NATURAL RESOURCES SYSTEMS PROGRAMME
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Project Title

Bridging Knowledge Gaps Between Soils Research And Dissemination In Ghana

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Organisation

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NRSP Production System

Forest Agriculture Interface

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ABBREVIATIONS AND ACRONYMS

AEA	Agricultural Extension Agent
AFFS	Agriculture, Forestry and Fisheries Sector
AGSSIP	Agricultural Sub-sector Services Investment Project
AKT	Agroecological Knowledge Toolkit
ARI	Animal Research Institute
CRI	Crop Research Institute
CSIR	Council for Scientific and Industrial Research
DDA	District Director of Agriculture
DED	German Development Service
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
IFCSP	Integrated Food Crop Systems Project
IITA	International Institute for Tropical Agriculture
IRNR	Institute for Renewable Natural Resources
IWMI	International Water Management Institute
KB	Knowledge base
KNUST	Kwame Nkrumah University of Science and Technology
LEXSYS	Legume Expert System
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
RELC	Research and Extension Linkage Committee
SFSP	Sedentary Farming Systems Project
SMS	Subject Matter Specialist
SRI	Soils Research Institute
WFI	Wenchi Farm Institute

1. EXECUTIVE SUMMARY

Many rural livelihoods depend upon the maintenance of soil fertility but adoption of technologies to maintain and enhance it have been low despite their apparent effectiveness in participatory on-farm research. This project set out to explore the reasons for low adoption of outputs from soils research in Ghana and to suggest ways to bridge a perceived knowledge gap between soils research and dissemination.

General reasons for low adoption of techniques to improve soil fertility and crop yield in Ghana are well understood and recognized by government. They include the high price of inorganic fertilizer, lack of availability of organic material and a low level of dissemination activity within the context of a relatively low level of investment in soils research. The need to undertake effective soils research and dissemination to overcome these constraints has been prioritized in a national soil fertility action plan.

A more fundamental constraint is the absence of an effective means of focusing research and dissemination on farmers with different circumstances. The soil fertility technologies available are only suitable for a fraction of rural livelihoods, predominantly those of male farmers producing high value cash crops. There is an absence of technologies directly relevant to women farmers and other marginalized groups.

This mismatch between the technology options being made available and the circumstances of poorer farmers in the forest savanna transition zones of the country arises because of:

- a lack of understanding of the different sets of constraints and opportunities faced by rural farmers; and
- the absence of an effective means to focus research and extension activities on farmers' circumstances.

A framework and suite of tools were designed to increase the relevance of soils research and dissemination. These focus research activity on what is relevant to rural livelihoods and provide a means of selecting appropriate interventions for particular farmers, together with assistance in marshalling the information required for effective dissemination, that is sufficiently flexible to adapt technology options to specific circumstances. Within the framework, technology specifications are linked to rural livelihood profiles via a set of key resource constraints and opportunities. The need for policy interventions as a prerequisite for adoption of technological improvements are identified where few options address the constraints faced by marginalized groups of people.

The tools which are used within the framework comprise:

- a set of knowledge bases including farmers' understanding of soil fertility in five contrasting locations in Ghana and comprehensive knowledge from a range of sources about cover crop technology;
- a diagrammatic livelihood description tool for disaggregating rural households in terms of common constraints and opportunities relating to adoption of soil fertility interventions; and
- a technology choice tool for matching interventions to rural livelihoods.

The framework and tools were field tested and found to fill a recognized niche within the changing national agricultural development scene in Ghana. A consortium comprising key people in agricultural research, training and extension have tabled a proposal to pilot the

approach in three districts of Ghana and build local capacity. There is scope for wide application of the generic aspects of the framework and tools with appropriate national and local adaptation.

2. BACKGROUND

Soil fertility depletion is a major problem worldwide, and specifically acute in relation to food security and poverty alleviation in Sub-Saharan Africa. Rural people are facing declining per capita food production as a result of soil nutrient depletion, and pressure on land is increasing in West Africa in particular because of increasing population pressure and migration, resulting in shortening of the fallow period in bush fallow systems and increasingly intensive cultivation of permanent agriculture leading to soil degradation. The future livelihood of farmers is, therefore, being threatened and effective dissemination of technical means to reverse soil nutrient depletion is vital.

Technical benefits have emerged from research and have been successful in increasing long-term yields, becoming widely adopted in some areas where farmers are investing in soil fertility in response to increasing rural population density. However, uptake of soils research outputs more generally has been low, despite fertility decline being a major problem. The project addressed an identified constraint that technically feasible outputs from participatory soil fertility research have not enjoyed high adoption rates (NRSP Workshop in Reading, 1997 and ICAR Workshop Bhopal, 1998).

We already know that technically proficient and participatory research does not necessarily produce appropriate outputs and that dissemination of research outputs in packages, rather than as targeted advice in terms of agroecological concepts already understood by farmers, may impede uptake and adaptation (Thorne *et al.*, 1999). Recent innovations where outputs of soils research are presented as decision trees begin to address this (Palm *et al.*, 1997) and a need for gender specific dissemination of soils research outputs in Africa has been demonstrated (Gladwin *et al.*, 1997).

The collaborating target institutions (FORIG, MOFA, IITA) have expressed the need for a methodology for disseminating soils research outputs which can be used by international research centres, and local and international NGOs working directly with farmers throughout West Africa. The geographical focus of the project was specified in the call for proposals in line with DFID priorities generally and the NRSP strategy in particular. The Government of Ghana already recognizes soil fertility management as a priority area. A *Soil Management Action Plan For Ghana* has been produced (Bonsu *et al.*, 1996), as well as a *National Soil Fertility Management Action Plan* (MOFA, 1998). The Action Plan recognizes the low inherent fertility of soils in Ghana and the low uptake of soils technologies. It sets out a diverse range of projects aimed at improving soil fertility management in Ghana.

Other studies relevant to Ghana that have examined soil fertility management are 'Rethinking natural resource degradation in sub-Saharan Africa (R7073CA) – a case study of soil conservation technologies in the semi-arid north of the country (ODI, 2000; Kranjac-Berisavljevic' *et al.*, 2000), 'Organic Agriculture in sub-Saharan Africa: Farmer Demand and Potential for Development, a study to inform policy' (R6362SA) which has assessed the potential for organic agriculture (Harris 1997, Harris *et al.*, 1998) and 'Agroforestry options for Ghana – land use planning with

integrated bio-physical and multiple objective models' (R6517) which assessed the potential for agroforestry interventions (Fawcett and Smith, 1999). There is also considerable information on farmers preferences for timber and non-timber species to be retained on farm, much of which is summarized in Amanor (1996). In addition a desk-based study is currently underway to identify knowledge dissemination domains in the Forest Agriculture Interface R7515.

3. PROJECT PURPOSE

The purpose of the project was to develop effective dissemination strategies for soils research outputs in Ghana in order to produce higher adoption rates for soils technologies. The provision of methodological guidelines for inclusion of explicit consideration of dissemination when research is being planned, could potentially have a wider impact on the effectiveness of DFID funded research on natural resource management.

4. OUTPUTS

4.1 Overview and dissemination

The project has produced three main outputs:

1. Information on the success and failure of the adoption of soil fertility research outputs
2. Reasons for the low adoption of soil fertility research outputs in Ghana
3. A rigorous framework for designing soil fertility research and dissemination strategies

These outputs are reported on in the sections below. Output one has been documented in Moss and Sinclair (2000) and is briefly reviewed in section 4.2. Output two presents analysis of the fieldwork stage. It suggests that overall soils research outputs and recommendations are not widely relevant to farmers' livelihoods in the forest and transition zones of Ghana. The general reasons for low adoption of technologies were reviewed in Moss and Sinclair (2000). Analysis of technologies in terms of disaggregated livelihoods suggests that more fundamentally the NARES is not functioning to produce technologies and recommendations that are relevant to the majority of rural farmers and particularly not women and other marginalized people.

Within Ghana the site reports (Moss 2001c and d) have been distributed amongst collaborators and other interested institutions and organisations throughout the south of Ghana. Outputs one and two have been discussed at the project workshops, although we note the desirability of wider distribution of Tables 4.1 and 4.2 in Ghana. Two articles are in preparation to disseminate the findings from outputs one and two to a wider international audience. One is an article about differences in rural livelihoods and adoption of soil fertility research outputs and will be submitted to the journal *Agricultural Systems*. The second is an article comparing knowledge across the five field sites, for which further data collection is required for validation. This is will be submitted to *Agriculture, Ecosystems and Environment*.

