a food crop (Collins 2003, Dayton 2003, *inter alia*). The misinformation was so widespread that the FAO was forced to issue a press release to counter it (Riddle 2003).

Fortunately, the FAO report stated that smallholders have maintained a "broad genetic pool which can be used for future banana crop improvement." While this is true, the report's author overlooked the diversity of production systems, in addition to the diversity of germplasm, which are used by smallholders. Smallholders continually innovate, improvise and evaluate their production systems in response to the many challenges and opportunities. Such flexibility frequently leads to outcomes unanticipated by agricultural scientists or policy makers. The unique banana emcapoeirada agroforestry system has facilitated continued banana production in the face of the Moko epidemic.

Ecology of Moko

Moko disease is a bacterial wilt caused by the bacterium *Ralstonia solanacearum* (E.F. Smith) Yabuuchi (formerly *Pseudomonas solanacearum*). The diversity of this organism has complicated attempts to classify it and elucidate its evolutionary lineage (Poussier, et al. 1999; Hayward 1985). A classification system breaking the species up into races based largely on host preference is widely used. Over one hundred plant species, in 50 families, have been recorded as hosts. Generally, race 1 is known to affect solanaceous crops, including tomato, tobacco and eggplant. Race 2 affects *Musa* and *Heliconia*, while race 3 affects potato (Buddenhagen and Kelman 1964).

Moko was first described in detail by J.B. Rorer, reporting on an epidemic which had crippled plantain production on the island of Trinidad in the late nineteenth century (Rorer 1911). Plantains of the variety named "Moko", widely planted for shade on cacao plantations, were especially hard hit. Since then the disease has spread through Latin America and the Caribbean, most likely facilitated by the movement of contaminated planting material. In Amapá, Moko devastated a strong banana production sector oriented towards domestic consumption. In the late 1970s prior to the epidemic, harvests in that state averaged approximately 150 tons per month. By the early 1980s, this had dropped to approximately 16 tons per month (Pinedo-Vasquez et al. 2003).

The symptoms vary depending upon the specific strain. The disease is normally characterized in bananas or plantains by a wilting of the leaves and a discoloration of the vascular tissue. Young plants may remain stunted. The symptoms are often accompanied by a bacterial ooze released from wounds in the pseudostem. Fruit symptoms range from premature ripening to dry, brown rot of individual bananas. Likewise, methods of disease transmission vary with the strain. Some strains of the disease can survive in the soil, and are able to enter plants through wounds in the roots. Others are spread by insects which pick up inoculum

1. Columbia University
2. Amapá is situated at the mouth of the Amazon River. In addition to normal seasonal flooding, floodplains in the estuary are subjected to twice daily tidal flooding, averaging 1.2 metres in height. When the river is high, tides can rise up to 2.3 metres. Unexpected spikes of seasonal and tidal flooding still occasionally inundate fields.

while visiting the flowers of infected plants. An important mechanism for the transmission of all strains of Moko is through the field activities involved in banana management, such as the pruning of leaves and suckers.

Further complicating disease management, Moko causing bacteria have been reported in a number of forest plants and weeds which are common in some banana growing regions of Latin America. The most notable of these is *Heliconia* (Thwaites et al. 2000; Kastelein and Gangadin 1984; Sequeira and Averre 1961; Ashby 1926). As a relative of *Musa*, it has been suggested that Moko originally was a pathogen of *Heliconia* which then jumped to domesticated *Musa* at field borders (Thwaites, et al. 2000).

Prescriptions for the control of Moko

In light of the massive economic toll which the disease has inflicted upon banana production in Amapá and other regions, experts have several recommendations to prevent the spread of the disease. They are built around regular field inspections to monitor for outbreaks of the disease, coupled with complete intolerance for any degree of infection. Infected mats are destroyed, often with direct injection of herbicide, and in the case of Amapá, by the burning of infected fields. Other recommendations focus on sanitation, with the use of formaldehyde solutions to sterilize field equipment and clothes. Additionally, quarantine has been imposed to prevent the movement of potentially contaminated planting material from Amazonia to the southern part of the country, where the disease has not yet established (Thwaites et al. 2000; Stover and Simmonds 1987).

While there is little doubt that all of these recommendations can control the spread of disease, they are impractical for most smallholders. However, this impracticality should not be interpreted as a shirking of responsibility on the part of farmers. To the contrary, smallholders have developed another solution through the diversification of their production system.

Banana emcapoeirada

Smallholders in Amapá have found a way to continue to produce bananas, without losing all of their plants to the disease. This banana emcapoeirada system was integrated into their existing system of swidden-fallow management through a process of innovation and adaptation. It has allowed people to resume banana production, making a substantial contribution to household income through the sale of these bananas and other products from the fallows.

Though bananas are often included in house gardens, larger scale production occurs in swidden-fallow systems. Caboclo swidden-fallow systems are sophisticated schemes for managing the production of annuals and perennials across a range of temporal scales. When new swiddens are opened in the forest, a mixture of annual grains, tubers and other useful crops are planted. Over time as the yields of annual crops decline, there is a shift in management towards perennial, less nutrient-demanding crops. This has historically included banana and cassava. As secondary forest growth is managed and other useful seedlings are added to the fallow, attention is shifted to the production of açai palm (*Euterpe oleracea* Mart.), fruit and timber trees. Fallows are managed by thinning and vine removal, in order to encourage the growth of favoured species. They are further enriched with the opening of gaps in the canopy to facilitate the planting of seedlings.

With the Moko epidemic, bananas no longer fitted into this production scheme. In young fallows, too many succumbed to the disease. For smallholders to survive, it is critical that they retain the ability to adapt their production systems to sudden changes. This tradition of change (Pinedo-Vasquez et al. 2002) has led to the development and popularization of the banana emcapoeirada system.[3] With this system, banana production is shifted forward in time, so that bananas are managed within older fallows, alongside açai, fruit and timber species. Fallow size is kept small, generally under 0.5 ha, depending upon the age of the fallow. In addition to this temporal shift within the system, the nuances of banana management were changed as well.

Rather than the clean weeding of plantation banana production or the mixture of bananas with cassava and other crops as in young fallows, selective weeding is used to shape the lower canopy structure. All weeds are removed, save the two monocots sororoca (*Calathea ornata*) and pariri (*Calathea micans*). These two species were selected by smallholders through a process of trial and error for their ability to act as a physical barrier to pathogens, without out-competing the bananas for light, water and nutrients. "Sao parientes que nao brigan", is the way in which one farmer described his rationale for selective weeding. Roughly translated, this phrase means, "They are related, but do not fight with each other". The combination of these two plants forms a dense understory layer up to one metre or more in height. In addition to selective weeding, pruning and other management activities are minimized, save the maintenance of paths used to harvest mature banana bunches.

Moko remains in the fallows. In fact, under this system, the first plantings of bananas are always lost to the disease. However, this loss is anticipated by the growers. Subsequent years show a much smaller loss. The disease remains contained and does not spread throughout the landscape. With this production system, smallholders are again able to produce bananas. Data from 2000 suggests that banana production is at approximately 90 tons/month, which is close to pre-epidemic levels (Pinedo-Vasquez et al. 2003).

3. Of the approximately 27 clones of bananas and plantains grown in the area, 6 or 7 are grown specifically in banana emcapoeirada systems. These are maintained despite the availability of improved, Moko-resistant clones released by the government, which have inferior eating qualities and fetch lower market prices.

Avenues for understanding diversification and the control of disease

Based on what is currently understood about the agroecology of Moko and banana production, it is possible to suggest the following factors that account for the success of smallholders in controlling the Moko through the practice of the banana emcapoeirada system.

Structural complexity The complexity of the canopy contributes to the formation of physical barriers to insect vectors. Banana emcapoeirada fallows have at least four layers: *pariri*, *sororoca*, banana and trees. This stratification, in conjunction with the high planting densities of the bananas themselves, hinders the movement of vectors from infected to healthy mats. The diversity of species, spatial complexity within the fallow and the high proportion of edge, also provide alternate hosts for insect vectors. Likewise, they provide a rich habitat for arthropod insect predators, insectivorous amphibians and reptiles, birds and mammals.

The dense shading from the canopy results in a cool enough microclimate as to hinder the rapid growth or long-term survival of the disease in the soil. The complex understory structure and heavy layer of leaf mulch and humus on the ground also interfere with rain splash transmission from the soil.

Asynchronous flowering Managing the bananas as uneven aged stands, at varying stages of maturity, fosters asynchronous flowering. As the insect-transmitted strains of Moko need to be carried from inflorescence to inflorescence, asynchronous flowering reduces the likelihood of this occurring.

