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Shortened bush-fallow rotations for sustainable rural livelihoods in Ghana

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NRSP Production System

Forest Agriculture Interface

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ABBREVIATIONS AND ACRONYMS

AEA	Agricultural Extension Agent
AGSSIP	Agricultural Sub-sector Services Investment Project
CRI	Crop Research Institute
CSIR	Council for Scientific and Industrial Research
DDA	District Director of Agriculture
DFID	Department for International Development
EPHTA	Ecoregional Programme for the Humid and Sub-humid Tropics of Sub-Saharan Africa
FORIG	Forestry Research Institute of Ghana
GOAN	Ghana Organic Agriculture Network
GTZ	German Development Cooperation
IARC	International Agricultural Research Centre
IFCSP	Integrated Food Crop Systems Project
IITA	International Institute for Tropical Agriculture
IRNR	Institute for Renewable Natural Resources
IWMI	International Water Management Institute
LEGINC	Integration of cover crops into cropping patterns in Ghana
LEXSYS	Decision support for the selection of legumes for incorporation into tropical cropping systems
MOFA	Ministry of Food and Agriculture
NARES	National Agricultural Research and Extension System
NARS	National Agricultural Research System
NGO	Non-governmental Organization
NRSP	Natural Resources Systems Programme
PRA	Participatory Rural Appraisal
PTD	Participatory Technology Development
RELC	Research and Extension Linkage Committee
SFSP	Sedentary Farming Systems Project
SRI	Soils Research Institute

1. EXECUTIVE SUMMARY

Farming systems in sub-Saharan Africa show a high degree of heterogeneity and complexity, determined by the wide range of socio-economic conditions and access to resources, and environmental diversity. Developing technologies appropriate to such diverse conditions clearly requires careful consideration of farmers' livelihood circumstances, as well as biophysical conditions, and with the equitable input of the farmers.

The objective of the project 'Shortened bush fallow rotations for sustainable livelihoods in Ghana' was to develop land use strategies to convert shortening bush-fallow rotations into sustained and more productive systems, through the process of participatory technology development, by incorporating farmers' indigenous ecological knowledge of management of the fallow into designs sensitive to local tenurial and cultural practices. The project was expected to contribute to the more general purpose of the development and promotion of strategies to secure the livelihoods of poor people dependent on agricultural systems near the receding forest margin.

To meet this objective, the project worked towards developing a process and methodology by which technology options addressing a common constraint across a range of socio-economic and biophysical circumstances could be identified and evaluated. The technology development process drew on an eclectic range of methods, integrating quantitative, qualitative and participatory methods to provide the best vehicle for meeting the project's information needs. A range of technologies was considered to enhance the experiential process, and to develop a 'culture of inquiry'. Participatory field work was conducted in two main livelihood systems, native and settler, in three villages across the forest, transition and savannah agro-ecological zones, namely Gogoikrom (Atwima District), Subriso III (Tano District) and Yabraso (Wenchi District) respectively. The criteria for the livelihood classification was primarily based on origin of farmers, which determined the land ownership status of households and/or individuals and consequently dictates the right, control and access to the use of land for particularly farming. Gender differences were in addition explored within the native and settler households. Five main interventions/technologies were identified as suitable for on-farm experimentation in the study villages. Maize-legume relay, permanent plantain, and cocoa-shade tree technologies were suitable for Gogoikrom-Atwima; maize-legume relay, permanent plantain and planted tree fallow were suitable for Subriso III – Tano, while maize-legume relay, yam-legume relay and planted tree fallow were suited to Yabraso-Wenchi. Farmers tested these technologies over two years, 2001 and 2002.

Farmer experiments were jointly monitored and evaluated by farmers and researchers and socio-economic and biophysical data were gathered by researchers. From the overall evaluation of constraints and opportunities, recommendation domains were identified for the technologies as appropriate for improving farm productivity under shortening fallows in the three study areas. Decision support tools and extension materials were developed from the project's findings to aid further development and dissemination.

The objectively verifiable indicator of the project purpose was to validate (by 2002) new approaches to husbandry and resource management which improve the sustainability and productivity of bush fallow rotations. The contribution to the NRSP purpose was in delivering new knowledge to enable poor people that are largely dependent on the natural resource base to improve their livelihoods. This contribution was both direct, by facilitating improving technologies, and indirect, by transferring new knowledge to the institutions supplying services to poor people.

2. BACKGROUND

Bush fallowing (or slash and burn agriculture), the practice of clearing small plots of land for a few (generally 2-5) years cultivation and then leaving the land under natural vegetation for much longer periods (> 5 years) to restore soil fertility, still remains the commonest agricultural land-use practice in Ghana and much of West and Central Africa. Nutrients are returned to the topsoil during the bush-fallow period as a result of the accumulation of vegetative matter. Trees and shrubs are deeper rooting than grasses; hence they may access nutrients from lower levels, so that restoration of fertility is much more rapid under forest fallow than grass fallow. 'All forms of agriculture remove essential nutrients from the soil in the harvested biomass; hence these must be restored by some means to ensure sustainability' (Upton, 1996).

The biological efficiency of this practice depends on the duration of the fallowing phase, and the structure, composition, biomass and functioning (especially mineral nutrient cycling) of the fallow vegetation. The traditional fallow systems are ecologically sound, indeed some authors consider the practice a rational farming system that reflects indigenous knowledge accumulated through centuries of trial and error, an intricate balance between product harvested and ecological resilience and an impressive degree of agrodiversity, (Cairns & Garrity 1999). However, they take several years to restore soil fertility while natural vegetation becomes established and reaches a peak of biological productivity, ecosystem functioning and nutrient cycling. Due to increased population pressure and the need to cultivate greater land area to produce more food, the long fallow periods have shrunk to a few years and the restoration of soil fertility is insufficient to allow sufficient recovery of secondary forest and rejuvenation of exhausted soils (Cairns & Garrity 1999). The principal reason that has been commonly attributed to this change is increasing population and its attendant decline in land available for farming. Consequently, fallow periods are shortening while cropping periods lengthening leading to rapid degradation of the environment. More generally, the practice is no longer sustainable as crop yields are declining while labour required to control weeds is increasing and the overall household food security and rural livelihoods are being threatened. Many authors have reported that weed infestation is one of the main reasons (with soil fertility decline) for smallholder farmers to abandon a cropped land (Moody & Datta, 1977; Jouve, 1993; de Rouw, 1995; Anderson, 1996; Roder *et al*., 1997; Akobundu *et al*., 1999 among others). In long fallow lands, de Rouw (1995) noticed a rapid growth of the early ligneous seed stock, which overtakes that of the grasses. By contrast, the cropping system with fallowing of less than 6 years (which she called the 'shortening' fallowing system) was rapidly dominated by herbaceous weed species of various groups. Meanwhile, in 'short-cycle' fallow systems (that is, systems with many cycles of 1-5 years of fallow/cultivation) the weed community appeared to be constituted mostly of grasses, among which *Chromolaena odorata* was the most abundant species. Shortening fallows eliminate many stages of natural vegetation succession, which would normally result in secondary forest species, resulting in their replacement by weedy herbaceous species which are thereafter present in the soil seed bank in greater quantities, resulting in greater weediness of subsequent cropping cycles. As outlined by Nye & Greenland (1960) and confirmed in southern Cameroon by Weise & Tchamou (1999), a farmer tends to abandon a stand when he finds easier to obtain subsistence production by clearing and cropping a new stand than weeding the existing one.