The final output is a framework and a set of tools (Moss *et al.*, 2001). A generic framework proposes ways of linking agricultural research and dissemination to rural livelihoods. A more specific framework for Ghana emerged from a series of workshops with members of the NARES where the tools were presented and discussed. A proposal to seek funds to pilot this approach in three districts in Ghana involving capacity building in training, research and extension at local and national levels has been tabled.

Outputs of the project including the tools are also available from the project website - http://www.bangor.ac.uk/afforum/research/farmer_uptake/frame.htm. Training and support for the knowledge bases and the other tools has taken place widely with institutions and organisations in Ghana. These include the project collaborators, FORIG and GOAN as well as MOFA and IRNR. Section 4.4.3 provides further details of the other organisations and people involved. A knowledge base resource centre has been set up at GOAN which links in with the more general resource centre located there which is visited by researchers, students and other development workers. Installation of the knowledge bases at IRNR has provided access to students and staff

of the University of Science and Technology. Wider distribution of Moss *et al.* (2001) in Ghana and internationally has been taking place and will continue to do so. Through their collaboration with this project, IITA and IRAD have adopted the AKT knowledge based systems approach in their research on multistrata cocoa in Cameroon.

4.2 Success and failure in the adoption of soil fertility research outputs

An initial literature review of soil fertility research outputs and their adoption in Ghana revealed little evidence of continued, significant adoption of soil fertility technologies that had been developed or evaluated by research and/or promoted by extension in the forest and transition zones of Ghana (Table 4.1; Moss and Sinclair, 2000).

Some participatory on farm research has been initiated in the last three or four years. Most notably this has included research on cover crops, green manure and animal manure in the Brong Ahafo region by an international NGO and a collaboration between British researchers and MOFA. Results have yet to be extended to farmers over a wide area. On farm trials have been included in soil fertility research carried out by government research institutions as a follow up to on station work e.g. cover crop research at CRI within NARP, but findings are less widely publicized. Moss (2001a) notes the lack of communication, and particularly publication, of national research findings. A comprehensive assessment of research outputs is difficult and research risks duplication of previous work.

The use of inorganic inputs has been promoted by the extension services. Current use is high amongst commercial vegetable farmers with some use for rice and occasionally maize and oil palm nurseries. Recommendation rates exist for the majority of crops although there are concerns that these may now be dated (MOFA, 1998). National policy, particularly structural adjustment has been responsible for the decline in fertilizer use since the 1980s. The removal of subsidies, the devaluation of the cedi, changes in the procurement and distribution network and declining agricultural credit has made fertilizer inaccessible to farmers not producing high value cash crops.

The use of organic soil technologies has been less promoted by the extension services. Mulch no burn farming has been researched and promoted, particularly following the bush fires of 1983. However this has proved an unpopular option due to high rates of weed infestation and the high cost of herbicide. Within peri-urban Kumasi participatory research and adoption of poultry manure technology has taken place by commercial vegetable producers. Elsewhere the absence of animal manure and traditional lack of integration of livestock within cropping systems results in little use of manure. Cover cropping and compost have received some research but limited dissemination and cover crop seeds are not conveniently available to farmers.

Table 4.1: Adoption of soil fertility research outputs in the FAI in Ghana (Moss and Sinclair, 2000).

Research outputs and farmer recommendations	***Technology***	**On-farm testing/farmer participation in technology design and method of dissemination**	**Farmer adoption**	**Proposed reasons for adoption/lack of adoption**
Inorganic fertilizers	Recommendations for new varieties of maize, fertilizer use and optimal planting practices (line planting/ optimal plant population density) for monocropped maize (Tripp, 1993).	On-farm adaptive trials involving collaboration between CRI, the Grains and Legumes Development Board (GLDB) and MOFA. Centrally organized, hierarchical research using farmer feedback but without active farmer participation. Extensive extension programme in conjunction with trials (following a number of previous chemical fertilizer awareness raising campaigns).	Significant adoption rates for the package in the 1980s. However fertilizer use in general fell in the 1990s. Commercial vegetable production is heavily dependant on inorganic fertilizers, use on cereals is more common in the savanna than the forest zones, in the forest zone perennial and root crops do not usually receive fertilizer (Harris *et al.*, 1998; Kiff and Floyd, 1997).	A number of campaigns have promoted fertilizer use in Ghana, but significant adoption only came with a focused program of on-farm research and an extension strategy that brought recommendations to farmers in terms they could understand. Since 1990 low levels of use reflect policy changes (lifting of subsidies and privatization of the input market) which have increased the cost and lowered the economic returns to usage. Considering the number and scale of projects to raise awareness about inorganic fertilizers it is unlikely that there are many farmers unaware of their use.
Inorganic fertilizers for mature cocoa production	Research has shown mean cocoa yield increases of 62 – 116% of fertilized mature cocoa plots over unfertilized plots, although response varied depending on site and management. Fertilized yields were over twice the national average. Fertilizer use was calculated to be economically feasible with a cost benefit ratio over 3.00, although the means of valuation are not given (Appiah *et al.*, 1997).	On-farm research (managed and supervised by field assistants). The Cocoa Services Division has recommended inorganic fertilizer use to farmers (Manu and Tetteh, 1987).	No evidence	Farming has traditionally relied on extending land area to increase yields. Although some evidence of different strategies for management have suggested that care-taker farmers are more interested in intensifying production than owner farmers (Blowfield, 1995), other evidence suggests more efficient labour inputs to cocoa yields are obtained by caretakers using less labour.
Oil palm and cocoa husk residues	Research outputs have shown that oil palm and cocoa husk residues both have a high K content and oil palm has a high pH with the potential for ameliorating soil acidity (Owusu-Bennoah, 1997; Bonsu *et al.*, 1996; Safo *et al.*, 1997)	On-station trials No evidence of dissemination. More interest in industrial development.	Oil palm husk may be recycled by oil palm growers.	
Continuous cultivation using minimum tillage with cover crops and mulches	Research by IITA in Nigeria has shown that planting through a live or dead mulch (involving herbicide use) of an established cover crop (*Centrosema pubescens* or *Psophocarpus palustris*) can sustain maize yields at 2.1 – 2.2 t ha^{-1}. Research in Ghana has shown that land preparation without burning cleared bush can increase maize yields over normal land preparation with the use of chemical fertilizers (Mulongoy and Adobundu, 1992 and Ghana Grains Development Project, 1992 in Bonsu *et al.*, 1996). Continuous cultivation using minimum tillage	Some minimum tillage on-farm trials have taken place in Ghana. It is unclear to what extent these technologies have been disseminated as the extension services have concentrated messages on the use of inorganic fertilizer.	Some evidence of *proka* (land preparation without burning) was found by Amanor (1996) in areas dominated by *Chromolaena odorata*. No suggestions are given as to why this is the case.	Farmers have reported that planting through cut bush leads to high rates of weed infestation and low yields. Minimum tillage appears to be a feature of bush-fallowing in the forest zone with increased tillage coincidental with more continuous cultivation in grassland areas and the savanna zone. Labour is one of the main constraints in farming systems, and herbicides are likely to be beyond farmers means.