Reduced human activities Minimizing human activities in the fallows, such as pruning, reduces the opportunities for the disease to be transmitted between hosts by the smallholders themselves.

Soil chemistry One report mentioned that the disease fared better in acid soils. Bananas managed using the banana emcapoeirada system produce copious inputs of organic matter as leaf litter, particularly from *sororoca* and *pariri*. This has the effect of raising the soil pH enough to hinder the growth and spread of Moko. The high organic matter favours the growth of decomposers in the soil, which grow rapidly and outcompete other species, and the chemical by-products of decomposition, such as ammonia and ethylene, can be toxic to some pathogens (Thurston and Abawi 1997).

It is unlikely that any one of these is the defining factor that keeps disease outbreaks from spreading throughout fallows. These and probably other factors may act synergistically to shape ecosystem function in complex ways.

Conclusion

The complexity and multi-functionality of smallholder systems show how agrodiversity is both a source of crop biodiversity and a source of management diversity in the form of knowledge, which can be marshalled to address challenges like the Moko outbreak. Genetic diversity is an important resource from which smallholders and plant breeders alike are able to draw upon to solve the problems which confront them. However, as shown here, it is not the only one−another critical component of agrodiversity is management diversity. Through reconfiguring management in both space and time, smallholders are able to negotiate novel paths through ecological and economic constraints. The banana emcapoeirada system is an example of the importance of innovation and management diversity in response to crisis. The smallholder approach utilizes the ecology of the system to control the spread of Moko, rather than relying on any one control measure. They take advantage of the many control measures inherent to the system. Biodiversity alone does not hold all the answers. Like the Caboclos, those concerned with threats to agriculture need to expand their vision beyond simple technocratic solutions.

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Learning the hard way: transformation of human-environment relationships in Wuzhishan region, Hainan, China: 1930s to present

Masahiro Umezaki [1], Hong-Wei Jiang[2], Jing-Yu Liang [3]

Introduction

Hainan Island is located to the south of the Chinese mainland. In 2000, about seven million people inhabited the island with its tropical and subtropical monsoon environment of 34,000 km^2. It was until recently one of the least developed regions in China. Large cities developed only in coastal regions and the road network did not fully extend to the mountainous inland until the 1970s. Developmental inequality between the coastal region and the inland region was remarkable. Since the 1980s when the transition from a planned economy to a market economy took place in China, various development projects have been launched, first in the eastern coastal regions and then extended to the inland (Liang, Umezaki and Ohtsuka 2003). In 1988, the entire Island became Hainan Province (previously Hainan Island was part of Guangdong Province). The province was designated a Special Economic Zone (SEZ) by the Chinese government for the promotion of tourism and economic development. Since then, a huge amount of money has been invested in development projects by enterprises from mainland China or foreign countries, and since the 1990s it has been one of the most rapidly developing provinces in China.

We have conducted human ecological study in the inland of Hainan Island since 2000. Our major concern was to reconstruct the transformation of the human-environment relationships in the communities under drastic change. In the target communities, enforcement of new government policy was regarded as the fundamental trigger of change. Tourism policy, for example, together with environment conservation policy, affected the people's daily subsistence behaviour. Economic development policy initiated change in the indigenous food production system toward the market economy by introducing cash crops. Transformation in land use, resource management and social organization followed, which eventually have affected health status and welfare of the people, as well as the biomass and biodiversity of the natural environment surrounding the communities.

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Research localities

Wuzhishan city is located in the mountainous inland, some 250 km to the south of Haikou (the provincial capital) and 90 km to the north of Sanya (tourism centre). It is the home of Qi dialect of Li ethnic minority people, and autonomous government of Li and Miao ethnic minorities existed until the 1980s. The name of the region came from Mount Wuzhishan (1867 m above sea level) located in the northeast of the current city territory (Figure 1). The mountain is a historical site. Since mature forest and rich flora and fauna have been well preserved, a nature reserve was established on the mountain and its surrounding areas in 1986. It became a resource for tourism development since the early 1990s.

Introduction of market-oriented cash cropping and tourism were two major development projects which were implemented in different intensities according to the infrastructure and environment in each area. Banana, rubber, litchi and longan were mainly introduced to the villages along the major traffic road at relatively lower altitude, while tourism development was devoted to urban/peri-urban areas and to the villages around Wuzhishan Mountain.

The fieldwork was conducted in two Li ethnic minority villages, Shuiman and Paoli (Figure 1). Shuiman village had 190 people (32 households), while Paoli village had 179 people (28 households) in 2001. Shuiman village lies at the foot of Mount Wuzhishan and has been influenced by tourism development, while Paoli stands on provincial road No. 29 (constructed in 1965) and has sought to increase income with cash cropping.

Shuiman village

Transformation of food production system from 1930 to 1980

Summarizing the Chinese literature on the Li people in eighteenth to nineteenth century, Nishitani (2004) concluded that all people living near Wuzhishan Mountain conducted shifting cultivation, hunting and gathering. Rice cultivation in paddy fields seemed to have started about the beginning of the twentieth century. A German ethnographer who traveled in Hainan Island in 1931 and 1932 stated that the people who lived near Mount Wuzhishan conducted rice cultivation in paddy fields and shifting cultivation in the mountains. Large areas around the villages were maintained as grassland by regular burning. The people depended more on shifting cultivation than on rice cultivation in paddy fields for their livelihood.

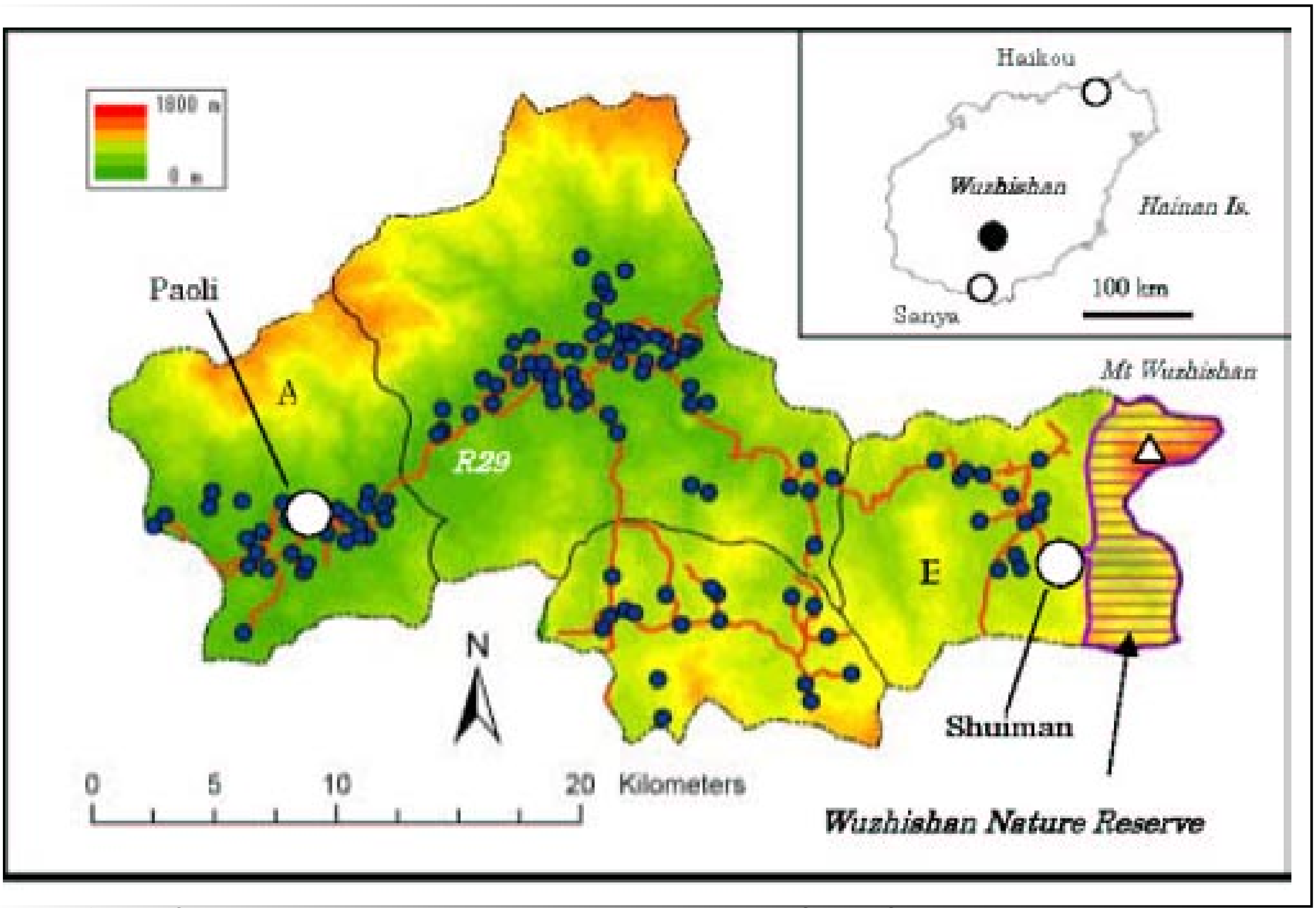

Figure 1. The four townships in Wuzhishan city in Hainan Island, China. Shuiman and Paoli villages are indicated with blank circle. Wuzhishan Nature Reserve within Wuzhishan city territory is also indicated

Rice, maize, foxtail millet, finger millet, sweet potato, bean, pumpkin and tobacco were planted in slash-and-burn gardens (Stübel 1935). Monkeys and birds that damaged the crops in the gardens and deer in the forest were hunted. Villagers gathered wild edible plants instead of growing leafy vegetables in gardens. There was only one rice crop a year.