Fallows play a crucial role in sustaining rural livelihoods. The fallow vegetation serves a number of purposes, the least of which may be restoration of soil fertility from the farmer's perspective, including being a source of wood (timber, poles, fuelwood, craft/carvings) and non-wood (food, medicines, fodder, thatch) products and protecting soil from climatic agents like rain, wind and solar radiation, (Amanor, 1994). The longer the fallow the more productive it is likely to be as a source of these products and services. Thus, fallows provide means for rural people to generate natural resource-based incomes. Shortening fallows result in scarcity in wood and non-wood fallow products, and hence, the loss of opportunity of supplementing farm income with these products. The social benefits of fallows for food and medicine as well as biodiversity and other environmental benefits also decline (Reijntjes *et al*, 1992). Consequently, fallows are generally of ecological, economic and social importance to rural people and to the nation at large. Non-natural resource-based sources of income may have to be sought for survival resulting in most cases in rural-urban drifts particularly among the youth to seek menial jobs, ultimately putting strain or pressure on already limited facilities in urban areas. Not to mention the many possible social vices and insecurity that emerge in addition to the congestion and its adverse consequences in the urban areas. Improving the productivity of fallows is therefore crucial for sustaining rural/farm livelihoods.

This has generated an urgent need for more sustainable farming systems and/or interventions that can improve the productivity of traditional fallows without exacerbating problems of weediness. Upton (1996), was of the view that with increased population pressure and shortening of fallows, production systems may prove unsustainable without increased use of manure and other forms of fertilizers (organic and inorganic). However, most farmers depend mainly on fallowing, using little or no fertilizers, either organic or inorganic (expensive or not easy to come by) to improve impoverished soils. This implies farm production and income will consistently decline over the years.

Several promising technologies have been developed in the last decade. Short-duration fallows with herbaceous legumes have been examined widely and found to increase yields of subsequent crops compared with grass fallows or continuous cropping systems (van Noordwijk *et al*., 1995; Dreschel *et al*., 1996; Carsky *et al*. 2001; Tian *et al*. 2001). This is also true for tree fallows which have the added capacity, particularly in seasonally dry climates, to take up nutrients from deep soil layers, and accumulate a large quantity of biomass through which nutrients can be recycled (Szott *et al*., 1994). Some trees also add nitrogen to the system by nitrogen fixation (Nair *et al*., 1999). Increases in yield following improved fallows are reviewed by Nair *et al*. (1999) who report that improved fallows are being promoted as a technology for soil improvement in N-deficient soils of Africa (ICRAF, 1997).

There arises the need, therefore, to develop some means of initiating systematic dialogue between farmers and scientists to develop interventions such as these to solve this pressing agricultural problem, through participation. Approaches are needed allowing researchers, development workers and farmers to interact on an action-research process (Defoer, 2002). Soil fertility management is particularly suited to this type of collaborative interaction and learning because it involves many issues that are complex and not directly observable (Defoer and Scoones, 2000). These particular challenges, through the complex nature of resource management, interact with other components of the farming system, and with other members of the community. It is also of critical importance to take account of gender and tenure in the development of appropriate technologies. It is widely accepted that women are disadvantaged when compared to men by the agricultural systems currently prevalent in West and Central Africa. Depending on the inheritance system they have less access to their own land, can farm less due to physical constraints and demands on their time, and need to rent more land and hire more labour. Of course, this is not always a clear-cut gender difference since there are other processes leading to social differentiation. In the forest transition zone, the division is reflected in the predominance of small holdings which cannot meet the requirements of the household, with an economy dominated by small migrant farmers leasing from large landowners (Amanor, 1996). Since there is insufficient land to meet household needs and labour potential, renting land becomes the norm for household members other than the household head, and women in particular depend on leased land to supplement household income. Many migrants to the frontier areas end up working as labourers for large landowners (Arhin, 1985 in Amanor, 1996). In Ghana, land is often given out to migrant farmers on sharecropping terms. The landlord may take one third of the produce, or one third of the land. This system is known as *abusa*, or 'third shares' arrangements. With a growing scarcity of land, landlords are able to demand a larger share of the proceeds, and in many areas the dominant sharecrop arrangement is the *abunu*, or 'half shares'.

'Participation' has become a critical concept in development, and various methodologies have emerged over the last 20 years, originating in farming systems research (FSR) or farming participatory research (FPR), participatory technology development (PTD) and Participatory Learning and Action Research (PLAR), with all advocating agricultural research in the context of the whole farming system, and including some degree of farmer participation. Yet the word 'participation' is contested, and would be interpreted differently by practitioners of these methodologies. Multidisciplinary teams of natural and social scientists have developed FSR (Okali *et al*., (1995), Amanor (1990), Farrington and Martin (1998) and others), while PTD has been evolved largely through the efforts of NGOs to tailor technical solutions to rural reality. As they are absorbed into the broader field of farmer participatory research, experience shows that modes of 'participation' in research can range from 'consultative' (scientists ask farmers for their opinions, usually at the problem-identification stage) to 'collegiate' (farmers control the research process, supported by scientists) (Biggs, 1989; Martin and Sherington, 1997; van Veldhuizen *et al*., 1997). All involve a range of methodological tools, from rural rapid appraisal (RRA) and later participatory rural appraisal (PRA) drawing on the work of Chambers (1997) and others, built into participatory learning and action research (PLAR) (Pretty *et al*., 1995; Defoer & Budelmann, 2000; Defoer, 2002). Considerable developments have recently occurred in processes of participatory monitoring and evaluation (PM&E) (Estrella, 2000), now considered intrinsic to participation. Participatory technology development (PTD), as described in the current context is considered to draw eclectically from all these methodologies.

A widespread lesson from participatory research is the need to 'scale-up'. Much of the research has been small-scale and in communities interacting with an NGO; the need to involve state institutions, NARS, and develop complementary relationships, has been a focus of more recent developmental research (Farrington and Lobo, 1997; Farrington and Thiele, 1998; Hagmann *et al*., 1998; Lawrence *et al.,* 1999).

The objective of this project was therefore to *develop a process and methodology* which would define the functionality and dynamics of the existing farming system; identify specific gender roles within the system; and build up rapport between researchers and farming communities such that, through the process of Participatory Technology Development, interventions for shortened bush fallows could be developed under regimes sensitive to local livelihood circumstances.

3. PROJECT PURPOSE

The project purpose was to develop land use strategies to convert shortening bush-fallow rotations into sustained and more productive systems, by testing and developing three interventions:

- improved management of natural fallows,
- planted improved fallows
- conversion of short fallow cropping systems into perennial agroforestry systems.

The objective was to examine farmers' indigenous ecological knowledge of management of the fallow and to design with them management regimes sensitive to local tenurial and cultural practices.

The purpose was subsequently reconsidered to reflect revisions in the Forest-Agriculture Interface logical framework introduced after preparation of the project documents. The project was expected to contribute to the development and promotion of strategies to secure the livelihoods of poor people dependent on agricultural systems near the receding forest margin. The objectively verifiable indicator of this purpose was to validate (by 2002) new approaches to husbandry and resource management which improve the sustainability and productivity of bush fallow rotations. This emphasis did not change the planned project activities.

4. OUTPUTS

4.1. Output 1.

The functionality and dynamics of the existing farming system characterised; specific gender roles within the system identified; and a rapport between researchers and farming communities enabled so that the process of Participatory Technology Development can be developed.

OVI: Reports on at least five village communities in Ghana on farming systems inputs, and collaborating farmers and technologies developed by June 2000.

The broadly descriptive elements contributing to this output were developed using a range of PRA tools, and documented in Obiri *et al*., (2000). Annex A describes in detail the tools used and the development and outcome of the process. Full details of the application of the process, implementing technology development, designating recommendation domains and identifying promotion pathways are provided in Annex C. Following initial PRA activities, it was decided to focus on three communities, instead of five, for logistical and practical reasons. Two main livelihood systems, native and settler were distinguished in three villages namely Gogoikrom (Atwima District), Subriso III (Tano District) and Yabraso (Wenchi District) in the project area. The criteria for this classification was primarily based on origin of farmers, which determined the land ownership status of households and/or individuals and consequently dictates the right, control and access to the use of land for particularly farming. Gender differences were in addition explored within the native and settler households.