	with/without herbicides, and with/without cover crops and/or chemical fertilizers in the forest zone has also been tested (Fedden, 1986).			
Green manures, cover crops and other leguminous annuals in rotations.	Some research has taken place obtaining higher maize yields with *Mucuna pruriens* in the forest zone (Boateng, 1997). The Integrated Food Crop Systems Project (IFCSP) has been experimenting with Mucuna, Canavalia and Crotalaria on vegetable production in the transition zone (Jackson *et al.*, 1999).	On-farm trials have been undertaken by the IFCSP with a range of farmers with different resource endowments with inputs provided by the project.	On going project. A 3 year crop rotation with maize, cowpea and cassava is replacing long duration intercropping in the transition zone. It is also displacing minor season maize in some areas of the forest zone. Cowpea cultivation has been the most successful innovation in the transition area (Amanor, 1993).	Cowpea is a good cash earner. Yields are more stable than maize under lower rainfall. However in more forested *Chromolaena odorata* - dominated areas yields are lower and systematic integration of cowpea into the crop rotation is absent. The main incentive for adoption is favourable market price. The main problems with adoption have been poor rainfall, poor rates of regeneration on grassland and the long period required to clear grassland for cultivation (Amanor, 1993).
Animal manures	The Land and Water Management Project and the IFCSP have undertaken on farm trials (Jackson *et al.*, 1999). Poultry manure has been found to increase maize grain yield by 53 - 67%, and cassava by 76 - 83% over a control over a 3 year period year in an intercropping trial (Quansah *et al.*, 1998a in Quansah, 1999)	On-farm participatory trials. Inputs were provided by IFCSP.	In some areas where it is available there is some evidence of the use of poultry manure, however use does not appear to be widespread.	Low level of availability of manures and perceptions that using animal manure is dirty and old-fashioned rather than a modern practice have been suggested as reasons for low levels of use of animal manures (Harris *et al.*, 1998). The success of poultry manure trials has been attributed to farmer participation in the technology development and the support of local leadership.
Cover crops grazed by sheep under cocoa	Kade Agricultural Research Station, (University of Ghana, Legon) (Fianu, 1998) has tested a number of different cover crops with sheep integrated into the system.	Researcher managed trials No evidence of dissemination.	No evidence of adoption	Adoption of this practice would require a large initial investment, and good access to markets for the purchase and sale of sheep, whereas infrastructural development generally decreases further south in the forest zone, (except for the provision of services relating to cocoa).
Alley cropping	Positive outputs from on-station trials using leguminous trees such as *Leuncaena leucocephala* and *Gliricidia sepium* are reported by Fedden (1986)	Adaptive trials throughout the country. Demonstration plots were set up by MOFA throughout the country (Anane, 1994 in Lawson, 1995).	No evidence of adoption	Excessive labour requirements, weediness of some leguminous trees and crop competition have been suggested (Anane, 1994 in Lawson 1995; Bonsu *et al.*, 1996).

4.3 The appropriateness of soil fertility management technologies to farmers' livelihoods: reasons for low uptake of soils technologies

The fieldwork was used for a general analysis of the appropriateness of four different soil fertility management technologies to the livelihoods of the disaggregated groups of farmers at the five field sites. The factors considered relevant to adoption potential are outlined in more detail in the Technology Choice Tool (Moss *et al.*, 2001) and are considered at each site in Moss (2001e). Farmers knowledge was also drawn upon from the five knowledge bases (Frost, 2000a; Moss, 2000a; Moss, 2000b; Moss and Jatango, 2000; Moss and Obiri-Darko, 2000).

The results are presented in Moss (2001e) and summarised in brief here. Overall it was found that the soil fertility management technologies that have been produced are only relevant to the livelihoods of a relatively small number of farmers. These are predominantly male farmers producing high value cash crops, particularly vegetables, rice and green maize (Table 4.2).

For some technologies, notably a mucuna cover crop and the use of herbicide, farmers' knowledge is lacking. For animal manure, changes are required in farmers perceptions before use even on a small scale is possible. There are far fewer actual and potential technologies directly relevant to women farmers. This is because of the different roles played by men and women within the household and the family, and women's secondary status as decision makers and cash earners (Moss, 2001f).

General reasons for low adoption rates of soil fertility research outputs in Ghana have been reviewed in Moss and Sinclair (2000) and are briefly summarised in Box 4.1. However a livelihoods approach that socially disaggregates farmers reveals which specific groups of farmers are lacking appropriate technology options (Table 4.2).

Table 4.2: The appropriateness of four general soil fertility management technologies to rural livelihoods at the five field sites (Moss, 2001e provides further details).

Technology	*Crop*	*Farmers who are able to benefit from technology*					*Requirements to make technology appropriate to a wider range of farmers*
		Oda	*Gogoikrom*	*Peri-urban Kumasi*	*Subriso*	*Yabraso*	
Inorganic fertilizer	Commercial vegetables, rice and green maize	None	Settler men	Men, especially younger age groups	Indigenous men	Men	Immediate possibilities: – Use on maize in conjunction with post harvest storage technology and improved management of cash flow by farmers Longer term – Improvements in input distribution services and national economic growth that reduce fertilizer prices and/ or increase the price received by farmers for food crops
Animal manure	Commercial vegetables, rice and green maize	None	None	Men, especially younger age groups	None	None	Immediate possibilities: – Use by female farmers in settlements where livestock are penned, women's farms are small and close to the settlement and on poor soil due to the scarcity of land. Awareness raising to change attitudes to handling manure, and a 'rough' composting method that women could perceive as simple and flexible and that did not produce additional labour requirements would need to be specifically targeted to women. Longer term: – Greater integration of livestock into the cropping system through an awareness raising campaign to change attitudes to the use of manure, as well as the creation of conditions (such as livestock markets and more accessible livestock health care) that would enable farmers to increase livestock numbers.
Mulch, no burn farming:							
Option 1	None	None	None	None	None	None	
Option 2	Commercial vegetables, rice, green maize and others e.g. maize where use is profitable	None	None	Men especially younger age groups	None	None	Immediate possibilities: – For other locations where land is scarce and commercial crops are grown increased use could result from better farmer knowledge of appropriate application rates to make spraying reliably effective on fallows with differences in vegetation cover
Mucuna cover crop:							
Option 1	None	None	None	None	None	None	Immediate possibilities: – for locations where land is scarce or weedy increased availability of mucuna seed and dissemination of the technology Longer term : – Further research with other cover crops more compatible with mixed and intercropping systems
Option 2	None	None	None	None	None	None	

Box 4.1: Reasons for the low adoption of soil fertility management technologies in the forest and transition zones of Ghana (Moss and Sinclair, 2000).

1. *Low use of inorganic fertilizer due to*
   - Unfavourable Value Cost Ratio of inorganic fertilizer for staple food crops e.g. maize, which limits the use of inorganic fertilizer to vegetable farming where profits can be higher. The unfavourable Value Cost Ratio can be attributed to:
   - The high cost of inorganic fertilizer that has risen due to:
     - Removal of subsidies
     - Devaluation of the Cedi
   - Disruption to the input distribution network due to:
     - Rapid privatization of the input sector
     - High interest rates and bank charges
     - Lack of dealer skills and knowledge of fertilizers
     - Low profitability of the fertilizer trade
   - Poor farmer access to institutional credit due to
     - Tenure arrangements limiting use of land as collateral
     - Reduction in lending to the agricultural sector
     - Closure of some rural bank branches
2. *Limited effectiveness of the research and extension system in the development and dissemination of soil fertility management technologies due to:*
   - Lack of co-ordination between research and extension
   - Low level of research and extension resources spent on soils technologies
   - Lack of promotion of organic soil management techniques even where research has been carried out e.g. low availability of seed and use of cover crops on oil palm plantations
3. *Lack of traditional management of the soil using animal manure and leguminous crops resulting in:*
   - Lack of farmer awareness of the benefits of organic techniques
   - Taboos on handling of animal manures in the forest and transition zones
   - Farmer perception that manure causes increased weeds
   - Low level of availability of manures in the forest zone

Fallowing has been the traditional means of restoring soil fertility in the forest and transition zones of Ghana and agricultural production maximizes returns to labour, management input and capital investment rather than land. Livestock and crops are not integrated into the same farming system. Intensification and the use of alternative soil fertility technologies requires a change in attitudes and farm management. Furthermore Scoones and Toulmin (1999) note that anticipated returns and other options available to farmers determine investments in maintaining and improving soils. Farmers in Ghana clearly respond to market incentives, even within a high risk environment, as the widespread adoption of small scale intensive commercial vegetable production, which is relatively capital, labour and management intensive shows. However movement out of agriculture into other activities is popular where opportunities exist, e.g. in peri-urban Kumasi.

Current terms of access to land also have an influence on soil management strategies. Farmers' choices within the peri-urban area where pressure on land is most intense shows that land sale reform is necessary to safeguard the livelihoods of more marginalized members of the community whose dependence on agriculture is greatest, as well as to encourage the use of low cost organic technologies in addition to high cost inorganic ones.

Where there is limited market development, bringing few profitable opportunities for cash crops and poor access to highly priced inorganic fertilisers the process of agricultural intensification can become blocked (Scoones and Toulmin, 1999). Marketing issues are highly significant to the profitability of different food crops in Ghana. In some areas inaccessibility is a problem whereas in others seasonally low prices or flooded markets reduce profitability. Improvements in post-harvest storage technology, agricultural credit and farmers' ability to manage cash flow in conjunction with the adoption of improved soils technologies could contribute to more profitable farming. Strategies to improve soil fertility management should not therefore focus on soils technologies alone.