In the 1930s there were two villages 4-5 km further up the river from Shuiman. In 1958, their people were moved to Shuiman to create a single collective. During the period of "planned economy" between 1958 and 1980, the collective farm conducted rice cultivation in paddy fields and slash-and-burn cultivation in the areas around the village. Buffaloes were reared collectively in the grassland far from the villages.

Transformation of food production system from 1980 to present

With the nation-wide economic-system transition from a planned economy to a market economy in the early 1980s, the collective was disbanded as an economic unit and the "Household Production Responsibility System" was introduced. Each household started to produce various crops in addition to rice in paddy fields so as to improve their own economic status. Also in 1984 a motorable road reached a small town 3 km from Shuiman, and a small path was constructed to Shuiman village in the late 1980s. Wuzhishan Nature Reserve was established in 1986 with 13,435 ha of land (Li et al. 2001). The reserve covered all territory of the former small villages together with the eastern part of Shuiman village. The Hainan Provincial by-law for Nature Reserves prohibits construction of buildings in nature reserves, deforestation, cattle grazing, hunting, gathering medicinal herbs, clearing for cultivation, collecting soil and stones, and mining. After this by-law was enforced, the people in Shuiman village abandoned slash-and-burn gardening in the mountain and regular burning for the maintenance of grassland. The frequency of hunting and gathering in the reserve was also reduced.

After these changes, the land use pattern of Shuiman has changed drastically. The sites previously used for slash-and-burn gardens and the grasslands around the villages have changed to secondary forest. People explained that the secondary growth currently dominated by *Haname lidacea* were the previous grasslands, while secondary growth where we could find pioneer species such as *Alchornea liukiuensis hayata* and *Mallotus japonicus* were former slash-and-burn gardens. We used this ethnobotanical knowledge to reconstruct the past distribution of grassland and slash-and-burn gardens. (Umezaki, Pahari and Jiang 2002). The area presently used for subsistence is far smaller than that used in 1980.

Introduction of cash crops paralleled the abandonment of slash-and-burn gardens and grasslands. Crops such as banana, tea, a species of medicinal herb (*Alpinia oxyphylla*) and a timber tree (*Cunninghamia lanceolata*) were planted in slope gardens behind the paddy fields. In 2001, the average area per household for banana was 0.18 ha, 0.01 ha for tea, 0.13 ha for *Alpinia oxyphylla*, and 0.03 ha for *Cunninghamia lanceolata*. Pigs, ducks and fish were also reared. Rubber (*Hevea brasiliensis*), longan (*Dimocarpus longan*) and litchi (*Litchi chinensis*), the major cash crops in lower areas in Hainan, were introduced to Shuiman but did not grow due to the cooler environment. Overall, cash cropping in Shuiman provided only marginal income.

Intensification of rice cultivation in paddy fields was another notable change in Shuiman village. Hybrid species of rice have been planted since the 1980s, to which were applied fertilizer and pesticide sold by the national agricultural institutions. Improvement of the irrigation system made it possible to stabilize water flow to the paddy fields. Liang et al. (2003) reported that the per hectare land productivity of rice increased from 1130 kg in 1952 to 2040 kg in 1980, then to 3000-4500 kg in 2000-2001. The difference between 1952 and 2000 was even greater (6-9 times) if we considered annual land productivity, because the people cultivated rice only once in a year in 1950s, while they grew two crops in 2000. Even during the last two decades, the land productivity of rice increased by 1.5-2 times. As a result, total production of rice in the village far exceeded the dietary requirement. The surplus rice was sold to the government who purchased at a fixed rate, or it was traded for meat, fish, or vegetables brought to the village by the motorbike peddlers several times a day.

Currently, the subsistence strategy in Shuiman heavily depends on intensified cultivation of rice in paddy fields. Per capita area of paddy field was 770 m^2 in 2001, which produced 450-690 kg of rice annually (Umezaki 2004). Since one person consumed 0.5 kg of rice in a day, per capita amount of surplus rice is 250-500 kg, equivalent to 400-800 Yuan in 2001 (1 kg rice = 1.6 Yuan) . About half of the surplus was used for obtaining cash to purchase fertilizer, pesticide, rice seed, and implements for the next cultivation cycle. The remaining surplus, equivalent to 200-400 Yuan, was used to purchase pig meat (6 Yuan/500g), fish (3 Yuan/500g) and other foods. In case one individual spent all of the 200-400 Yuan just for pig meat, they could purchase 17 to 33 kg of pig meat in a year, or 50-100 g daily. During an 18 days period in August 2001, on the average, six out of 10 Shuiman households purchased pig meat or fish from motorbike peddlers at least once a day. It was judged that the people's nutritional requirement could be fulfilled mostly by the production of rice in paddy fields, if they could obtain appropriate amount of vitamins and dietary fibres from other sources. This is in great contrast to the situation in 1980; a one-time village leader explained that the several households were then short of rice during the period before the harvest.

In Shuiman village, side dishes other than purchased ones included wild plants/animals, and vegetables grown in kitchen gardens adjacent to the villages. Sweet potatoes, cassava, and maize were also planted in mixture with cash crops. It is worth noting that various wild grasses were frequently collected in or around paddy fields. Of 38 species of grasses found in an irrigation channel, 25 were edible. Of the 29 species in a ridge between rice fields, 5 were edible. Of 19 species grown in paddy fields, 8 were edible. Also 13 species were used as medicinal herbs for daily health problems.

Wild edible grasses harvested in the paddy fields

Impact of tourism development

After unsuccessful trials by several enterprises in the 1990s, full-scale tourism development was undertaken by a joint venture, Wuzhishan Tourism Limited (WTL) (Liang et al. 2003). This joint venture opened the resort on 1 May 2002.[4] The concept was to show the "exotic culture of Li ethnic minority" as well as the "beautiful primeval nature around Wuzhishan Mountain". More than 1000 tourists visited the resort for the first three months from opening. They enjoyed the view of Mount Wuzhishan, and looked around the replicas of traditional houses and storehouse in the villages. The resort is still under development. In 2004, a 5 km promenade was constructed in the adjacent forest around Shuiman village. A butterfly garden operated by a different company was also opened. The company has a plan to link the peak of Mount Wuzhishan and Shuiman village first with a 16 km of wooden trekking path and then with an aerial ropeway in the near future.

The tourism development has influenced the daily life of the Shuiman people in several ways. People could earn money by being employed by the company or by selling the materials (bamboo and timber) for construction of the resort. They also received compensation payment for the crops and trees in the customary land the collective use

4 The company was formed in partnership between Wuzhishan local government, a tourism company in Beijing, and a Hainan Island company.

right of which was transferred to the company. Secondly, the indigenous resource management norms showed signs of change. The Li people had long made very strict distinction between what was "planted/grown" and what "grew naturally". While the planted crops were used only by the people who planted them, the plants that grew naturally were used by any people, irrespective of their residential place or ethnicity. Medicinal herbs, edible plants, wild animals, honey, and wild tea leaves, for example, have been utilized not only by the Shuiman people but also by the neighbouring Li villagers, Miao ethnic minority people, or Han people. No spatially defined commons under collective resource management existed. The people who have such magnanimous resource management norms were good guides for the visitors who wished to make money from wild resources. Traders of precious butterflies, giant stag beetles (Genus *Docus*), orchids, or medicinal herbs, arrived at Shuiman village and exploited such animals or plants, despite the fact that collection in the reserve is prohibited by law. The Shuiman people did not complain at first, but some of them later started to claim that such economically valuable resources around Shuiman village should not be exploited freely by the people from outside. The indigenous norms for resource management may change toward "tight" ones as the people understand their economic value in the world market.