An analysis of the farming systems and more specifically, the livelihoods of the three villages in the study area revealed that the populations in Gogikrom and Subriso III were dominated by settlers, the majority of whom are tenants accessing land for cultivation through mainly sharecrop arrangement and rental by cash. The population of Yabraso on the other hand was dominated by natives cultivating land owned. It was observed that the livelihoods of at least 90% or more of the population in these villages depended largely on the cultivation of land/soil as farming was the main occupation and income source for households. Nevertheless, some 30-40% of the farmers may in addition be involved in variable off farm employments. Livestock, particularly, chicken, goats and sheep were kept although not in large numbers for food and sale to supplement farm income.

Five main interventions/technologies were identified as suitable for on-farm experimentation in the study villages. Maize-legume relay, permanent plantain, and cocoa-shade tree technologies were suitable for Gogoikrom-Atwima; maize-legume relay, permanent plantain and planted tree fallow were suitable for Subriso III – Tano, while maize-legume relay, yam-legume relay and planted tree fallow were suited to Yabraso-Wenchi. Farmers tested these technologies over two years, 2001 and 2002. Farmer experiments were jointly monitored and evaluated by farmers and researchers and socio-economic and biophysical data were gathered by researchers. From the overall evaluation of constraints and opportunities, recommendation domains were identified for the technologies as appropriate for improving farm productivity under shortening fallows in the three study areas.

In terms of whether the project had provided new knowledge to farmers; those who experimented with the maize-legume relay, permanent plantain and the improved/planted tree fallow described their experience with the legumes for improving soil fertility and suppressing weeds as new knowledge they have acquired. Before the introduction of the technologies, no farmer in any of the three villages had ever deliberately planted any plant species to enhance fallow productivity or planted trees in plantain to enhance yield. 12% of the participating farmers interviewed reported of seeing non-participating farmers planting *Canavalia* on their fields. Similarly, the cocoa experimenters in Gogoikrom mentioned the deliberate planting of shade trees as new knowledge as shade trees on cocoa fields more usually occur from naturally occurring coppice shoots of desirable trees left during clearing of the vegetation to plant cocoa (cocoa farmers traditionally plant cocoa under thinned secondary forest, but suitable areas for forest clearance are becoming scarce resulting in new plantings on, particularly *Chromolaena*-dominated fallows. This therefore requires the introduction of shade species). For the cocoa farmers planting systematically at wider spacing was new as this had never been done in the village. At least 53% of the participating farmers interviewed had observed non-participating farmers adopting the technology. The paring of plantain suckers associated with the permanent plantain experiment was also a new technique farmers learned as this had not been practiced in Subriso III and Gogoikrom where this experiment was established. Farmers were very appreciative of the faster development of pared suckers producing many other suckers at the stem base making available planting material for extension of the plantain farm or sale to earn income.

Early indications of further adoption and dissemination were positive; 88% of the maize farmers observed that noxious weeds such as *Panicum maximum, Rotboellia exaltata, Cenchrus ciliaris* and *Chromolaena odorata* were suppressed on their fields by the introduction of legumes. They also observed moist soil conditions beneath the legumes and they anticipated that the reduction in weed competition and improvement in soil moisture would further increase maize yield when their experimental fields are cultivated in the 2003 growing season. The majority of farmers indicated that they would extend the technologies to other fields in the 2003 growing season. Knowledge was being effectively disseminated farmer to farmer with 88% of the farmers trying the various technologies reporting of having discussed the new techniques they had learnt with friends and relatives in their respective villages as well as some visiting friends from nearby villages such as Techimantia (Subriso III). In Gogoikrom-Atwima, some nearby villages like Abasua and Kyenedaso approached the project for support in implementing cocoa-shade tree experiments. The chief of Abasua had already started a tree planting project with his subjects, thus planting cocoa and shade trees was a an opportunity to encourage his people to plant trees.

4.2. Output 2.

Three interventions for the improvement of bush fallows developed and tested and the mineral nutrient cycling; weed management and biodiversity of the unmanaged fallow characterised and scientific evidence of the effects of different management regimes on soil and crop productivity obtained.

> *OVI:* Trials established and interventions adopted and adapted by participating farmers by December 2002 and scientific evidence of mineral nutrient cycling status, weed management and interactions of existing and improved fallow systems generated by June 2002.

Following the initial PRA activities, it was realised that restricting the choice of interventions would be counter to the objectives of encouraging wide participation, and monitoring adoption and adaptation would be better served by facilitating a wider range of interventions. For example, adding materials to farmers' fields or part of a field that is about to be put into fallow. It was perceived that, if there were 4-5 examples of this, these would constitute a sufficient presence to enable discussion, comparison of experiences that would have an acceptable degree of rigour. The monitoring activity would be the joint farmer-extension-researcher discussion of the outcome of the intervention. Thus, a broader range of interventions were considered than initially planned (Annexes B and C).

On-farm trials of the interventions/technologies were established in the study villages. Maize-legume relay, permanent plantain, and cocoa-shade tree technologies in Gogoikrom-Atwima; maize-legume relay, permanent plantain and planted tree fallow at Subriso III – Tano, and maize-legume relay, yam-legume relay and planted tree fallow at Yabraso-Wenchi. Demonstration sites were established at Wenchi Agricultural Station (WAS) and on community lands in Gogoikrom and Subriso No. 3 to facilitate exposure visits by the farmers and for seed multiplication in the first year of the project. On-station trials were established at WAS to address gaps in technical knowledge relating to time of planting and legume planting density; to establish any phosphorus limitations and to screen introduced legumes for biomass production and growth characteristics. Full details of these trials are provided in Annex B.

The results from farmers' assessment of the experiments in the first year were not encouraging as most of the experiments did not establish well due to sudden drought soon after they were planted. Maize yield in the legume intervention plots did not show an increase over the control (Figure 1a), although with control yields of greater than 3.5 t ha^{-1}, it is unlikely that the intervention would have resulted in increased yields anyway (Vanlauwe *et al*., 2001). Timely planting of experiments, reduction of spacing for legumes in the maize and planted tree fallow, timely production of adequate planting materials for plantain, planted tree fallow and cocoa-shade tree and timely supply of planting materials for all experiments were identified as key activities that required tackling in the second year if the experiments were to be successful.

All the above concerns were addressed in the second year and the rainfall distribution was good throughout that growing season. Consequently, by the end of the growing season all the experiments had successfully been established except the yam-legume relay in Yabraso which, because the first year farms were mixed could not be continued. The effects on maize yield showed an increase in this season (Figure 1b) of up to 40% over the control, which is within the range predicted by Vanlauwe *et al*. (2001), for maize-legume relays with maize grain yields in control plots of between 2-3 t ha^{-1}. However, the farmers' evaluation indicated that positive effects on weed suppression and moisture conservation as a result of legume cover had been realised and were equally, if not more important outcomes. Judging from this, farmers were hopeful of an increase in the yield of a succeeding maize crop in the coming season as they anticipated decomposition of the legume biomass and conserved moisture to improve soil fertility. They also anticipated a reduction in the labour for clearing the legume fallow as compared to the *Panicum*, *Cenchrus* and *Rottboellia* grass and/or *Chromolaena* fallow on the control plot. Preliminary estimates indicate this to be the case (Figure 2) and further recording is currently taking place (Annex C). The permanent plantain, cocoa-shade tree and planted tree fallow experiments were not expected to yield results until the next season, although farmers anticipated positive results judging from the good growth and establishment of the plants. Farmers gave as much importance on positive effects in reducing labour requirements, and provision of food from dual-purpose legumes as they did on their aggregate concept of soil fertility ('strength', crop yield, moisture-holding capacity where a fertile soil is regarded as one that is moist (not water logged), on which the standing crop has dark green leaves and is likely to give a good yield (Obiri *et al*., 2000)).