The lack of technologies for particular groups of farmers suggests that there are more fundamental reasons why low adoption rates occur concerning the structure and functioning of the NARES. During the cover crop case study it emerged that international and national scientific knowledge is not fully utilized during the development of technologies and that there is insufficient documentation within the NARS about research activities (Moss, 2001a). Neither is there adequate information about the livelihoods of rural people for researchers to draw upon, even at the district level. The socio-economic and national policy environment is not sufficiently taken into account in the design of research and dissemination activities. It is difficult for researchers within NARS based in centrally located research institutions such as in Kumasi to undertake participatory work with farmers at distant locations outside of externally funded research projects.

Research results do not always reach farmers due to poor functioning of the extension services. Both the research and extension systems over-rely on external sources of funding for maintaining activities (MOFA, 2001). This approach commonly leads to a breakdown in services when sources of funding are finished and is not sustainable. It creates an environment where research and extension activities are supply driven rather than focusing on the end users. Government policy in Ghana invokes decentralization. The implementation of AGSSIP (Agricultural Subsector Services Investment Project) promises a more demand driven extension service (MOFA, 2001). Changes in the roles of district MOFA staff are required as decisions are made at district level and pro-active approaches to driving extension activities are necessary if services are to meet the needs of client farmers. This in turn requires a pragmatic framework in which the NARES can re-orientate its activities towards a focus on rural livelihoods.

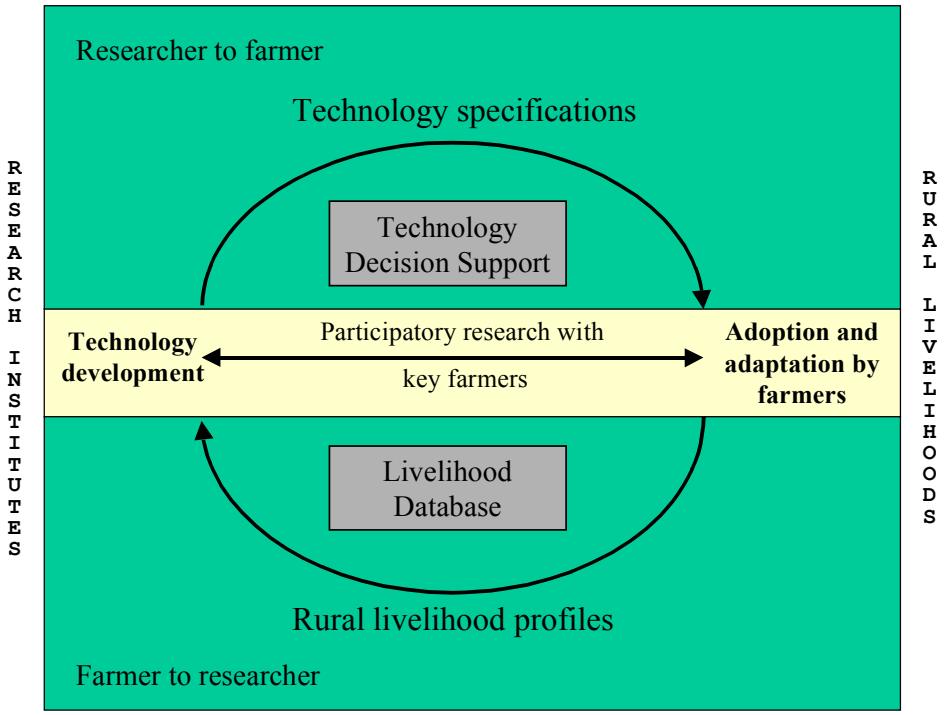
4.4 A framework for designing soil fertility research and dissemination strategies

A methodological framework and tools for linking research and extension activities with rural livelihoods developed during the project were presented at a series of workshops in Ghana. These were critically evaluated and discussed by participants. Details of the tools, which are outputs from the project can be found in the project documentation (Moss *et al.*, 2001).

4.4.1 Generic framework

A generic framework was produced that suggests ways of linking agricultural research to rural livelihoods (Figure 4.1).

Figure 4.1: A generic framework for linking agricultural research and dissemination to rural livelihoods.



Research and development activities develop a wealth of information about communities in rural areas. Activities are frequently costly in terms of time and, or, resources. However maximum use of this information is rarely made due to its low distribution and lack of availability to other researchers. Conversely agricultural researchers in national agricultural research systems are often isolated from the majority of the rural population. Participatory technology development is resource intensive and in Ghana, for example, the closest partnerships between farmers and research and development involve externally funded international or national NGOs. Government agricultural research institutes are clustered near urban centres and frequent, close collaboration with farmers in distant locations is simply impractical and likely to remain so. Furthermore, participatory research is carried out in conjunction with only a limited number of farmers.

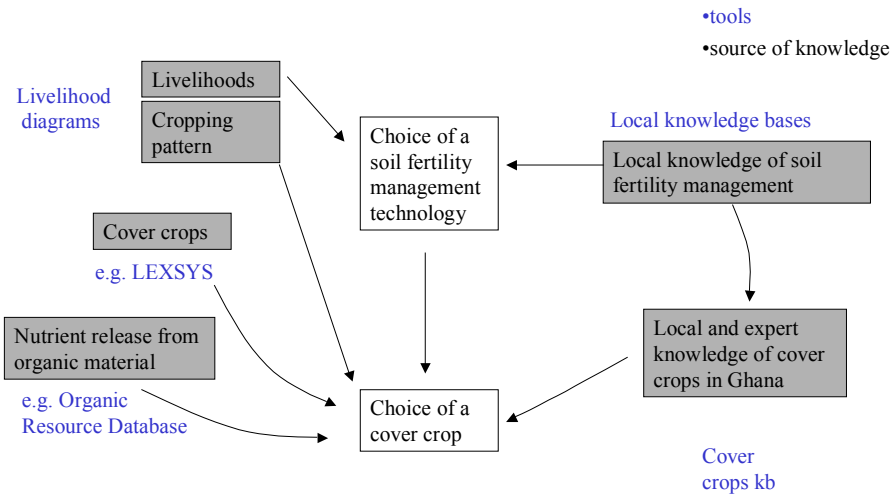
To make research results appropriate more broadly to farming communities, particularly in situations where livelihoods and access to resources are complex, additional feedback is required from farmers to researchers about livelihood circumstances. Information on rural livelihoods can be generated locally as paper

based resources and then aggregated nationally on computer. Livelihood and land use diagrams (Moss *et al.,* 2001) suggests a method for analysing and recording resource use by land based rural livelihoods that includes consideration of land type and ownership, land use practices, divesification of income generating activities, agricultural labour and its competing demands from other sources.

The resulting database of livelihood profiles becomes a resource that provides direct access to disaggregated information about rural livelihoods to researchers helping them to target research effort either to be relevant to large numbers of people or to specific marginalized groups. Technologies are linked to livelihoods via explicit sets of constraint and opportunities faced by farmers that limit which technologies are relevant to them. Where particular groups have few technology options, policy intervention may be required to alleviate constraints before technical dissemination can be effective. For example, insecure land tenure and low capital availability may render people unable to invest in soil improvement without provision of low risk credit and/ or reform of land tenure.

Research and extension workers need to be able to draw on expert and local information to come up with appropriate technology specifications. This can be assisted by development of technology decision support tools that integrate information from local and expert knowledge bases and databases for particular technologies (Figure 4.2).

Figure 4.2: Components of a technology decision support tool using the example of cover crops.



4.4.2 The tools

Farmers' knowledge of natural resource management: the Agroecological Knowledge Toolkit (AKT) and Ghana knowledge bases

A tool for exploring knowledge of soil fertility management held by farmers, researchers and extensionists in the forest and forest-savanna transition zones of Ghana was produced. Farmers' local knowledge from five different areas of the Brong Ahafo, Ashanti and Western regions was recorded, in addition to the knowledge of researchers and extensionists working with cover crops in the Brong Ahafo region. The tool includes the Agroecological Knowledge Toolkit software, six knowledge bases and the instructions for using them. It is targeted at researchers who have less contact with farmers and are therefore less aware of their existing knowledge than extension personnel.

Livelihood and land use diagrams
This is a tool for synthesizing information about rural livelihoods. It is intended to be used as part of a Participatory Rural Appraisal exercise to help researchers maximize use of existing information, to bring greater definition to PRA exercises and to guide researchers in thinking about different social groups. The tool focuses on land use as this is of major significance to the majority of rural livelihoods, however users are encouraged to adapt the tool as appropriate to include other aspects of livelihoods such as the use of NTFPs. The output of using the tool is a set of disaggregated livelihood profiles for different categories of rural people that highlights their resource constraints and opportunities.