Wuzhishan mountain and Nature Reserve

Paoli village

Introduction of banana, rubber, longan, and litchi

Paoli is one of villages in Fanyang township that is located in the northwest of Wuzhishan city. Provincial Road No. 29 runs along Chang Hua Jiang River that flows from east to west through the township. Paddy fields and villages are located in the flat areas between the river and the mountainous hinterland. The people in Paoli speak the Ha dialect of Li ethnic minority.

The indigenous food production system in Paoli, in the 1930s for example, consisted of cropping of rice in paddy fields, slash-and-burn cultivation, hunting and gathering. In contrast to Shuiman, the people may have depended more on rice cultivation in paddy field than on slash-and-burn cultivation (Odaka 1944; Stübel 1933). Per capita annual production of rice has increased from 130 kg in 1952 (double cropping; South-Central College for Nationalities 1992) to 240 kg in the early 1970s, then to 480 kg in 2000 (also double cropping; Jiang 2004). This was due to introduction of hybrid species of rice and improvement of the irrigation system, together with the application of effective pesticides and fertilizer. The production of rice exceeded the nutritional requirement level and the people produced surplus just as in Shuiman.

After the economic-system transformation to a market economy in the early 1980s, banana was first planted as a cash crop in Paoli village. Since banana shoots could be reproduced in the village, most households started to plant bananas in their gardens by 1984. A part of the production was sold to the market, while the remainder was consumed in the village. In 1985, rubber was introduced. One person decided to purchase 600 rubber seedlings for 600 Yuan (equivalent to the price of 4000 kg of rice in 1985) and planted them in his slash-and-burn gardens where he planted rice and cassava in the previous year. In 1987, among the 24 households in Paoli village, 12 planted rubber when the township government provided free seedlings according to the number of holes people prepared in their gardens. However, many of them did not take serious measures such as drainage or fencing to protect seedlings from damage by buffaloes. Many rubber gardens were neglected.

An event that changed the people's understanding of cash cropping occurred in 1995. The person who had first planted rubber started tapping and could earn a considerable amount of money. He used the profit for protein-rich foods and also for the professional training of his son in an agricultural college in an urban area. The people in Paoli village had a clear image of success. The area of rubber gardens has rapidly increased and the people started to manage the rubber intensively.

Another epochal event occurred in 1998. One person in a neighbouring village succeeded in harvesting the longan and litchi fruit and earned what looked to the Paoli people like an enormous sum of money (400 to 600 Yuan from each tree). He received an official commendation as a model farmer from the Chinese government. He traveled to Beijing to participate in an award ceremony. His success shocked the people in the township. Many people in Paoli started to devote their effort more on growing litchi and longan. Almost all secondary forest areas were converted to cash crop gardens for litchi and longan. The people spent longer hours on cash cropping than before, while surplus rice from paddy fields was used for the investment in cash cropping rather than for purchasing protein-rich foods such as meat and fish.

Abandonment of buffalo, logging, and rural-urban migration

Notable changes in Paoli village in the recent past are the abandonment of rearing buffalo, increased frequency of logging in mature forest far from the village, and migration of all unmarried females to urban areas. Buffaloes were indigenously reared in higher altitude grasslands or secondary forest around the villages. After the government's by-law regulated the burning of grasslands and most secondary forest were converted to cash crop gardens, the people came to tie buffaloes to stakes in the village to prevent damage to crops and trees. They were fed with edible grasses grown around paddy fields. In 2001, the people finally decided to sell all buffaloes and purchased tractors to do their work.

Logging of valuable trees such as *Dalbergia odorifera* or *Gmelina hainanensis* is a common activity for men during the agricultural off-season. Of 52 men between 15 and 40 years of age, 36 logged in 2001. A portion of the earnings was used for investment in cash cropping. On the other hand, all 17 unmarried women in Paoli (aged 16-30 years) migrated to urban areas in the northern part of the province. They worked in the service sector to remit to their families regularly and also to bring electrical goods, such as televisions and videos, or motorbikes back to the village. Sometimes a portion of their remittances was also used for investment in cash cropping.

Comparative perspectives

Food security and environmental conservation

During the authors' fieldwork in 2000-2004, the human-environment relationships in Shuiman and Paoli villages were still undergoing rapid transformation. The Government further intensified the policy to encourage re-growth of secondary vegetation around Shuiman village. The people could receive money depending on the area where they planted tree crops (e.g. the medicinal plant *Alpinia oxyphylla*, rubber, longan, and litchi). They will continue to receive the same amount of money in the following years if the forest is managed well. This policy led most Shuiman people to plant tree crops in every part of slope gardens or secondary forest. Some of the people also planted tree crops in the customary lands of the village, which were then registered to those individuals. Understandably, inequality among the villagers in the amount of money received brought about some tension among the people.

Paoli people started to plant cucumber in the paddy fields, in place of the first rice crop in 2004. An entrepreneur explained the methods of planting and the expected profit per unit area. In the first year, although the people produced cucumbers, they could not sell them all due to a drastic decrease of the market price upon harvest (to 1/15 of the expected price). The people faced double burdens: the loss of one rice crop and loss of their unsuccessful investment in cucumber cultivation.

Currently, the Shuiman people consume a nutritionally sufficient diet by maintaining rice cultivation. The surplus rice was exchanged for protein, and wild vegetables are harvested around paddy fields. Shuiman people tended not to spray pesticide on the ridge between paddy fields or in irrigation water channels, because of concern about chemical pollution of the wild vegetables, but the Paoli people usually did so. Miyazaki (2002), in his vegetation survey, reported that five plant communities were found in paddy fields in Shuiman, while only one was found in Paoli. Although Paoli people also produced a certain amount of surplus rice in their paddy fields, they used that not to buy meat but for investment in cash cropping. Paoli people endured a poorer diet for a future success of cash cropping.

The environment around the villages has also been affected in different ways. Secondary forest has grown in the previous grasslands and slash-and-burn gardens around Shuiman, while the exploitation pressure on valuable wild plants/animals has gradually increased due to tourism development. Indigenous species of crops grown in slash-and-burn gardens almost disappeared, while the edible plants around the paddy fields have been well preserved. In Paoli village, while the grassland changed to secondary growth, all the areas where slash-and-burn cultivation was conducted before were converted to gardens for cash crops. Indigenous species of crops grown in slash-and-burn gardens also disappeared. Specific species of tree in mature forest were logged for money.

Satisfaction of life

Ownership of industrial goods such as motorbikes or televisions is usually a symbol of wealth in rural Chinese society. In this regard, Paoli people were wealthier than Shuiman people in 2001; there were 28 motorbikes in Paoli, while there was only one in Shuiman. Televisions were owned by 14 households in Paoli but only by 2 households in Shuiman.

Subjective evaluation, however, showed different patterns. Generally speaking, Paoli villagers always complained about the poor life in the village. In contrast, Shuiman villagers tended to evaluate their life positively, explaining "they enjoy eating meat and fish and also drinking home-made alcohol as much as they like", the "burden of daily labour was reduced over time", "they enjoy watching TV in one house in Shuiman even though most of them do not own", and so on.

For systematic evaluation, the authors asked all the villagers about the satisfaction level of their life, and their recognition of the difference between the current situation and ideal situation in many aspects of life (e.g. income, diet, labour intensity, life in general). As was expected, the recognized difference between the current situation and an ideal situation was relatively smaller among Shuiman villagers than with Paoli villagers. For example, ideal household income in Paoli (17,000 Yuan) was more than 10 times of the average reported annual income (1500 Yuan). In Shuiman, the ideal household income (8000 Yuan) was only 1.6 times more than the reported income on average. The fact that the Shuiman people have recently experienced drastic improvements (electricity, road, tourism development) and are exposed to continuous praise for their "traditional" lifestyle from tourism enterprises, may have contributed to raise their satisfaction level. In contrast, Paoli people have devoted themselves to cash cropping so as to have future success at the cost of current life. To raise people's satisfaction level of life is the most fundamental aspect of developmental projects, but the people's subjective evaluation for their life may reflect very recent changes but not the accumulative improvement of their life

Conclusion

Our reconstruction of human-environment relationships in two Li ethnic minority villages in Hainan Island indicated the contrasting transformation patterns between villages that experienced different policies and development processes. Human-environment relationships in Shuiman village seemed to be more stable, sustainable and environmentally-sound than those in Paoli village at present. However, the human-environment relationships were influenced by various factors such as government policy, conditions of the Hainan or Chinese economy, development ideas and decisions of the villagers, and resilience of the natural environment. Any fluctuations in these factors can change the human-environment relationships in Shuiman either toward vulnerable outcomes or more sustainable ones. Paoli people may or may not succeed in obtaining sufficient money from cash crops in the near future, depending on the price of crops and the climatic conditions of the years. The lessons that we learned from the Shuiman and Paoli cases were that it was difficult to generalize the impact of development on the people's survival strategies from individual examples, because they were, by nature, variable over time. People learn from their successes and their failures, and the conclusions of one moment or place can easily be reversed. Only long observation can lead to formulation of paths to sustainably sound development.