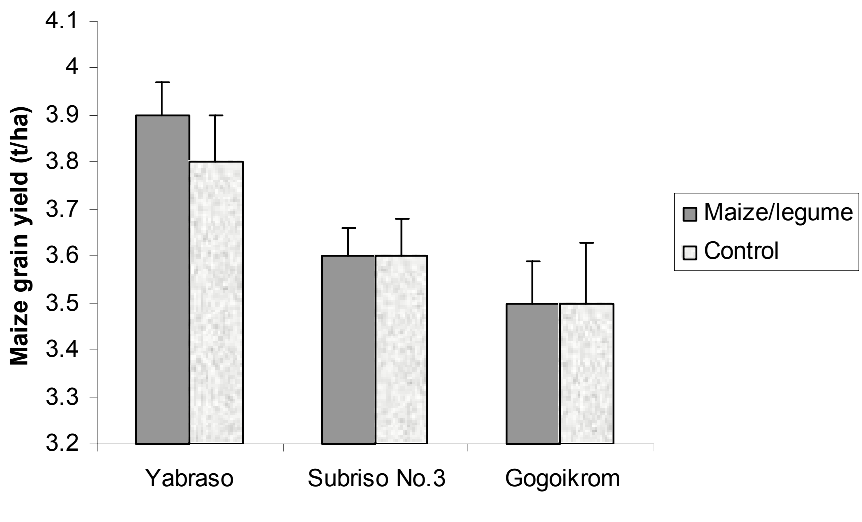

Figure 1 a) On-farm maize yield 2001

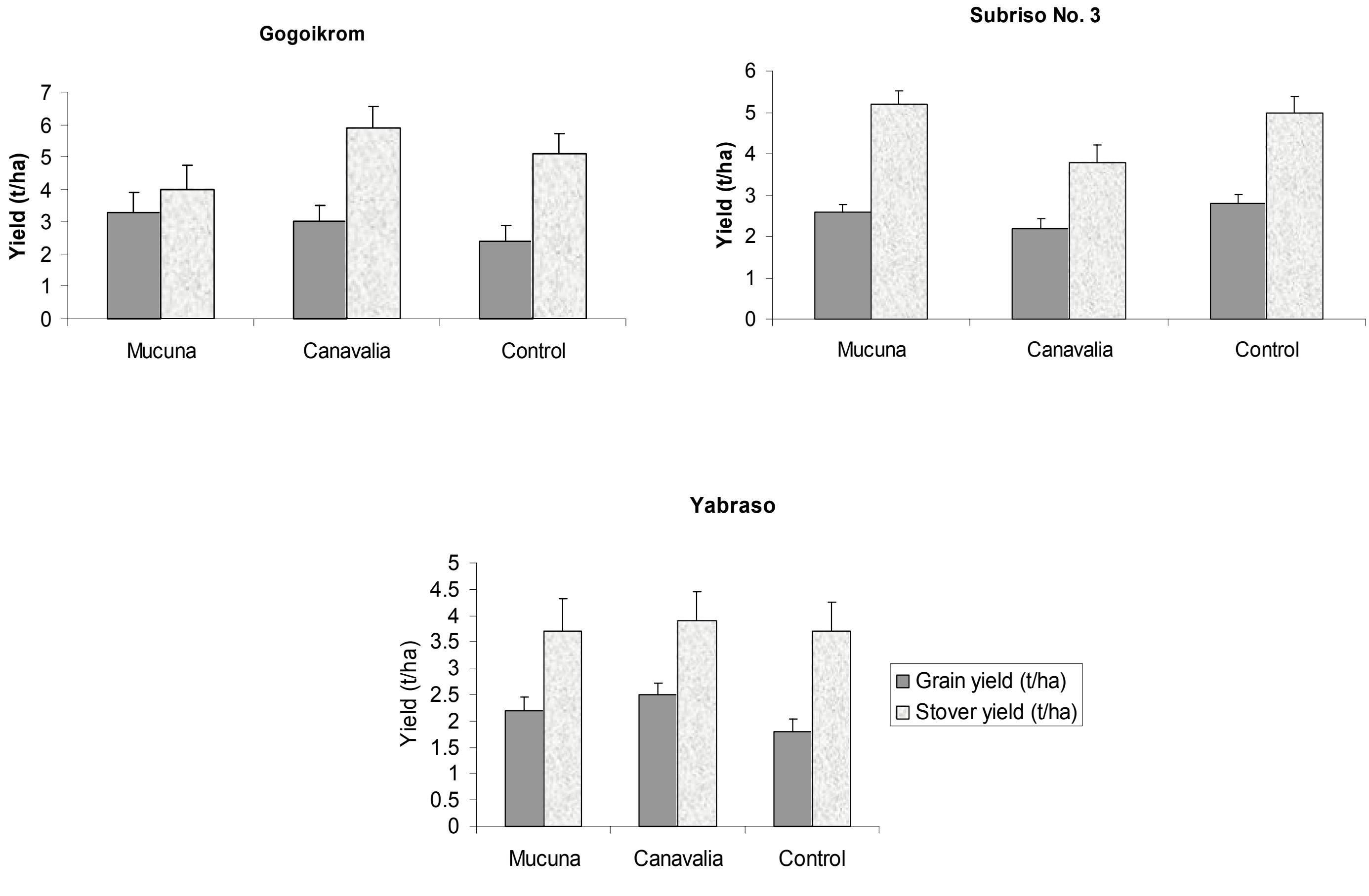

Figure 1b): On-farm maize yield 2002

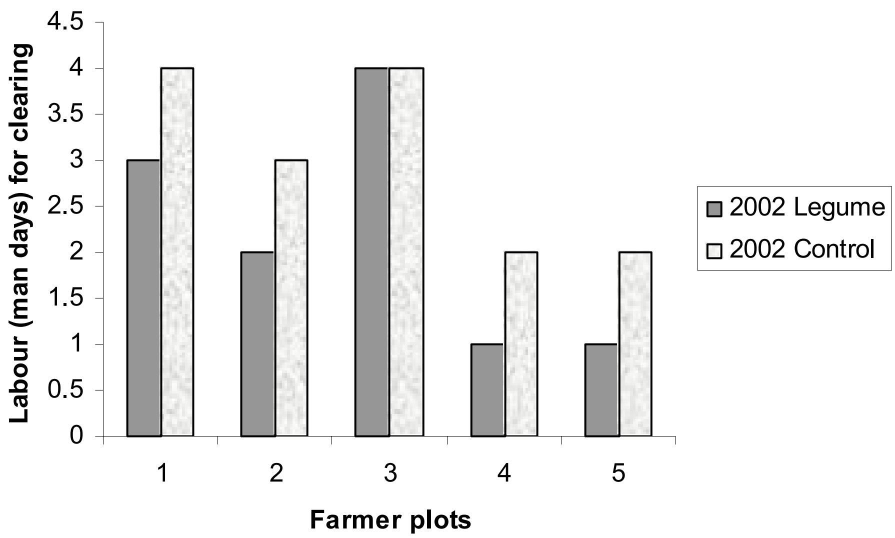

Figure 2: Estimates of labour required for clearance (per farmer trial plot)

4.3. Output 3.

Extension manual of techniques for the improved management of fallows for West and Central Africa produced together with smaller site-specific handbooks in local languages.

OVI: Manuals and extension materials produced and disseminated by December 2002.