Technology Choice Tool
This tool brings together information about livelihoods and technologies to facilitate the choice of appropriate technologies based on farmers' circumstances. It can be used to determine which groups of farmers a particular technology is suitable for and hence to prioritize research work in consideration of its potential impact, or to produce a technology specification for a target group. The output of this tool is a set of resource constraints and opportunities faced by farmers and required by technologies.

4.4.3 Specific framework for Ghana

Three one day evaluation workshops and one final workshop with key senior members of the NARES were held in Ghana from 10 – 20 June. The project findings and the tools produced were presented, discussed and evaluated. The first workshop focused on the research sector and was attended by members of CRI, SRI and FORIG. The second and third workshops focused on the government and NGO agricultural dissemination sectors and were attended by members of GOAN, MOFA and collaborators of GTZ's Sedentary Farming Systems Project (Table 4.3). As a result of the workshops a specific framework for linking agricultural research to rural livelihoods was produced for Ghana.

Participants at Sunyani, FORIG and GOAN were asked to complete a brief evaluation questionnaire. The majority of respondents made very positive comments (Figures 4.3 and 4.4). They indicated that the day had been useful, that the tools were relevant to their work and that they would like to continue exploring their use (which they had felt unable to do sufficiently in the time available to them at the workshop). It was clear that researchers are not currently encouraged or required to incorporate clear or rigorous thinking about the relevance of research outputs to rural livelihoods in their work, but they considered tools that guided them through this process useful.

Figure 4.3: Evaluation of the utility of the workshops held at FORIG, GOAN and Sunyani in June 2001 (41 respondents).

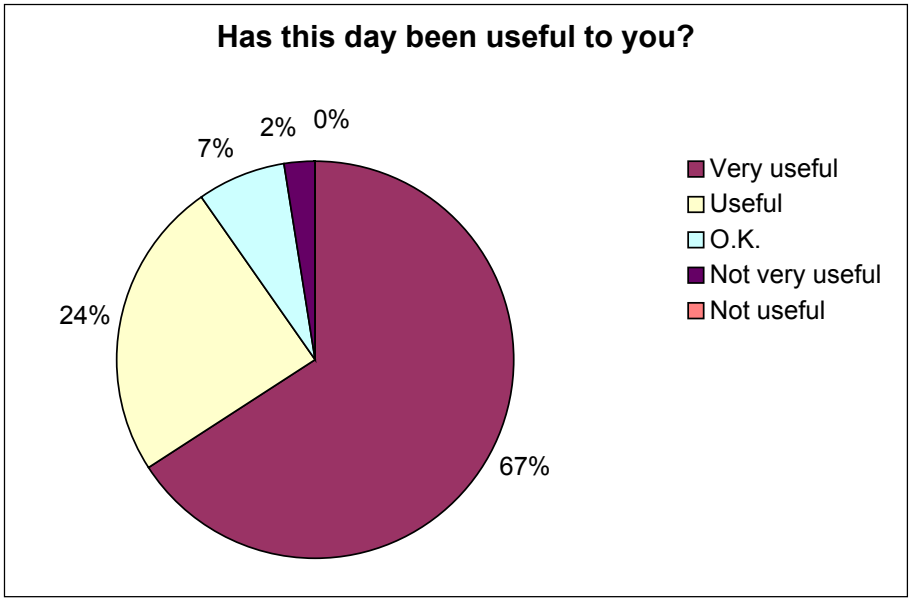


Figure 4.4: Evaluation of the individual tools presented at the workshops held at FORIG, GOAN and Sunyani in June 2001 (41 respondents).

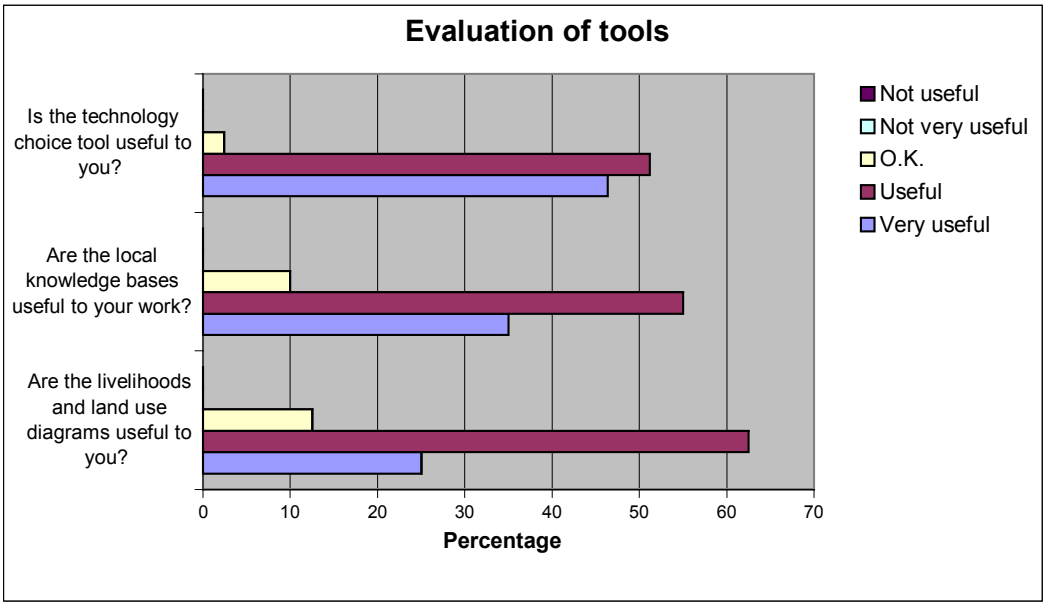


Table 4.3: Participants at three workshops entitled 'Local knowledge and livelihoods tools for soils research and dissemination in Ghana' in June 2001.

Name	Organization/ Role
Participants at the FORIG workshop on Tuesday 12 June 2001	
Luke Anglaaere	FORIG Researcher
Beatrice Obiri-Darko	FORIG Researcher
Eric Owusu-Adjei	SRI Researcher
Ernest Foli	FORIG Researcher
Eric Nutakor	FORIG Researcher
Dr Dominic Blay	FORIG Researcher
Charles Adu-Anning	FORIG Researcher
Patterson Osei-Bonsu	CRI Researcher
S. Osei-Yeboah	CRI Researcher
Sam Peprah	CRI (Kwadaso) Researcher
Dr D. Siaw	FORIG Researcher
E. Owusu-Sekyere	FORIG Researcher
Participants at the Sunyani workshop on Friday 15 June 2001	
A.K.Owusu	MOFA DDA Sunyani
A.B.K.Puplampu	MOFA
Duut Nelson	MOFA
Philip Boahen	GTZ – SFSP
Dr S. Oppong-Yeboah	MOFA DDA Tano
E. Asante-Krobea	MOFA DDA Wenchi
Elizabeth Adubea	MOFA AEA Wenchi
J.K.Appiah	MOFA SMS Crops
David Gyan	WFI, MOFA
Rita Weidinger	GTZ – SFSP
Felix Ofasi	MOFA AEA Tano
L.K. Kramda	MOFA
P.M.K. Agbekoh	MOFA
H. Looz	GTZ – SFSP
Dr Nsiah-Gyabaah	Sunyani Poly (Head)
K. Amamkwa – Poku	Wenchi Farm Institute (MOFA)
F.Blay Kenyah	Research and Development Unit, MOFA
R.D. Schrous	DED, SFSP, Asunafo
T.O. Larbi	MOFA/ Integrated Crop Protection Project
Francis Johnston	Brong Ahafo District Support Project
Participants at the GOAN workshop on Monday 18 June 2001	
Kofi Amoako Tweneboa	MOFA (Ashanti region), human resources units
Joseph Kwesi Sarpong	Kwadaso Agricultural College, teacher
Ayim Daniel	Kwadaso Agricultural College, technician
Kwabena Asante	KNUST, former student
Isaac Ampomah	MOFA AEA, Asamamepaese
Simon Abugre	KNUST, IRNR student
Shu-aib Jakpa Sumaila	KNUST, IRNR student
Andrews Cudjoe Bayuko	KNUST, IRNR student
John K.G. Amonoo	KNUST, IRNR Dpt Agroforestry, teaching assistant
David Castel	KNUST, IRNR student
Benjamin Quarcuo	KNUST, IRNR student
Samuel Adimado	GOAN, field officer
Funke Cofie	IWMI, KNUST
Lawrence Tsimese	GOAN, information officer
Raymond Bokor	GOAN, field officer

In Accra a final workshop was held with senior members of CSIR and MOFA (Table 4.4) where the tools were presented and discussed in the context of national agricultural research and dissemination in Ghana.