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Revitalizing the solar system in Mexico

G. Nava-Bernal, M. Chávez-Mejía, O. Castelán-Ortega, C. Esquivel-González and C. Arriaga-Jordan[1]

For generations, agrobiodiversity in mountain regions has been in the hands of traditional farmers. Traditional systems of knowledge and management have been developed in order to adapt livelihood systems to their specific local conditions. When farmers recognize their unique role and skills their interest in conservation activities is stimulated. Projects on sustainable agrobiodiversity management also encourage farmers to set up their own conservation movements, experiments, demonstrations, and extension services, and also helps farmers to strengthen their livelihoods (Singh 1999).

This paper illustrates how campesinos use and manage plant species in the solar system in the Central part of Mexico. In this system, a number of local varieties of maize are grown with associated crops, as an adapted form of the characteristic Meso-american traditional farming system.

Methodology

Two institutions conducted the PLEC project in the Mexican Highlands. The Centro de Investigación en Ciencias Agropecuarias (CICA) and the Asociación Mexicana para la Transformación Rural y Urbana, A.C. (AMEXTRA) worked in the Mazahua communities of San Pablo Tlalchichilpa, municipality of San Felipe del Progreso, and San Marcos de la Loma, municipality of Villa Victoria, respectively, both in the State of Mexico (see Castelán-Ortega et al. 2003). The communities had worked on agrodiversity management since 1996 which resulted in a very close and successful relationship between the community and researchers.

Criteria were developed to select solar sites that covered the range of socio-economic, cultural, and agro-ecological variability. The selection criteria were:

- Cultural and socioeconomic diversity. At least one site should include ethnic minority members of the family and the sites should reflect a range of socioeconomic status, both between and within sites.
- Strong home gardening traditions reflecting the existence of indigenous knowledge, skills and traditions in managing the home garden system.
- Importance of home gardens for livelihoods and community with a range of home gardens from partly commercialized to primarily used for home consumption.
- Communities had already expressed interest in participating in the project and willingness to cooperate with research partners.
- Accessibility.
- The capacity of local research institutions was evaluated, and those with the greatest capacity to undertake the research were chosen.

The two communities reflect variations in demography, ethnicity, access to markets, distance from natural ecosystems and resource limitations such as water availability and soil fertility. Viable demonstration sites were set up. The sites are not so much physical plots, but rather people-centred processes. Coalitions and partnerships between scientists, local communities and other stakeholders searching for sustainability had to be established. The information was recorded following the campesinos´ own categories for agrobiodiversity management in the solar system.

Solar system

The solar includes the home garden where trees, medicinal, ornamental, ritual and food plants are grown, and the field adjacent to the family house, characteristically an area with high diversity of animal and vegetable species. This space has been identified with diverse names in Spanish as: "huerto familiar" or homegarden, "patio" or yard, "traspatio" or hind-yard, "jardín" or garden, and "solar".

This work considers the solar system as all of the area managed and used by the campesino family corresponding to the house (inguma), and an area for cultivation which may be the agricultural field adjacent to the house (milpa), as well as the borders of the plot (conguare), the orchard or garden, the animal pens (corral), the patio or yard outside the house (trii), and the washing area. The distribution of solar components is not homogeneous. Animal pens may be behind or at the side of the house, the orchard or garden may be at the front, the back or the side of the house.

The spontaneous vegetation from disturbed non-agricultural land (different from wild plants found in the natural ecosystem) includes edges of roads, fields (besanas), footpaths and the borders of solares. Associated vegetation (weeds) of crops is called "vegetación arvense" in Spanish.

Species diversity in the solar

Useful garden and associated vegetation species were identified, and their abundance recorded. For spontaneous vegetation only useful species were identified; and their abundance was not recorded since they are mixed with other species in borders and edges. For example, in the edges of solares, magueys (agave) are associated with shrubs, trees and herbaceous plants.

The arable plot next to the house is the main arable field which is sown usually to rainfed maize. Traditional multi-cropping patterns take place here, associating maize with

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common and faba beans, chilacayote (*Cucurbita ficifolia* Bouche) and squash (*Cucurbita mostacha* Duch). Wheat and oats are also sown. The same cultural practices are undertaken in the solar as in other plots, as described by Chávez-Mejía et al. (1997). Herbicides are not used since the milpa is a source of edible plants (quelites) and forage (hierbas). Weeding is done by hand as the weeds are an important source of forage (64% of the species are used for this purpose), and also for medicinal or food purposes. Weeds as forage are collected in the rainy season from July onwards when maize straw has been used up. Fruit trees receive some pruning in the early stages of their growth, and besides watering, do not receive any other management. Timber from the solar trees, or firewood, is taken from the bigger and older branches of the trees. Species planted for these purposes are cypress, eucalyptus and pine; and are usually given by the local authorities to promote reforestation of the forest areas and plot edges, and some are used in the solar. Table 1 shows the plant diversity in the two communities by use.

Traditionally, Mazahua campesinos did not grow vegetables in specific seed beds or spaces, since the main source of vegetables were the quelites from the milpa. However, government agencies have been promoting vegetable gardens as a means to improve nutrition.

Table 1. Number of species by use type in studied communities

Use	San Pablo Tlalchichilpa	San Marcos de la Loma
Food	75	20
Live barrier	28	
Fuel	32	4
Condiment	5	2
Building	12	
Forage	69	12
Medicinal	89	28
Ornamental	100	12
Ritual	12	4
Shade	11	
Utensils	1	
Other	3	
Two or more uses	86	5

Commercialization

The primary function of most home gardens is subsistence food production. However, in some cases the products are sold in an informal way within the community. For example, fruit trees are purchased from traveling vendors who visit the villages, or in the main town (San Felipe del Progreso). They are planted with the objective of having fruit for home consumption, although the sale of fruit among neighbours is sometimes practised and may bring some cash income. For example, a kilogram of plums is sold at 0.30 US dollars. Capulines (*Prunus capulli*, Mexican cherries) are also sold. Children usually climb the trees and cut the fruit, and women walk to the main road where they sell them at 0.50 US dollars per kilogram. Pears are liked as refreshments, and are usually cut and taken to the milpas where they are given out to the people harvesting maize. They may also be sold on request at 0.20 US dollars per kilo.

The magueyes, usually sown by the border of the solar, have three purposes: for sale as plants, sap extraction, and live fence. The use of the sap from which pulque is fermented largely depends on a campesino's religion. Protestants do not drink alcohol, so they do not extract sap. They either just use them as live fences, or they sell them to Catholic campesinos. Catholic farmers may utilize their own magueyes for sap and consume the pulque; and they may also sell them. Magueyes are sold when they are ready for castration, at a price between US$1.50 and US$2.00.[2] The yield of sap depends on the size of the maguey and the variety, as well as soil moisture and fertility. They yield between 3.0 and 5.0 litres of sap per day for around 90 days. A litre of pulque is sold at between US$0.10 to $0.15. A practice commonly observed is that the magueyes from the solar are given to the older men who can no longer work, so that they sell them and get some cash income - "so that they may buy themselves a soda drink", as commented by campesinos.

The tender stems of nopales (*Opuntia ficus*), are eaten as vegetables, and there are a number of local recipes for their preparation. Some families may eat the fruit (tuna or prickly pears) but this is not a widespread practice in the studied communities. Herbs of the milpa are used as medicinal and ornamental plants, and the shrubs are used for medicine or fuel. Medicinal plants are usually acquired as gifts or exchanged for other plants, and women pick their leaves or stems as required. No special management of these species was observed. Shrubs grow spontaneously in the solar, as is the case for the "devil's herb" or the "donkey herb". They are allowed to grow among the magueyes and nopales, and their leaves are picked to prepare infusions. When their branches dry out, they are used as fuel.