The same issue relating to output 2 arose and was discussed during the mid-term review. We perceived the need to reassess the individual fallow/soil management practices that were assembled, and to broadly describe the opportunities and weaknesses of each of these, and to assess the importance of these strengths and weaknesses in the different contexts (agronomic, social, economic etc.). The process of developing such a matrix was seen to be an important decision-making research tool if the farmers' and the research experience overall is added. NRSP could then utilise it more widely. Consequently, it was decided to realise opportunities for interactively-produced decision support tools as being one significant methodological output from this research. An option presenting considerable 'value for money' was the development of LEXSYS. LEXSYS was conceived and developed by the International Institute of Tropical Agriculture with NARS and IARC collaborators in West and Central Africa interested in integrating legumes into farming systems. The computerised database contains information on 113 tropical herbaceous and shrub legume species and a small number of woody legumes and tropical crops. However, due to problematic programming, and limited dissemination, there has been little use made of this tool. We redeveloped the database and have disseminated widely (Annex D). LEGINC was a further development based on information generated by the project. The tool asks a series of questions for the user to respond to, and provides a suitable way (or ways) of integrating legumes into cropping patterns. So far four main areas are (fully or partially) covered by the decision support tool:

1. *Integration of the legume into an ecological system niche in the existing cropping pattern*
2. *Matching the legume to desired products or services*
3. *Matching the legume to site conditions*
4. *Matching management of the legume to farmers' labour and management constraints*

Detailed information sheets are an output of the decision process. They are designed to be concise but provide as much useful practical information as possible (Annex D and attached c.d.).

More traditional extension material was produced in relation to the cocoa/shade tree intervention, at the request of the farmers, and the extension services. Farmers in Ghana traditionally plant cocoa in thinned secondary forest, and so have few tree management skills. Cocoa extension has recently been transferred to the Ministry of Agriculture from the Cocoa Board and this extends beyond their previous mandate and knowledge. Thus, a clear need was expressed. The leaflets have been produced in draft (Annex E) and will be distributed by organising village community meetings to explain and distribute the leaflets to the farmers. This will cover not just Gogoikrom but Abaasua and Kwankyeabo - the two other communities which received project support. Another key dissemination channel is using the Agricultural Extension Agents (AEA's) operating within the various communities. Workshops will be organised for the AEA's and some key farmers to explain the material to them and then pass on the leaflets to them for onward and effective dissemination. This will include all our participating farmers (130 farmers), who will also be sharing the material/information with colleague farmers within and in neighbouring communities in a multiplier effect.

5. RESEARCH ACTIVITIES

Initial participatory appraisal and knowledge acquisition

Building on the EPHTA resource management surveys throughout the Forest Benchmark which identified resource management domains of contrasting livelihood situation, this research was initiated with "targeted" participatory appraisal and knowledge acquisition. This participatory rural appraisal principally involved researchers from FORIG and MOFA interacting with the farmers. The communities were from areas representative of major farming systems but constituting groups/households that have contrasting livelihood situations.

Three districts were selected based on ecology and livelihood strategies (Figure 3). Atwima District lies in the moist semi-deciduous forest zone (Southeast Sub-type), favourable for cocoa production. The district is the major Cocoa District of the Ashanti Region where most old cocoa lands are being replanted after several years of abandoning and conversion into food crop production. This made it a suitable place for testing and developing the multistrata cocoa-foodcrop-tree agroforestry intervention aimed at converting short fallow cropping systems into perennial agroforests.

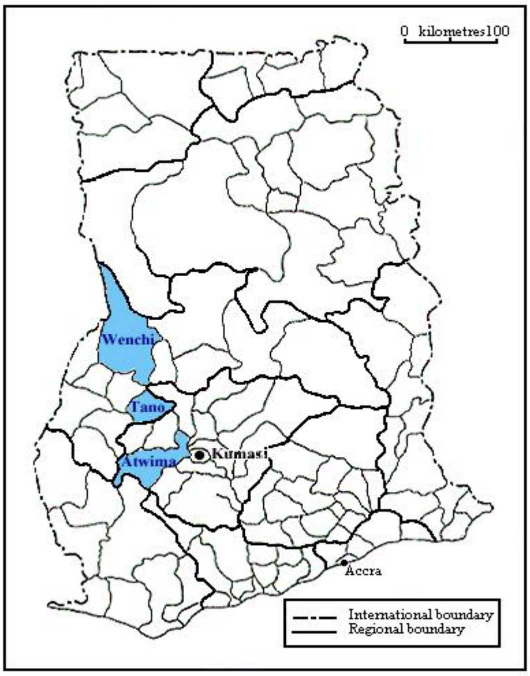

Figure 3: Map of Ghana showing the 3 study Districts

Tano and Wenchi Districts are located in moist semi-deciduous forest (Northwest Sub-type) and the dry semi-deciduous (forest-savanna transition) zones respectively. These districts are typically characterized by rapidly shortening fallow periods that have been caused by changes in the farming system (resulting from drought, wild fires, population pressure, etc.) from cocoa tree-based into mainly maize, yam and vegetable systems. The process of savannisation is evident in these areas as the vegetation in most previously forested farming areas is rapidly changing and being dominated by grasses such as *Panicum maximum*, *Pennisetum purpureum* and *Imperata cylindrica*. The prevailing shorter bush or grass fallows allow more intensive land use and therefore require maintenance and/or improvement of soil fertility for more sustained farm productivity.

Initial RRA/exploratory surveys of a number of farming communities in the three districts were undertaken to select study villages as pilot sites to represent major farming systems in each ecological zone for detailed characterization to be followed by testing and developing of suitable interventions. The various District Directors of Agriculture (DDA's) proposed candidate areas suitable for implementing the interventions in the three districts. The team in consultation with the DDA's and Agricultural Extension Agents (AEA's) identified candidate areas where PRA exercises could be conducted. For each district, a two-day familiarization visit was conducted to tour the selected areas by the team (comprising research and extension staff). A number of farming villages were visited to secure general information on the farming system. At each community visited information on the farming system, particularly, the major crops grown, ethnic background of the people, land availability and tenure (acquisition), trends in agricultural production, availability of fallow lands, trends in fallow periods and production constraints among others was obtained. The team deliberately avoided larger settlements and settlements along major trunk roads. This was to ensure that the study villages are not too big in size to enhance cohesiveness and are typical farming villages with the majority of the people in farming.

In the Tano and Wenchi areas intensively vegetable cultivated areas were also ignored. This is because first of all there was hardly any fallowing as such production systems are heavily dependent on inorganic fertilizer and other agro-chemicals. Vegetable cultivation was most often in rotation with a two-year cassava crop, which farmers believe rejuvenates the fertility of soil. Furthermore, another DFID project, "Integrated Food Crop System Project" has worked on improving the productivity of vegetable system in certain parts of these districts, thus there was no point re-inverting the wheel. It was also observed that fallows were particularly important in maize and yam production systems as no fertilizers are used and productivity decline is usually restored by the shortening natural fallow.

In the Atwima District, Gogoikrom was selected as the pilot study village whereas in the Tano and Wenchi Districts Subriso No. 3 and Yabraso were chosen respectively as pilot study villages.

Stakeholder workshop and development of technology options

To ensure maximum use was made of the diagnostic phase, a workshop was held soon after the collection of baseline/PRA information. The aim of the workshop was to present the PRA findings to all project collaborators (UWB, FORIG, IITA, MOFA, GOAN, etc.) and other stakeholders namely, District Agricultural Officers, Cocoa Research Institute of Ghana, Crops Research Institute, University of Science and Technology and the GTZ Sedentary Farming Systems Project.

The information so presented was analysed/discussed to consider local ecological, agronomic and socio-economic (cultural and tenurial) conditions. The major constraints to farmer livelihoods were considered and a range of interventions conceived. After analysis and discussion of the livelihood systems, ten interventions were proposed to alleviate the identified constraints, six of which were considered to be mutually applicable to Wenchi and Tano and four to Atwima. Protocols on various interventions were then developed for discussion and rating by farmers in the three districts.