Table 4.4: Participants at a workshop for senior members of the NARES at the CSIR Secretariat, Accra on Wednesday 20 June 2001.

Name	**Organization/ Role**
Mr Franklin Donkoh	Director, Agricultural Extension Services, MOFA
Dr John A. Poku	Deputy Director, Crop Services, MOFA
Prof. E. Owusu-Bennoah	Deputy Director General, AFFS, CSIR
Dr S.G.K. Adiku	Head, Soil Science, University of Ghana, Legon
Dr F.K.Kumagya	Crop Science, University of Ghana, Legon
Mr J.B. Ofosu	Agriculture, Forestry and Fisheries Sector (AFFS), CSIR
Dr Joseph Cobbina	Head, Natural Resource Management, AFFS, CSIR
Dr Kofi Debrah	International Fertiliser Development Centre for Africa, Lome, Togo
Dr J.K.Adu	Acting Director, Animal Research Institute
Mr Jacob Tetteh	Rural Livelihoods Programme Officer, Rural Livelihoods Office, DFID

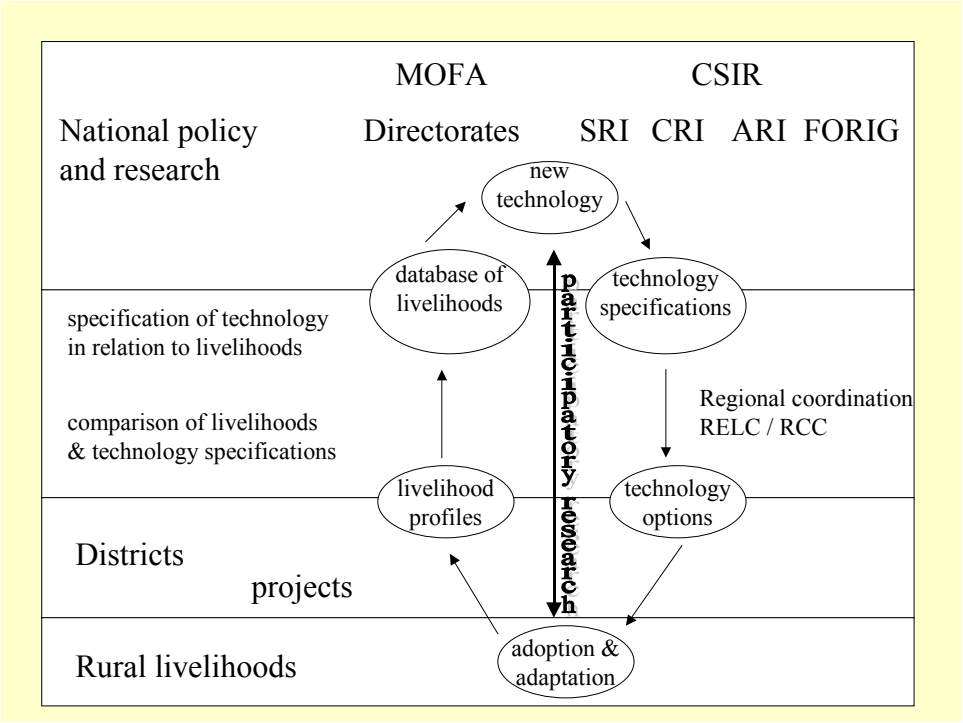
A framework emerged from the workshops for incorporating the tools into the NARES in Ghana (Figure 4.5). Within the framework a database of livelihood profiles is created by aggregating data from livelihood analyses carried out at a local level. Researchers use the database and soil fertility knowledge bases to enhance understanding of rural livelihoods and potential technology options. They are required to make explicit the specifications for different technologies and use these resources to guide technology development. Similarly technology specifications can be used by District Directors of Agriculture to make informed choices about technology promotion. Both the database of livelihood profiles and technology specifications can be used by high level decision makers to guide choices about the organization and planning of research and dissemination activities. In this way research can be made cost effective by investment in technologies that are relevant to large numbers of the population or alternatively research outputs are produced that target marginalized groups of farmers such as women or the rural poor. Where changes in policy are necessary for successful uptake of technologies, or where a coordinated approach to extension activities is necessary e.g. where post-harvest storage technologies would help farmers profit from investment in soil fertility, this becomes clear.

Livelihood profiles can be built up from research work at district level. They can be compiled as a paper based resource by MOFA district staff as an output of pre-existing projects. Data from the profiles can then be compiled in the form of a database at regional and national levels jointly by MOFA and CSIR, to make the profiles more accessible to a wider range of people.

The profiles in the database could be accessed by agricultural researchers within the national research institutes, MOFA regional staff responsible for technical backstopping of the districts and by national decision makers. Quantification is a necessary feature of the database, both as part of the tools themselves and in terms of producing estimates of numbers of people to whom interventions may be relevant. As livelihoods change over time the profiles in the database have limited life spans

(possibly five years or so) before requiring updating. This approach has to be seen as a process, with dynamic data resources.

Figure 4.5: A framework for linking research and dissemination to rural livelihoods in Ghana.



The database can also form a resource for decision makers making choices about the allocation of funding for research and development activities based on an understanding of rural livelihoods. Population figures permit the prioritization of research and development work that is efficient in reaching a large proportion of the rural population. The database could also be used to facilitate the targeting of specific groups of the population such as women or the rural poor. It could also be made available at district level in those locations where MOFA or district assemblies have computer resources available. At present resource availability is variable.

Researchers themselves, within the relevant CSIR institutes and the universities could also use the livelihood database and the tools. These could help them to specify technological innovations in terms of the livelihoods for which they are relevant. Technology specifications thus explicitly state their requirements and suggest whom they are applicable to. Where a technology has further requirements for farmer uptake (e.g. provision of credit) this becomes clear and MOFA staff can coordinate activities accordingly.

Use of the database and tools clearly requires access to computing facilities by NARS researchers. However, although computer facilities are generally poor, and there is a high proportion of researchers to machines available, this situation is also true of paper based information resources (Moss, 2001a). Where funding has been obtained computing facilities are being upgraded as are library and resource centres (e.g. at GOAN and FORIG). The Ghana Agricultural Information Service forms an information network with a central coordination point at the Institute for Scientific and Technological Information aimed at facilitating information flow and encouraging the use of electronic media. Computer literacy is improving especially amongst the younger generation of researchers and electronic databases form an interesting

alternative means of accessing information. They are easy to update and dissemination is rapid and cheap.

Ghana's policy of decentralization from national and regional level to districts makes decision making an essential requirement of MOFA district staff. Information resources at this level are however, sparse. The framework suggests a potential role in the compilation of technology specifications produced by researchers into technology options relevant to local livelihoods in particular areas at a regional level by RELC committees. These technology options could provide a resource for district directors to draw upon and enable them to make simple informed choices about the promotion of different technologies. Conversely, requirements for research (researchable constraints) emerging from livelihood profiles at district level could be compiled regionally to drive research priorities nationally. However, with the decentralization of power to district level it remains unclear how effectively regional activity will function in the future.

Implementation of the framework would also be complementary to AGSSIP (Agricultural Sub-sector Services Investment Project), the instrument by which Ghana intends to improve agricultural, and hence national economic growth rates. In keeping with the aims of AGSSIP implementation of the framework would strengthen agricultural extension services provision, increase the effectiveness of agricultural research, encompass capacity building within agricultural training schools and provide resources for informed policy decision making.

At the meeting held in Accra with senior decision makers key issues that emerged were as follows.

1. The framework and tools are a sound basis for meeting an immediate need, already a priority for MOFA and CSIR, to make research and dissemination more relevant to diverse rural livelihoods, and especially for those in greatest need.
2. Implementation of the framework and tools will require extensive capacity building to effect change in attitudes and acquisition of appropriate skills by extension staff (this requires training of trainers in the Human Resources Development Directorate of MOFA and introduction of appropriate curricula at a University level. It also includes the introduction of news concepts such as rural livelihoods in addition to the acquisition of new skills).
3. Procedures for aggregation of information on livelihoods across spatial and temporal scales will need to be developed and tested.
4. Procedures for developing and applying strategic policy on a selection of target livelihoods and prioritization of research and dissemination will need to be developed and tested.
5. Further development of specific tools to relate research results on key topics to locally appropriate evaluation of resources is required.

It was decided that:

- the framework and tools should now be piloted in Ghana, requiring some further tool development, capacity building and trial implementation at national, regional and district levels, and
- a proposal for pilot implementation will be developed and resources sought to implement this.