The consumption of quelites begins with the rains in May, and ends just before the frosts set in September, on the eve of the maize harvest. Women and children set out to collect quelites searching for the specific desired species for that meal. Some species, like chivitos (*Calandria micrantha*), are found in the milpas further away from the house or in the open grasslands of the llanos. Some species like rape (nabo or *Brassica campestris*) are found in grasslands or in milpas where herbicides are not applied year after year. Campesinos value it very much, and they regret that they can not find it in the milpas near their houses any more. Two women were identified who collect seed of this species in the fields and grow them in their garden in the dry season. Others are interested in cultivating it. Another woman cultivates quintoniles in the same way.

1. Maguey reaches maturity at 7-10 years when the centre of the plant begins to swell and elongate, sending up a single flower stalk up to 4 m in height. This is cut short by "castration". The top of the heart is cut off creating a cut surface, in which a scar forms. The scar is punctured creating a shallow cavity into which the 'agua miel' or pulque seeps.

The spontaneous vegetation growing on the edges of roads, pathways and fields includes herbaceous plants, shrubs and trees and has an important use as fuel or forage. Campesinos graze their animals on the edges, and cut the branches of shrubs for fuel. There is little care or special management of these species.

Gender analysis

The different values placed on diverse resources and their environmental functions vary according to gender. The gender division of labour resources, knowledge, and products reflect conflict, complementarity, or coincidence of men and women's interest in land use systems. The care for vegetable patches is usually done by women and consists of making fences from available materials such as mesh or shrub branches to keep poultry and other livestock away from damaging the plants. These vegetable gardens are watered and weeded. Women are interested in sowing or planting and looking after ornamental species, while men usually plant trees. Women are interested in medicinal plants since they are responsible for caring for sick members of the family, they grow ornamentals because they feel proud about their achievements in growing beautiful flowers, interest in quelites stems from their responsibility in preparing food, and since food preparation still relies on firewood, women are also interested in these plants. Once planted women rarely give any particular care except occasional watering to medicinal, ornamental and condiment plants.

It was perceived that men have an interest in trees and in planting tree species. Pines, cypress or eucalypts provide wood for home repairs or to build pens for the animals. Both men and women have an interest in fruit trees as a seasonal food resource for consumption and occasional sale.

Agricultural practices modify weed communities such that each type of crop and its management develop a characteristic flora. Each crop with a particular growing cycle and management has certain weeds, and different crop management results in variation in weed communities. Crop rotation tends to diversify weed communities, and monoculture to simplify them. Other factors which affect weed diversity are the use of fertilisers and herbicides. The year-after-year monoculture of maize is practised by most campesinos in San Pablo Tlalchichilpa, which may influence the low diversity indices recorded. However, the main factor which seems to determine the diversity of weeds is the use of fertilisers, synthetic or organic.

Adoption and adaptation of agrobiodiversity

Once the solar was characterized and the systems of biodiversity management among farmers were studied and documented, the restoration of the traditional solar system in the participating communities started, with two main objectives. As preliminary trials showed the traditional solar and associated crops are a way to increase the outputs from limited land area (particularly restrictive in San Pablo and San Marcos), more relevant now in the face of diminishing prices and increasing costs for the monoculture maize cropping. Restoring the traditional crop and other useful plant diversity which was a characteristic of the traditional farming systems, provides a number of ecological and agronomic advantages (Ortega Paczka 1999). These include an increased production of food crops from small areas, increased variety of food and therefore improved nutritional status of the household members, improved soil fertility, increased cash income through the sale of surplus food, and preservation and enhancement of biodiversity.

The work was carried out as on-farm trials so that farmers who have largely abandoned associated crops had the possibility to explore the potential of these cropping patterns under the current economic and social conditions. Milpas of maize/faba/peas, ayocote, or common bean/squash and Amaranthus were established during the spring/summer cropping cycles of 2001 by participating campesinos (Castelán-Ortega et al. 2003). The main outcome of the project was that more than 90% of participating farmers recognized the importance of preserving and enhancing current agrobiodiversity resources. They were also able to appreciate the economic benefits associated with biodiversity preservation and the substantial improvement in the variety and richness of their diets. Table 2 summarizes the main arguments used by campesinos in order to conserve multiple crops in the solar system.

Table 2. Management decisions of campesinos

Campesino	Arguments
Yolanda García from San Pablo Tlalchichilpa	The associaction between maize and beans has the best yield. Peas and faba beans have the best yield only if grown as monocrop. The incorporation of "sand" (pumice) improved the quality of the soil.
Ofelia García from San Pablo Tlalchichilp	In my case, the best way to grow maize and faba beans is to put them in the same place. Maize plants protect faba beans.
Inocente Francisco from San Marcos de la Loma	Planting at the same time and place both maize and faba beans decreased yields, so I suggest to plant alternate strips of maize and faba beans
Octavio Felipe Remigio from San Marcos de la Loma	Planting in the same place both maize and faba beans brought the best yield in my plots. I have used manual weeding and no chemical fertilser to grow my crops.
Cirilo Mariano from San Marcos de la Loma	Maize and faba beans planted in the same place did not work well. Maize plants blocked sunlight to faba beans.

Determinants in the management of the solar system

Lack of labour is the constraint factor in the milpa systems. Campesinos comment that it is difficult to cultivate all the agricultural surface available. For example, one campesino mentioned that he is not able to cultivate more that 2500 m^2 because of lack of labour. He used to grow up to 5 ha of beans (*Phaseolus vulgaris, L*) but his grown-up children have now migrated and it is more difficult to cultivate more land.

In San Pablo Tlalchichilpa, there is an important impact due to the lack of labour to carry out all agricultural activities in the households. For example, weeding is done by hand and requires most of the family members to stay at home. Nowadays, the fields located far from the household are weeded using chemical herbicides, while the solar close to the house is weeded by hand. As a result, the milpa is conserved in association with other crops such as beans, faba beans or quelites. Campesinos from San Pablo mentioned that it is difficult to do the weeding by hand all the time because they require at least ten people during two weeks. Additionally, the costs of producing maize have increased in the last years. Campesinos mentioned that young people prefer to go to the cities rather to stay in the community.

Conclusions

The complex structure of the solar system is influenced by interactions between several factors. Depending on local markets, labour available and traditional cultures, the composition and structure of the solares can vary widely. The results provide an interesting view between conservation and development. Solar resources are oriented towards food security or income generation depending on the concerns of the family. There is a potential to recover or introduce crops. Each participating farmer seemed to adapt associated crop technology to his/her own local conditions. For example, they are concerned that without improving soil conditions, it will not possible to increase crop productivity. Campesinos in San Pablo Tlalchichilpa incorporated "arena" (pumice) to improve the crop yields.

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Reports

Launching the UNU/PLEC-Ghana book

Edwin A. Gyasi

Managing agrodiversity the traditional way: Lessons from West Africa in Sustainable Use of Biodiversity and related Natural Resources. Edited by Edwin A. Gyasi, Gordana Kranjac-Berisavljevic, Essie T. Blay, and William Oduro. United Nations University Press, Tokyo

On 3 March 2005 the book was launched at the University of Ghana, Legon. It is the product of the UNU/ PLEC project which was funded mainly by the Global Environmental Facility.

The ceremony was attended by over 80 people. They included: Deputies of Government Ministers; other representatives of Government Ministries and Departments; the Acting Director of the United Nations University Institute for Natural Resources in Africa; the Executive Director of the Environmental Protection Agency; a Traditional Chief; a representative of the Food and Agriculture Organization; representatives of NGOs; PLEC scientists and other academics; university students; PLEC farmers and their school-going children. Another 13 school children and their teacher provided music.

Proceedings started with an opening prayer by Dr. William Oduro. Subsequently, Prof. Essie T. Blay, introduced the Chairman for the occasion, Prof. Edward Ofori-Sarpong, Pro-Vice-Chancellor, University of Ghana, who said the University was proud of the PLEC work because of its positive bearing upon natural resource conservation and development, and on university research. PLEC, he noted, provided avenues for research and publication towards the University's basic mission of teaching and research. He expressed the University's admiration for the lasting linkage forged between farmers, scientists and policy makers through the PLEC project. He stressed that the book is concrete evidence of PLEC achievements in Ghana and West Africa as a whole. Prof. George Hagan, Chairman of the National Commission on Culture presented a review of the book (see pp. 17-19).

Prof. Edwin Gyasi, Co-ordinating Leader of PLEC-Ghana traced the historical background. A chance encounter with Harold Brookfield in 1992 in Washington D.C. introduced him to PLEC. He also acknowledged the role of the UNU, GEF, the University of Ghana, Prof. Brookfield, PLEC scientists and farmers in the production of the book. He paid special tribute to the farmers and dedicated the book to them.

Mr. Clement Eledi, Deputy Minister of Food and Agriculture formally launched the book on behalf of the substantive Minister. He noted that agrodiversity, which is fundamentally important for food security, is better managed traditionally and indigenously.