Farmers rated the proposed site-specific workshop interventions to assess suitability with respect to socio-economic, cultural and ecological needs (preferences, species, tenure, other constraints) to refine them to suit farmers. It was also to set priority on interventions to be implemented based on most preferred farmer choices, and ecology. The interventions were first presented to farmers in the three villages in separate fora for discussion and to assess their preferences for the interventions for prioritisation. The proposed interventions were represented pictorially, to simplify or facilitate presentation of the interventions to farmers. It was also to ensure that farmers understand the technological components and their respective functions. However, the descriptions were intended to be frameworks for the farmers' to consider and adapt to their own circumstances. The description covered technological components and problem(s) the intervention was to address as well as potential benefits. After each of the options had been thoroughly described, farmers asked questions for clarification. The farmers were then given a sheet with the pictorial interventions and twenty matchsticks. They were asked to distribute the twenty match sticks among the interventions presented; giving the highest number to the intervention preferred most, the next highest to the second preferred intervention in that order. The results were disaggregated on the basis of gender and tenure (Annex C). The data on the various ratings made by farmers was analysed by researchers to ascertain priority choices for the interventions among the different strata of farmers. The outcome was presented to the farmers and reasons for the observed scores or preferences were discussed. Following the second discussion with the farmers, and their further iteration, feasible on-farm interventions were developed from the prioritised choices made by farmers.

On-farm and on-station trials

Feasible on-farm interventions were selected among the prioritised choices made by farmers by the researchers upon a second analysis of the information from discussions with farmers on their priority choices and local production systems. After the presentations and discussions, farmers interested in particular technologies for on-farm experimentation were then listed. Roles that farmers, researchers and extensionists would play during experimentation were also defined. Researchers and extension agents were to assist farmers technically and with some planting materials whereas farmers were to manage their fields (which should have at least a year's tenancy remaining in the case of tenants), plant crops and weed when necessary. At the beginning of the second year, the previous years' activities were first reviewed with the farmers to identify bottlenecks that required redress. The review was followed with the discussions on the experiments to remind the farmers of the functions of the technological components, after which they exercised their choices for on-farm experimentation. Researchers developed field protocols based on the local cropping patterns for the on-farm experiments. For maize and yam experiments, the protocol was developed for combination of appropriate legume cover species with particular crops and cropping patterns. This was based on earlier discussions with farmers on technological components.

Farmer field trips were organized during the first and second years of experimentation to expose farmers to researcher experiments and those of farmers participating in a GTZ project in other parts of the Brong Ahafo Region. Participating farmers in the 3 villages visited the project demonstration plot at the Wenchi Agricultural Research Station during the first year. During the second year farmers of Gogoikrom and Subriso III went on exposure visits to GTZ-MOFA farmers' plantain experimental plots in the Asunafo District of the Brong Ahafo Region. The objective of this trip was to enable the farmers to interact with farmers having more experience of the technology. The farmer experiments visited included plantain-legume (*Canavalia*, *Cajanus cajan*), plantain-animal manure and plantain-household residue systems. The farmers owning these experiments explained how they went about establishing their fields and what they expected to gain. The farmers in addition had the opportunity to visit GTZ maize-legume (*Mucuna, Canavalia* and *Cajanus*) experiments in the Sunyani District. The briefings from farmers, GTZ and MOFA staff on the various experiments visited strengthened the visiting farmers understanding of strategies for improving productivity of maize and plantain systems. The exposure visits facilitated social interaction between farmers from different communities, which permitted exchange of ideas and experience. This served to increase farmers' confidence in their experimentation.

Monitoring and evaluation

The on-farm experiments were jointly monitored by researchers and farmers at the start of each planting season, mid-way through the cropping cycle, and at harvest. The first monitoring visit was done to ascertain whether participating farmers had planted their fields. Thereafter, the performance of the food crops, trees and legumes legume growth and performance was monitored throughout the growing season; and farmers' behaviour/attitudes and perceptions and management, tenure and environmental factors that were impacting on the process. Quantitative assessment of the on-farm experiments was conducted with participating farmers at the end of each season for the two seasons. An open-ended questionnaire interview of individual participating farmers was first conducted before following up with group discussions in a village meeting. Matrix scoring was conducted using matches. The farmers' allocated a fixed number between the different criteria against which each indicator was being judged.

Promotion

Decision support tools were developed to outline guidelines for adoptable interventions to improve fallow management. Recommendation domains were described by synthesis of results from the initial PRA, subsequent experiments and farmers reactions to them, including formalisation of farmer decision criteria relating to adoption of interventions. These tools have been widely disseminated (Annex D). Extension materials were developed in relation to the cocoa/shade tree intervention, at the request of the farmers, and the extension services. These will be distributed by village community meetings to explain and distribute the booklets to the farmers. Workshops will also be organised for the AEA's and some key farmers to explain the material to them and then pass on the booklets to them for onward and effective dissemination (Section 4.3).

6. ENVIRONMENTAL ASSESSMENT

The project had beneficial environmental impacts. The incorporation of biological material into the interventions increased biodiversity both in terms of biological organisms and more generally by provision of habitat by increasing perennial cover on farmers' land. The species used were largely already naturalised in the areas where the work is proposed. Work accomplished under the Alternatives to Slash and Burn Programme has identified shaded agroforests as having significant environmental benefits in terms of biodiversity, carbon stocks and watershed function. With successful establishment, up to 70 tons of carbon ha^{-1} can be sequestered over a bush fallow. Quantification of this is on-going in on-station trials (Anglaaere, 2000). The farmers' indicated (although there was no evidence to date) that they would be more prepared to protect their farms from wild fires if they had made an investment in planting of, particularly, tree species.

7. CONTRIBUTION OF OUTPUTS

The Goal of the Natural Resources Systems Programme is to generate benefits for poor people by the application of new knowledge to natural resource (NR) systems. This has been at least partially achieved through delivering new knowledge that can enable poor people who are largely dependent on the NR base to improve their livelihoods (see section 4.1). The central focus of knowledge generation is on changes in the management of the NR base that can enhance the livelihood assets of the poor over a relatively long timeframe, thus providing greater livelihood security and opportunities for advancement of poor individuals, households or communities. Thus, there is a need for longer-term monitoring, which is being facilitated by the target institutions. Integrated management of natural resources is central to the research. The term 'integrated management' defines not only the adoption of a holistic view of the NR base (landforms, soil, water, vegetation and organic residues) but also appreciates the integrated and dynamic nature of people's livelihood strategies and how these affect their decision-making and capacity to use and manage the NR base. Studies of the livelihoods of the poor and their interaction with other (less poor) sections of society are an important part of NRSP's research, and this emphasis will be maintained in the continuing research led by FORIG with multidisciplinary teams.

The goal of the forest/agriculture interface production systems is to improve livelihoods of poor people through sustainably enhanced production and productivity of RNR systems. The outcome of the technology testing so far has indicated the potential to demonstrate improved productivity and stabilisation of short fallows, meaning that the farmers themselves will adapt the technologies. Communication of this to target institutions has resulted in the incorporation of the outputs in the programmes of these institutions and thus further promotion to be resourced by them. The work fits in with the current and future research profiles of the target institutions and will be a starting point and basis for their future activities and dissemination. At this stage of the project period, we are at different levels of testing with the different interventions, and the ongoing monitoring will therefore be assumed by the target institutions. The lead target institution for this is CSIR and the project has strong linkages with them. Dr Cobbina, previously the local collaborator at FORIG for R7446, is now technical specialist in charge of natural resource management in CSIR, and one of his primary responsibilities is implementation of AGSSIP. AGSSIP is resurrecting the Research and Extension Linkage Committees (RELC) and our team has been assisting in preparing the guidelines for this, drawing on outputs of R7446. CSIR are the lead organisation within RELC. R7446 is continuing as an AGSSIP funded project (Nov 2002-Dec 2004) with FORIG as the lead institution.