5. RESEARCH ACTIVITIES

The research process consisted of the following different phases:

1. An initial in-country workshop
2. A review of available information on soil fertility research outputs, farmer recommendations and their adoption and adaptation resulting in the production of an evaluation matrix
3. Field work studies in five locations looking at farming and livelihood characteristics and local knowledge of soil fertility management
4. Analyses of the generation and flows of knowledge for two case studies
5. Data analysis of knowledge flow from the fieldwork phase
6. Development of a methodological framework and tools for soil fertility research and dissemination
7. Dissemination of methods for the design of soil fertility management research and dissemination strategies

5.1 Initial in country workshop

The inception workshop (held in conjunction with project R7446 in January 2000) was used to make arrangements for the fieldwork phase of the project and to gather background information on soils research in Ghana. It is documented in Youde and McDonald (2000).

5.2 Review of available information

The literature review started off by looking at reasons given for the generally low adoption of technologies produced through participatory research. It then detailed previous and current assessments of soil fertility research outputs and their adoption in Ghana. Reasons given for the low adoption of soil fertility technologies were reviewed, and a matrix was produced that linked technologies, research and dissemination methods used, and farmer adoption. The review and matrix are documented in Moss and Sinclair (2000)

5.3 Field survey: local knowledge and livelihoods

5.3.1 Site selection

Fieldwork took place at five sites: two in the Brong Ahafo region, two in the Ashanti region and one in the Western region (Figure 5.1), during March to December 2000 and is documented in detail in Frost (2000b); Moss (2001c and d); Obiri-Darko *et al.* (2000). The sites were chosen to provide a contrast in agro-ecology, livelihood strategies, soil conditions, market access and population density (Figure 5.2). Fieldwork at three of the sites (Wenchi, Tano and Atwima) was carried out in conjunction with the Bush Fallow project (R7446). The southernmost three sites (Atwima, peri-urban Kumasi and Wassa Amenfi) fall within the three blocks of the EPHTA forest pockets benchmark, but there was little available information at the time of the research to further coordinate research activities.

Figure 5.1: Location of the five field sites within the forest zones of Ghana (Map source: Hall and Swaine, 1981).

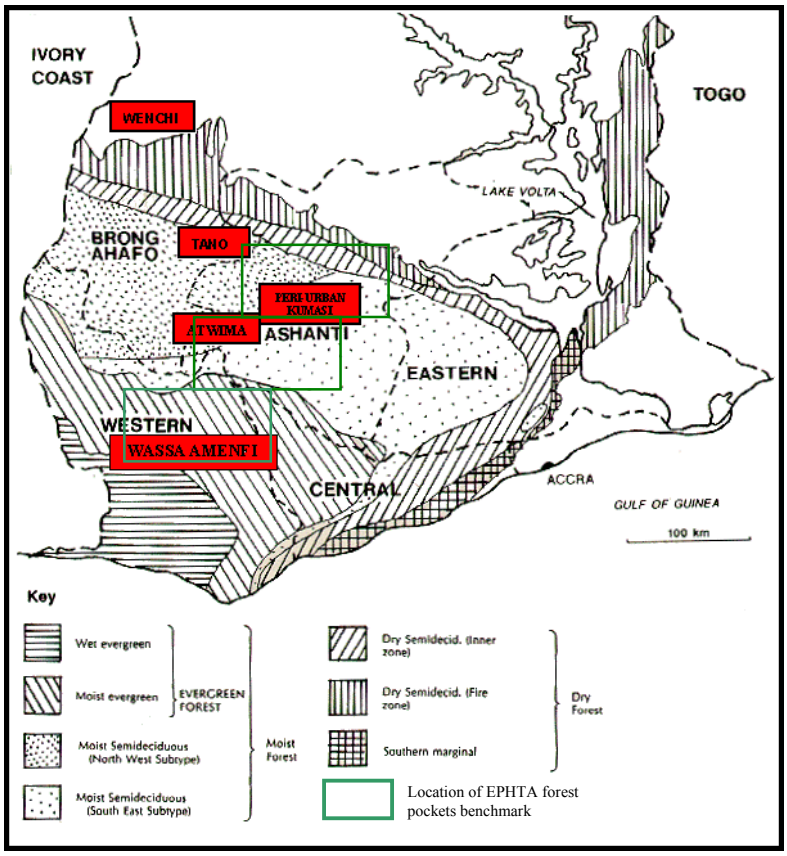
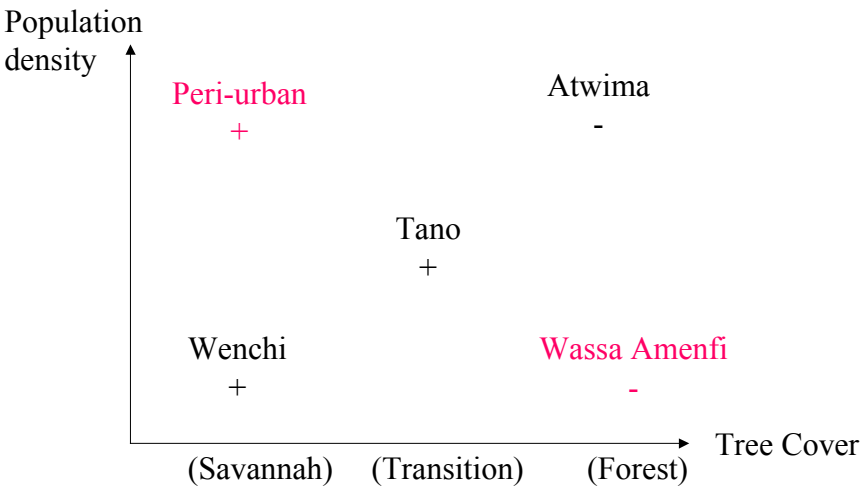


Figure 5.2: Characteristics of the five field sites.



Key

Black	sites covered by the Shortened bush fallow project and the Knowledge Gap project
Red	sites covered by the Knowledge Gap project
+	good market access for the sale of food crops
-	poor market access for the sale of food crops

The villages where research work took place (Table 5.1) were selected following discussion with Ministry of Agriculture district staff and visits to a number of villages in each area where basic information concerning the structure of the community, the livelihoods of the people and the crops grown was collected. Locations were chosen to provide an interesting contrast to one another.

Table 5.1: Village locations and other sources of information used for field survey of local knowledge and livelihoods.

Type of information	*Villages in Wassa Amenfi*	*Villages in Atwima*	*Villages in peri-urban Kumasi*	*Villages in Tano*	*Villages in Wenchi*
Livelihoods	Oda-Kotoamso	Gogoikrom	Project reports	Subriso No. 3	Yabraso
Local knowledge	Oda-Kotoamso Bremang Afiena Tano Agya	Gogoikrom Kyereyase	Boankra (Ejisu Juaben) Besease (Ejisu Juanben) Aboaso (Kwabre) Abuakwa (Atwima)	Subriso No. 3	Yabraso

5.3.2 Analysis of livelihoods and local knowledge

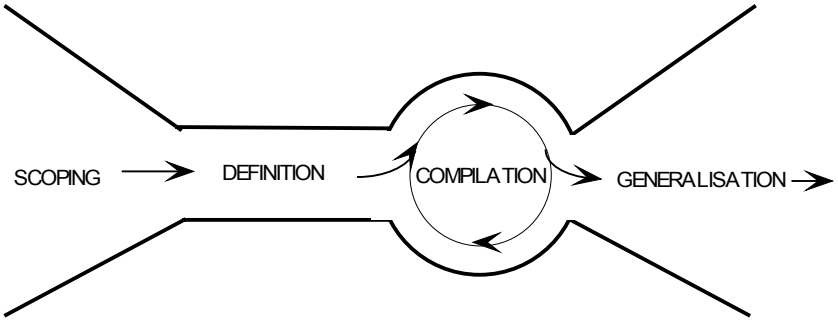
An analysis of livelihoods and local knowledge are essentially two separate operations. However as it is useful to know something about local farming practises, biophysical and socio-economic conditions prior to embarking on local knowledge research an analysis of livelihoods was used to inform the local knowledge research process.