Speaking on behalf of farmers, Mr. Emmanuel Nartey, from the Sekesua-Osonson PLEC demonstration site, gave an overview of the achievements and how the project had benefited farmers. These included an increased awareness of a need for resource conservation, soil erosion management, risks of indiscriminate felling of trees, bush fires and bad hunting practices. There have been many and varied outcomes of scientist-farmer collaboration. The PLEC approach is particularly unique since it learns from farmers, and encourages and makes use of farmer knowledge. On behalf of his farmer colleagues, Mr. Nartey appealed to policy makers to emphasize traditional knowledge in land management and rural development programmes.

Mr. Samuel Quarcoopome of the Ministry of Environment and Science read a statement on behalf of the Honourable Minister of Environment and Science. The Minister observed that the book seeks to promote food security, biodiversity conservation, poverty reduction and sustainable development. She was particularly touched by the role women play in food security and biodiversity conservation in Ghana. The theme of the book is in line with the Millennium Development Goals on Sustainable Development in Ghana. She recommended the book to all potential users, especially policy makers, academics and the general public.

Theresa Naa Ameley Tagoe, Honourable Deputy Minister for Lands, Forestry and Mines, who represented the Minister, Honourable Prof. Dominic Fobih, said the government acknowledges the importance of traditional gene pools that provide plant materials for the perpetuation of species, which might be threatened with extinction by habitat destruction. The Biodiversity Conservation Project (HFBCP), she said, has established selected reserves as Globally Significant Biodiversity Areas. The launching of the book was timely since it provided a rich store of knowledge and other useful lessons which will assist in the implementation of HFBCP programme supported by Global Environmental Facility.

A PLEC farmer drew the attention of the Deputy Minister of Lands, Forestry and Mines to indiscriminate felling of rare trees by holders of timber harvesting concessions, which results in destruction of farms. He pleaded for the intervention of the Deputy Minister.

The ceremony was interspersed by melodious renditions of music by school children of the Otwetiri Junior Secondary School, which is located at Otwetiri, a village in the PLEC Gyamfiase-Adenya demonstration site. It concluded with vote of thanks, a prayer, and refreshments after successful auctioning of copies of the book.

Managing agrodiversity the traditional way: A review

Professor G. Hagan
Chairman, National Commission of Culture, Ghana

[This review is adapted from the review presented as part of the book launch in March 2005. Eds]

Knowledge is the basis of human survival, security and development. In all cultures, human beings discover and use knowledge of the physical properties and characteristics of minerals, plants and animals as much for what promotes life as for what endangers and destroys life. This, one finds in even the most remote and isolated communities, rich indigenous bodies of knowledge transmitted by oral and other traditional modes, and, especially by constant application. In folk traditions we find knowledge of the sky and stellar constellations, climate and seasons, rainfall patterns, geography, soil, flora and fauna. One also finds a great variety of practices associated not only with the protection, conservation and management of the habitat and its bio-stocks, but also with the selection, conservation, and propagation of diverse plant and animal species that, in a special way, subserve and sustain their special way of life. Such practices go beyond the demands of mere physical survival: they reflect social and religious options derived from a certain concept of the world and an intense collective moral consciousness about the sacredness of life.

For traditional societies, the protection, preservation and propagation of species of plants and animals represent a primal moral obligation that translates into social and religious obligations embodied and fulfilled in rituals and ceremonies relating to planting and harvest activities. Nature is perceived as a cosmic whole: the earth is sacred and both living and non-living things are sacred. The death of a species, call it "speciecide", is considered to be as grave as human genocide. Some cultures hold funerals for some animals and perform special rituals before felling certain species of plants. The extraction and use of plants and animals imposes, therefore, the obligation of compensatory and restorative propagation of vital resources to ensure cosmic balance.

Few biological and social sciences take this philosophic basis of African cultures seriously enough to see its relevance in their research and intervention protocol - after all such stuff reflects the mystical mentality of the "prelogical mind". This, however, is the innovation and logic of the research approach adopted by the researchers and scholars whose papers appear in the book Managing Agrodiversity the Traditional Way, edited by Edwin A. Gyasi, Gordana Kranjac-Berisavljevic, Essie Blay, and William Oduro. And the publication of the lessons of the research should give new insights to policy makers and development agencies on the use of culture as an indigenous resource for sustainable development in third world countries. Let me clarify this point.

Traditional knowledge, technology, management practices, social institutions, values, world-view, religion and ritual, attitudes and patterns of behaviour have a role to play in Africa's development. Indeed, these constitute the only basis for mobilizing Africa's human and material resources for development. This, however, can have practical meaning only where policy makers are enlightened to see the need for the active involvement of local communities and their leaders in the design of programmes and action for development. To recognize the importance of 'culture in development' and to devise a heuristic approach to formulate, test, demonstrate and apply the idea in real life situations, especially, in the vital area of agricultural production which is strategic not only to the effort to eliminate hunger and poverty, but also to create wealth, is, in my judgment, the most significant contribution that the United Nations University, with its PLEC Programme and the publication emanating from it, has made to the search for effective strategies for African and Third World development.

Besides a Preface, Foreword and Acknowledgements, the book has 21 Chapters presented in four parts. The preface makes this claim: "The PLEC research across the tropical world confirms that inherent in used biophysical environments are indigenous, endogenous, local, or traditional practices that favour conservation of biodiversity through agrodiversity, i.e. agricultural diversification in all its forms – management diversity, agrodiversity, biophysical diversity, and organizational diversity (Brookfield, Stocking, and Brookfield 1999).

The preface bemoans the fact that this cultural heritage, which is fundamentally important for the ecological stability and genetic pool of plants and animals needed for food security, has come under threat mainly because policy and modern development planners and practitioners alike largely ignore it. A lack of emphasis on traditional knowledge in educational curricular associated with exotic values and the absence of relevant textbooks are contributory factors.

And it goes on to state: "On the basis of case studies carried out under nearly 10 years of PLEC multidisciplinary, participatory research work in three major agroecological zone (forest, savanna, and forest-savanna mosaic) in West Africa…this book shows how, traditionally, farmers cultivate and conserve biodiversity while, at the same time, using the land for food production. It highlights PLEC interventions for sustaining agrodiversity for rural livelihoods, as it does lessons for teaching, policy, and development planning. (pp xix,xx)"

The PLEC approach points to "possibly cost-effective ways of recognizing, tapping, demonstrating, and upscaling conservation practices of exceptionally knowledgeable farmers" and also reveals "Ghanaian farmers, both men and women, as skilled, astute, and innovative in the face of quite difficult conditions of uncertain rainfall, low and sometimes declining soil fertility, rising pressures of population on resource, and the effects of globalization on the markets for crops".

For recognizing and addressing these factors, *Managing Agrodiversity the Traditional Way* has to be recognized as one of the most significant contributions to the growing body of literature and knowledge on a subject that I hesitatingly but quite prophetically introduced into the FUE African Studies course in the early 1980s both in the University of Ghana and in the Kwame Nkrumah University of Science and Technology.

The articles in *Managing Agrodiversity The Traditional Way*, rest on a number of major and exciting heuristic assumptions. The first is that Africa has a great variety of plant and animal species. That is, there is a great variety of each type of edible plant like maize, cassava, yam, rice, sorghum, beans pepper, eggplant, okro; and of animals like sheep, goats, chicken, bush fowls, that are deliberately grown to protect, preserve, and propagate them to ensure their survival on the one hand, and the food security and survival of humans on the other.

The second heuristic assumption is that the propagation of the plants and animals rests on a body of traditional knowledge:

- of the names and characteristics of species and subspecies of plants and animals, and the desirable attributes and qualities of each;
- of the soils suitable for the cultivation of each variety of plant;
- of the weather and amount of water or rainfall desirable for each type of plant and the survivability of plants to drought and sparse rainfall;
- of plants suitable for each type and condition of soil.
- of mode of preparing the soil and planting each type of crop.
- of the tools and techniques suitable for cultivating, caring for, and harvesting crops.
- of the half-life and techniques of storage of crops
- of ways of interplanting crops that do well together to ensure good harvest and food security.

These and many other kinds of knowledge are subjected to evaluation in the PLEC research.

The third important assumption of the book is that intervention to improve the management practices of small-scale farmers and ensure greater food security in line with modern or scientific know-how, should recognize the farmer as an active partner in a dialogue and a collaborative effort in which the farmer enters with valuable knowledge and practical experience. This collaboration establishes a model methodology that could be applied in other types of intervention based on local knowledge, for example, in maternal care, child delivery, traditional medicine, environmental hygiene, and agricultural engineering.