The CSIR-Ghana has mandated all research institutes under its umbrella to develop demand driven and user focused technologies appropriate for adoption by end users under the National Agricultural Research Project (NARP) the CSIR emphasized the importance of socio-economics and Farmer-Research-Extension linkage to facilitate this process. The Crops Research Institute under the Ghana Grains Development project funded by CIDA and the Savannah Agricultural Research Institute funded by GTZ are two main institutes of the CSIR which have had the to opportunity to involve farmers extensively in technology development by way of on-farm trials using the farming system research approaches and other methodologies, and will build on the outputs of R7446

Technology development with end users is still not well entrenched in the activities of most of the other CSIR institutes. The documentation of the PTD process adopted by the Bush Fallow Rotation Project is thus of enormous importance to the CSIR. This, together with the decision support tools will be useful to a number of institutes including the Forestry, Crops, Soils, Animal, Food and Oil palm Research Institutes for adaptation or as guidelines for technology development.

To FORIG, the project was timely. FORIG has over the years been conducting mainstream research and consultancies to its clients. The institute revised its mission in accordance to the CSIR mandate of conducting demand driven and user focused research for its clients. Research on issues on forest and environmental degradation were given prominence. The identification and processing of lesser-used timber species as alternatives to reduce the degradation of the traditional well known species has also become paramount on FORIG's agenda. Technologies for sustainable use and development of non-timber forest products by local communities needed to be developed to enhance rural livelihoods. Farmers and local communities have identified as target groups that need to be involved in the development of suitable natural forest rehabilitation and plantation/agroforestry schemes particularly off-reserve areas to improve the vegetation and land resources at the Forest-Agriculture interface. All these require skills in participatory approaches which were not well developed in FORIG. The project was thus of great value to the institute as the FORIG members on the project team (scientists and technicians) have had first hand opportunity to develop skills in participatory approaches with farmers. Skills have been acquired also in the acquisition of local knowledge for integration into technology development, development of rapport with farmers or local people, development of technologies like the cocoa-shade tree and planted tree fallow that are of crucial importance of improving land productivity and generating other products that the institute can comfortably include/continue under its agroforestry programme.

The Ministry of Food and Agriculture (MOFA), particularly its Agroforestry, Land and Water Management Division of the Crop Services Directorate, as a major target institution, with other stakeholders and farming communities can now provide a better platform for the process of PTD and collaborating with a wider range of stakeholders. Particular mention has been made of the opportunities of getting researchers, MOFA staff and farmers together through community meetings and seminars and workshops to build a team for the purpose of improving agricultural production and protecting the environment. The demonstration and/or trials plots established both on-farm and on-station have contributed to raising MOFA's image. Research institutions, universities, agricultural colleges, NGOs (both local and international), farmers, agricultural extension agents and other beneficiaries have visited and continue to visit these areas. The visits of the farmers to the species screening plots have done much to improve MOFA's standing with the farming community.

8. Publications and other communication material

8.1 Books and book chapters

8.2 Journal articles

8.2.1 Peer reviewed and published

8.2.2 Pending publication (in press)

8.2.3 Drafted

McDonald, M. A., Shrestha, P. K, Obiri, B. D. Lawrence, A. *People, place and participation: Reflections on the Participatory Technology Development Process.* International Journal of Agricultural Sustainability.

A number of other papers are planned, drawing on results presented in annexes B and C.

8.3 Institutional Report Series

8.4 Symposium, conference, workshop papers and posters

8.5 Newsletter articles

Tyfiant ("Growth"), the newsletter of the School of Agricultural and Forest Sciences ("SAFS"), University of Wales, Bangor, UK, Issue 1 (Spring, 2001)

8.6 Academic theses

White, M. R. 2002. Cocoa agroforests: The natural regeneration and architectural form of farmer preferred choice of trees to shade in Kumasi, Ghana. B.Sc. thesis, University of Wales, Bangor, 125pp.

Stewart, T. P. 2002. The contribution of small ruminants to soil fertility management in the forest and savannah zones of Ghana. M.Sc. thesis, University of Wales, Bangor, 100pp.

Obiri, B. D. 2003. Improving fallow productivity in Forest and Forest Savanna Transition Zone of Ghana: A Socio-Economic Analysis of Livelihoods and Interventions.. Ph.D. thesis, University of Wales, Bangor (in preparation).

Ayisi Jatango, J. 2003. Improved Fallow Management Studies in the Forest and the Forest-Savanna Transition Zones of Ghana. Ph. D. thesis, University of Wales, Bangor (in preparation).

8.7 Extension-oriented leaflets, brochures and posters

McDonald M. A & Anglaaere, L. C. N. 2003. Producing shade trees for cocoa on-farm and in the community. Extension leaflet, UWB/FORIG, 11pp.

8.8 Manuals and guidelines

8.9 Media presentations (videos, web sited papers, TV, radio, interviews etc)

Features on the project appeared in the Ghana Times, Financial Times (Ghana) and the Daily Graphic following the stakeholder workshop on January 21st, 2000. Drs McDonald, Sinclair, Cobbina, and Mr John Ayisi Jatango and Mrs Beatrice Obiri were interviewed by TV3 and GBC News at the same workshop.

8.10 Project reports and data records

8.10.1 Citation for the project Final Technical Report (FTR)

McDonald, M.A., Obiri, B. D., Jatango, J. A., Anglaaere, L.C.N., Cobbina, J., Moss, C and Nolte, C. 2003. "Shortened Bush-fallow Rotations for Sustainable Livelihoods in Ghana" (DFID Project R7446) Final technical report. 24pp + appendices.

8.10.2 Project technical reports including project internal workshop papers and proceedings

Youde, E. and McDonald, M. A. 2000. Proceedings of an initiation workshop 17 - 21 January 2000, FORIG, Fumesua, Kumasi, Ghana. "Shortened Bush-fallow Rotations for Sustainable Livelihoods in Ghana" (DFID Project R7446) and "Bridging Knowledge Gaps between Soils Research and Dissemination in Ghana" (DFID Project R7516). School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 46pp.

Anglaaere, L. C. N. 2000. Progress report to the Biscuit, Cake, Chocolate and Confectionery Alliance of the UK: "Improving the productivity and sustainability of cocoa farms in West Africa through utilization of native forest trees in agroforestry systems". Forestry Research Institute of Ghana, Kumasi. 33 pp.

Ayisi-Jatango, J. 2000. Draft site report: Dec 1, 1999 – June 30, 2000, Shortened Bush Fallow Rotations for Sustainable Livelihoods in Ghana. Ministry of Forestry and Agriculture, Sunyani. 22 pp.

Obiri, B. D. **2000**. Livelihood Systems & Farmer Knowledge of Subriso No. 3, Tano District - Brong Ahafo Region. Forestry Research Institute of Ghana, Kumasi. 84 pp.

Obiri, B. D., Ayisi-Jatango, J., Anglaaere, L., Cobbina, J., Moss, C., McDonald, M., Sinclair, F. and Young, E. 2000. Livelihood systems and farmers ecological knowledge in Ghana: a report on three districts. University of Wales, Bangor, UK. 146pp.

Obiri, B. D. 2001. Bush fallow management systems in Ghana: a socio-economic analysis in the Forest & Forest Savanna Transition Zones of Ghana. Colloquim/seminar to FORIG, Kumasi, Ghana.

8.10.3 Literature reviews

8.10.4 Scoping studies

8.10.5 Datasets, software applications

Moss, C. & Obiri, B. D. 2000. Indigenous knowledge of farmers of Subriso 3, Tano district and Brong Ahafo region, Ghana. WinAKT Knowledge base.

Moss C. and Jatango, J. 2000. Local knowledge of soil fertility in Yabraso, Wenchi district, Ghana. WinAKT knowledge base.

LEXSYS. 2003. This is a computerised database which contains information on 113 tropical herbaceous and shrub legume species and a small number of woody legumes and tropical crops. Users can use the database to select for ecological criteria which provide decision support for incorporation of legumes into tropical cropping systems.

LEGINC. 2003. This is a decision support system which guides users on the integration of legumes into cropping patterns in Ghana on the basis of: identification of the ecological niche in the cropping pattern that a legume could occupy, also including consideration of socio-economic factors e.g. security of access to land for a specified duration; finding a legume that provides desired products or services to the farmer; matching the legume to site conditions; matching management of the legume to the farmer's labour and management constraints.

8.10.6 Project web site and/or other project related web addresses

http://www.bangor.ac.uk/afforum

9. References cited in the report, sections 1 - 7

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10. PROJECT LOGFRAME

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
GOAL: Productivity of forest systems optimised and sustainable	Improved forest resource use patterns implemented in target areas by 2005, including: - offtake increased by 10% - no depletion/some enhancement of soil fertility over period of land use (measured through offtake over time against baseline) - forest integrity maintained	- national production statistics - reports of target institutions - research programmes reports - evaluation of NRSP - monitoring against baseline data	- Enabling environment (policies, institutions, markets, incentives) for widespread adoption of new technologies and strategies exists
PURPOSE: Land use strategies developed to convert shortening bush-fallow rotations into sustained and more productive systems	1. System tested, validated and adopted by 10% of farmers in target areas by 2000. 2. Soil fertility benefits quantified in at least two agroforestry/perennial crop-based systems in two target countries by 2003	1. Research programme reports 2. Research programme reports	- Target institutions invest in the uptake and application of research results
OUTPUTS: 1. The functionality and dynamics of the existing farming system characterised; specific gender roles within the system identified; and a rapport between researchers and farming communities enabled so that the process of Participatory Technology Development can be developed. 2. Three interventions for the improvement of bush fallows developed and tested and the mineral nutrient cycling; weed management and biodiversity of the unmanaged fallow characterised and scientific evidence of the effects of different management regimes on soil and crop productivity obtained. 3. Extension manual of techniques for the improved management of fallows for West and Central Africa produced and smaller site-specific handbooks in local language.	1. Reports on at least five village communities in Ghana on farming systems inputs, and collaborating farmers and technologies developed by June 2000. 2. Trials established and interventions adopted and adapted by participating farmers by December 2002 and scientific evidence of mineral nutrient cycling status, weed management and interactions of existing and improved fallow systems generated by June 2002. 3. Manuals and extension materials produced and disseminated by December 2002.	Project reports FAI evaluations and reports Journal papers Popular articles Web site linked to UWB and partner institution pages	Interventions proven to have beneficial effects on soil fertility accepted and adopted by farming communities
ACTIVITIES: **Phase 1: 6 months** **Initial participatory appraisal and knowledge acquisition** 1.1 Participatory rural appraisal principally involving researchers from FORIG and MOFA interacting with the farmers. The communities will be from areas representative of major farming systems but constituting groups/households that have contrasting livelihood situations. The PRA will include prioritisation of problems and causal factors, identification of potential solutions and reactions to possible interventions, and the identification of farming groups willing to participate in the strategic trials, and their evaluation criteria.	PROJECT MILESTONES: 1.1 PRA conducted by May 2000 1.2 Workshop held by June 2000 1.3 Knowledge base constructed by May 2000	Quarterly, calendar and annual reports	- Typical cross-section of farmers are willing to collaborate - Target institutions retain ability to collaborate - Weather conditions throughout

1.2 After separate reviews and baseline studies of indigenous fallow management practices and institutional experiences in the area, farmers, NGO's and scientists will be brought together in a series of small rural workshops. Each group of stakeholders will make informal presentations about their fallow management practices. This will create opportunities to discuss new ideas, and farmer groups can then plan their own trials building on new information acquired at the workshop 1.3 Farmers' current knowledge and practice will be acquired using a combination of PRA tools and knowledge-based systems techniques. The PRA in 1.1 will be used to define the domain for knowledge collection and select a small purposive sample of farmers who will be interviewed in depth. Farmers' knowledge of fallow improvement; their ideotypes for woody species for fallow improvement; and companion species for agroforestry systems will be incorporated into the knowledge base. **Phase II: 24 months** **Participatory technology development** The protocol design will be guided by results of the initial surveys and knowledge acquisition but will involve replicated field experiments. On-farm plots incorporating the amendments and interventions chosen in Phase 1 will be established with the participating farmers identified. The treatment combinations will allow determination of synergistic effects of the amendments in comparison with control situations. The formal knowledge base will be developed as farmers and researchers discover new knowledge through the research and acquired through farmers' responses to the experimentation. The multi-disciplinary research will emphasise the collaborative partnership between the farmer, the extension workers and scientists in a process of Participatory Technology Development (PTD). The entry point of the PTD will be the joint PRA analysis of the current situation and the development of mutual understanding of the capacities and opportunities that exist for development. Within this framework, we will establish strategic trials incorporating interventions. The explicit statement of stakeholder differences and the facilitation process in 1.2 will enable participants to debate the types of technology which are appropriate, different research strategies, sources of information and communication needs. This will be initiated in the rural workshops which will prepare the participants for more detailed discussion of PTD and plans to operationalise the research methods. Bringing together heterogeneous groups with different goals is a promising approach to disseminating and scaling up the results of participatory research 2. Strategic trials will be established which build on protocols of IITA to extend their work into Ghana, incorporating interventions for shortening of			experimental period are typical - Infrastructure continues to permit travel and communications between project sites

fallow periods: 1) improved management of natural fallows (organic amendments) 2) planted improved fallows 3) conversion of short fallow cropping systems into multi-strata agroforestry systems (with BCCCA funding);			
2.1 The plots will be of a standard size 8m x 12m. The experimental protocol will follow a rigorous design developed in consultation with biometricians from the Statistical Services Unit of Reading University. However, farmers will manage the plots. 2.2 Soil samples will be taken prior to the installation of interventions and thereafter on an annual basis and analysed for a range of physical and chemical properties, including total and available nitrogen and phosphorus, exchangeable cations, pH, particle size analysis and biological activity and bulk density. The soil nutrient analysis will be conducted in the laboratories of the Soils Research Institute in Kumasi, and in UWB laboratories. 2.3 Bioassays of agronomic productivity will be conducted by monitoring sub-plots of crop production within plots under the different interventions. The methodology for this will vary according to the different farming system, management regime and intervention, but will be continuous over the project period. 2.4 Interventions incorporating trees or woody species; these components will be monitored for survival, height and basal diameter. Foliage will be analysed for macronutrients. 2.5 All plots will be monitored for weed presence; cover, biomass and identification	2.1 Survey of potential interventions incorporated into experimental design, and trials established by December 2000. 2.2 Monitoring of soil productivity over the period June 2000 to June 2002. 2.3 Measurement of crop productivity over the period December 1999 to June 2002 2.4 Monitoring of woody perennial survival and growth over the period December 2000 to December 2002 2.5 Measurement of weed management/interactions over the period June 2000 to December 20002		
Phase III: 6 months **Promotion** 3.1 Development of guidelines for adoptable interventions to improve fallow management and specification of their recommendation domains through synthesis of results from the initial PRA, subsequent experiments and farmers reactions to them, including formalisation of farmer decision criteria relating to adoption of interventions. This will in fact be done iteratively throughout the project but converging in a stable set of guidelines in the final phase. 3.2 Production of an extension manual of techniques for the improved management of fallows for West and Central Africa, demonstrating the potential for capital transfers. 3.3 Production of smaller site-specific handbooks in local languages. 3.4 Annual workshops will be conducted for all participants	3.1 PTD over period June 2000 to December 2002 3.2 Material generated for dissemination materials by June 2002 3.3 As 3.2 3.4 Workshops completed by December 2002.	BUDGET: Staff £ 51,899 Overheads £ 23,355 Overseas Travel £ 77,752 Equipment £ 3,500 Miscellaneous £ 80,772 TOTALS £ 237,278	

11. KEYWORDS

Fallows; Ghana; Legumes; Participation; Soil fertility; West Africa

12. ANNEXES

Annex A. Process Documentation

Annex B. Biophysical Findings

Annex C. Socio-economic Issues

Annex D. Decision Support Tools

Annex E. Cocoa extension leaflets

Annex F. Project Inventory