And the fourth assumption is that there is a vital link between agrodiversity and biodiversity and their respective conservation techniques and regulatory mechanisms. In several chapters of the book, the link is indicated. Indeed it is clear that conservation of nature's biodiversity and natural biodiversity provided the backup for the practice of agrodiversity and its associated management techniques.

There are a number of factors reported in the book on which traditional agrodiversity was based. Some of these are:

- migration and ethnic heterogeneity tends to increase crop and animal varieties in a community.
- taste and gastronomy make people reject certain crops: e.g. feeling of fullness after eating, digestibility, and allergic reactions;
- prestige and ranking of crops and animals;
- social uses of crops;
- ritual, religious values and use, and beliefs associated with crops e.g. yam in the north;
- social organization e.g. men cultivate the prime area and women the peripheral area;
- quantity and quality of labour required for land clearing, weed control, harvesting and processing;
- mode of preparation and cooking;
- staple and non-staple status;
- aesthetic appeal of crops and animals;
- resistance to drought, insect and disease;
- economic value of crops;
- soil fertility and physical properties;
- resource management and distribution of land;
- time to maturity, and storage life and quality; and
- growth, yield and management techniques.

The book is rich in ethnological material on management practices. And some of the materials raise important questions. With regard to yam domestication practices in northern Ghana, "Fetish priests…commonly domesticate new yam types, brought into the community in shrines, even though individual farmers can cultivate yam brought from the forest on their own. New yam types are cultivated about four to seven years before being given a name…The essence of cultivation in the shrine is to receive blessing of the newly discovered yam types." (p 84) This also serves as a quarantine regime and needs to be further studied.

On the erosion of yam types (p 94), "…farmers believe that the baamamuyegu yam type has spiritual powers and is thus the leader of all yam types. It is believed that it leads the other yam types spiritually during night (to drink water). When this type of yam increases on a farm, there will be a struggle for "leadership" among the yams, and the farmers will lose all other yam types. Thus only experienced farmers keep the baamamuyegu type of yam on their farms." This reads like a folk Darwinian theory. Do the species compete for water in the soil, eliminating those with slow water drawing capability?

And on (p 100), "Women rice farmers also tended to have their farms situated in disadvantaged portions of the toposequence compared to those of men. Their fields, however, are usually better managed than those of man, probably due to the smaller sizes and fewer crops they generally grow." What would happen to women's lifestyle if they are given bigger plots?

Finally, the PLEC approach gives us a model of the steps and activities that may be employed to make interventions in programmes and activities that recognize indigenous people as collaborators and their traditional knowledge as a resource. The question is, can this model be universal in application? Yes and No. Since the PLEC approach is culturally-sensitive community-targeted intervention, the model has always to respond to the social and authority structure of each community, especially on gender issues. Nevertheless the approach should prove useful everywhere.

I congratulate the editors and authors for this brilliant and useful book. This is a book that is marked to be recognized as a classic. It should appeal to scholars, students, policy makers, development agencies and, of course, farmers. To the farmers, I say congratulations.

Farmer to farmer visit to Cameroon

Emmanuel Nartey, PLEC farmer

The practice of PLEC methodologies in ecosystem conservation presented me with the opportunity to travel to Cameroon from 25th April to 3rd May 2005 to share my experience in PLEC approaches towards biodiversity conservation to enhance sustainable land use for livelihood security. The trip was financed by HPI (Heifer Project International) Ghana and based on lessons and practices of *in situ* conservation that I offer to farmer colleagues, especially to beneficiaries of HPI programmes.

At a plenary session during the celebration of 30 years of HPI Cameroon, the Country Director of HPI Ghana gave me the opportunity to make a statement on PLEC methodologies especially collaboration, which has improved the livelihoods of farmers. The statement was based on extracts from the statement read during the launching of the book 'Managing agrodiversity the traditional way: lessons from West Africa in sustainable use of biodiversity and related natural resources' in March 2005. Most of the participants, who are directors of HPI from Kenya, Rwanda, Tanzania, Uganda, Mozambique, Zimbabwe and Zambia and the Senior Vice President of HPI Headquarters in the USA, were impressed and expressed concern that the ecosystem could be threatened if farmers are not involved in decision making towards sustainable land use. I took the opportunity to exhibit the book, after which most of them took addresses and promised to visit the website and possibly call for copies from Ghana.

The main activities of the visit took place in the mid-west province and the western highlands of Cameroon. After the anniversary celebration, I traveled to two farming communities in the western highlands from the North West province. Farmers in the province mostly crop irish potatoes, sweet potatoes, beans, maize, pepper, banana, coffee, plantain and a little of yams. Their staple is maize and beans, and animals ranging from pigs, cattle, rabbits sheep, goats and chicken. Most of their farms can be found around the settlements because of the mountainous nature of the region. Land preparation is made by raised beds along the contours. Compost developed from animal droppings is mainly used to improve soil fertility.

Crops planted in the Western Highlands are almost the same as in the North West province. The western highlands farmers are mostly pig and cattle farmers. Most of the cattle placed by HPI are dairy cows and the farmers have been trained on processing milk into cheese and yoghourt. I had a good time explaining in situ conservation of crops like cocoyam, which are abundant in the areas to serve as food security. Little yam cultivation is practised mainly because of the hilly nature of the areas I visited.

The way forward

The ecological conditions of Cameroon seem more favourable than that of Ghana in terms of rainfall despite the hilly conditions, where sometimes most of the hillsides are barren. Ghanaian farmers could make use of the practice of adaptation. Cameroonians are faster than Ghanaians in planting diverse crops to ensure food security. Intense use of compost in farming could be encouraged in Ghana in order to cut down cost of food production in the area of chemical use.

PLECserv issues since April

PLECserv provides an introduction to recent articles or other publications of interest to people working among developing-country farmers, and concerned about development and conservation. PLECserv, can be found at **http://c3.unu.edu/plec/index.html**. Recent titles are:

53. Interplanting of different rices can lead to gene flows. What are the consequences? April 05, 2005. (Jun Rong, Hui Xia, Youyong Zhu, Yunyue Wang and Bao-rong Lu 2004. Assymetric gene flow between traditional and hybrid rice varieties (Oryza sativa) indicated by nuclear simple sequence repeats and implications for germplasm conservation. *New Phytologist* 163 (2004): 439-445.)

54. Helping the poor within the free market? April 20, 2005. (D. Porter and D. Craig, The third way and the third world: poverty reduction and social inclusion in the rise of 'inclusive' liberalism. *Review of International Political Economy* 12 (2004): 387-423.)

55. Maintaining diversity while changing varieties: rice in northern Thailand. May 04, 2005. (Sirbanchongkran, A., Yimyam, N., Boonma, W., Rerkasem, K., Coffey, K., Pinedo-Vasquez, M. and Padoch, C. 2004. Varietal turnover and seed exchange: implications for conservation of rice genetic diversity on farm. *International Rice Research Notes* 29(2): 12-14.)

56. A land rental market has improved productivity in Ethiopia. May 19, 2005. (Benin, S., Ahmed, M., Pender, J. and Ehui, S. 2005. Development of land rental markets and agricultural productivity growth: the case of northern Ethiopia. *Journal of African Economies* 14 (1): 21-54.)

57. How do people come to accept conservationist thinking?. June 03, 2005. (Agrawal, Arun 2005. Environmentality: community, intimate government and the making of environmental subjects in Kumaon, India. *Current Anthropology* 46 (2): 161-190.)

58. Fair trade bananas: a counter-hegemonic movement?. June 22, 2005. (Shreck, A. 2005. Resistance, redistribution and power in the Fair Trade banana initiative. *Agriculture and Human Values* 22: 17-29.)

59. Resource degradation in Mali: cotton, not the poor. July 06, 2005. (Moseley, W.C. 2005. Global cotton and local environmental management: the political ecology of rich and poor small-hold farmers in southern Mali. *Geographical Journal* 171: 36-55.)

60. Ten thousand tonnes of wild meat in Papua New Guinea a food source at risk. July 21, 2005 (A.L. Mack and P. West 2005. Ten thousand tonnes of small animals: wildlife consumption in Papua New Guinea, a vital resource in need of management. Resource Management in Asia-Pacific Working Paper 61. Canberra, Resource Management in Asia-Pacific Program, The Australian National University.)

People Land Management and Ecosystem Conservation (PLEC) involves a collaborative effort between scientists and smallholder farmers from across the developing world to develop sustainable and participatory approaches to conservation, especially of biodiversity, based on farmers' technologies and knowledge within the agricultural systems of the farmers.

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