Categorization of different livelihoods was primarily based on the type of crop farms cultivated, differences in terms of access to land where this was relevant to agricultural intensification and additional income generating activities. These differences were broadly associated with differences in gender, age, farmer origin and marital status although not all factors were considered at each site. At Yabraso, Subriso and Atwima where research took place in conjunction with project R7446 gender and farmer origin were initially considered. Following the mid-term review it was agreed that these categories would be reconsidered by project R7446. At peri-urban Kumasi analysis was based on existing reports from previous projects which primarily considered age and gender, although differences between indigenous and settler farmers were noted where these were relevant. At Oda gender, age and female marital status were considered. Differences in livelihoods of the indigenous Wassa population and settler farmers were not assessed due to the low proportion of settlers at Oda (less than ten percent of the population) and the wealth of existing literature relating to the livelihoods of settler cocoa farmers in Ghana (Hill, 1963; Okali, 1983; 1975; Arhin, 1985).

The Agroecological Knowledge Toolkit (AKT - formally known as the Agroforestry Knowledge Toolkit for Windows) approach was used to document and analyze local knowledge of soil fertility management at each site. Using this approach local knowledge is elicited from informants and recorded and analysed using knowledge based systems software (AKT). The methodology for this approach is divided into four stages (Figure 5.3) which have been outlined in detail elsewhere and are essentially iterative in nature (Dixon *et al.*, 2001; Sinclair and Walker, 1998 and Walker and Sinclair, 1998).

The aim of the first stage of the process is for the researcher to familiarize themselves with the source community, gather basic information about the livelihoods of the farming population and cropping practices, carry out a preliminary assessment of what is known by the whole community and identify parameters that may be used to stratify informants. This stage thus serves to provide information to produce a more detailed knowledge elicitation strategy and to further define the objectives of the research (Walker and Sinclair, 1998).

Figure 5.3: Approach to knowledge elicitation for knowledge base creation using AKT. Source: Walker and Sinclair (1998).



Objective	To refine knowledge acquisition objectives	To generate a broad understanding of domain & define boundaries & terms	To create a coherent and comprehensive knowledge base	To test how representative the knowledge base is of farmers generally
Informants and activities	A broad range of activities across the community	One or two intensive interactions with a small number of purposively selected informants	Iterative cycle: repeated interaction with stratified sample of key informants, knowledge representation and evaluation of emerging knowledge base	A variety of questionnaire-based survey approaches on a sufficiently large and randomly selected sample of informants from the community

The activities that were carried out for the first stage also served to provide information for the analysis of land based livelihoods at each site. These analyses are reported in Frost (2000b); Moss (2001c and d) and Obiri-Darko *et al.* (2000). Activities used at this stage commonly include the consultation of existing literature and local experts, group and individual interviews and RRA and PRA exercises. More specifically the following activities were carried out:

1. District development plans, project reports and other documents were consulted where these were available. Sufficient information about livelihoods and cropping practices could be gathered for the peri-urban Kumasi area from these sources so that it was not necessary to hold any further interviews and discussions as listed below, for this site.
2. Interviews and interaction with key informants including past and present assemblymen, chiefs and elders, well-known village farmers, ordinary village people and the agricultural staff working in the area (predominantly district staff of the Ministry of Agriculture) took place to gather general information about the community.
3. Short structured interviews with about 40 farmers for each site chosen to represent a mixture of men and women, older and younger people, settlers and indigenous people, wealthy farmers and more ordinary farmers (where these strata were present) took place. Basic household information was elicited together with information about farms under cultivation and soil fertility management practices.

4. Separate group meetings were held with disaggregated groups of farmers. Participatory causal diagramming – an approach to on-farm action research developed by the University of Reading (Galpin *et al.*, 2000), was used to analyze farming constraints[1]. Other topics relevant to disaggregated groups were also discussed.

[1] It should be noted that this form of participatory causal diagramming is distinct from diagrammatic representation of statements in knowledge bases. Although it is possible to contrast the outputs from participatory diagrams and AKT diagrams, methods for the validation of knowledge involve

The second and third stages of the approach consist of elicitation and recording of detailed local ecological knowledge. During knowledge elicitation it is necessary to talk to a few knowledgeable and articulate members of the community in depth, rather than trying to obtain statistically representative samples. Exceptional members of the community (such as local teachers) are avoided, but willingness to participate is an important criterion as repeated interviews are important for explanatory clarification. The selection of informants is stratified to ensure that variability in knowledge is covered and five informants from each strata is considered sufficient at this stage (past research has found that larger numbers of similar informants produce little new knowledge, Walker and Sinclair, 1998).

Stratification criteria included gender, age and ethnicity but where there were small numbers of farmers within any one stratum present in a community or actively engaged in farming fewer interviews were carried out. For example, in peri-urban Kumasi there were few young women engaged in farming. At each site semi-structured interviews about soil fertility took place with a total of about 20 farmers. Information on the gender, age and origin of individual informants can be retrieved from the knowledge bases. The interview process was iterative. Analysis of information from one interview was used to formulate questions for further interviews. Informants were interviewed on more than one occasion so that points could be clarified and triangulation was used to verify information gathered from multiple informants. The knowledge elicited was used to create five knowledge bases – one for each site (Frost, 2000b; Moss, 2000a; Moss, 2000b; Moss and Jatango, 2000; Moss and Obiri-Darko, 2000).

The final stage of the methodology is the generalisation stage which involves the testing of the representativeness of the knowledge across a wider (and statistically verifiable) group of informants (Dixon *et al.*, 2001). This stage was not intended to form a part of the research during the lifetime of the project but is being planned as a follow up exercise.

5.4 Analysis of generation and flows of knowledge

Two case studies were conducted to examine the transfer of knowledge about soil fertility management. (Although a larger number of case studies was originally considered, it was agreed to limit the number of case studies at the mid-term review in January 2001).

The first case study was conducted between August 2000 and May 2001 by GOAN and involved follow up interviews and farm visits to the first two communities who had benefited from GOAN's new strategy for the dissemination of organic methods of farming (pest and soil management) through Farmer Field Schools (Bokor 2000; Bokor 2001). These communities were Offinso and Duase in the Ashanti region.

The second case study (Moss, 2001a) concerned the dissemination of cover crop technologies in the Brong Ahafo region. The following activities were carried out between January 2001 and March 2001:

1. A cover crop knowledge base (Moss, 2001b) was created using the Agro-Ecological Knowledge Toolkit software to assess knowledge flow and to

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administration of non-leading questionnaires to a large random sample of people (Walker and Sinclair, 1998).

document knowledge storage. The knowledge entered consisted of internationally held knowledge of cover crops which had been documented and was available in Ghana, and knowledge held by members of the the National Agricultural Research and Extension System. The majority of information available in Ghana was about mucuna species as these have been better researched than other cover crops and therefore the majority of the statements that were entered were about mucuna.

2. Members of the National Agricultural Research System who have worked with cover crops were interviewed to gauge their perceptions on the ease of access to knowledge.
3. A database of sources of information about cover crops with particular emphasis on West Africa was created using Microsoft Access.

5.5 Development of a methodological framework and tools

Using the lessons learnt from the fieldwork phase of the project a set of tools was produced to link research and dissemination to rural livelihoods. One of the tools – the set of knowledge bases, was created using existing software – the Agroecological Knowledge Toolkit. Significant and innovative modifications were made to the software directly as a result of the experiences gained during the project.

These included enhancement of the utility for entering and searching disaggregated farmer interview sources within the knowledge bases. This has improved the capacity for comparison of the knowledge of different groups of farmers within the community. The second set of modifications improved the capacity for working with and comparing multiple knowledge bases. The third modification provided a facility for the incorporation of livelihoods information into a knowledge base to provide contextual information to go alongside local knowledge.

5.6 Dissemination of methods for the design of soil fertility management research and dissemination strategies

Following the development of tools for the design of soil fertility management research and dissemination three one day evaluation workshops and one workshop with senior members of NARES were held in Ghana from 10 – 20 June 2001. At each workshop the project findings and the tools produced were presented and then discussed. Participants at the one day workshops were given the opportunity to try out and evaluate each tool, both through group discussion and formally through a questionnaire. Some modifications to the tools were made as a result of the discussions and evaluation.

If the outputs are adopted in Ghana as outlined in section 7.3 then

- Research will be better targeted to rural livelihoods improving technology options for farmers and hence the productivity and sustainability of rural livelihoods.
- Dissemination will be better targeted making information generated from research available to farmers for whom it is relevant, again improving the sustainability of rural livelihoods.
- Marginalized groups who cannot be effectively targeted with current technological options will be identified and policy interventions revised as a precursor to agricultural improvement for the people highlighted.

The framework (section 7.3) sets out the promotion pathway for using the outputs in Ghana. There is enthusiasm for adopting the outputs at a national and local level and a proposal to pilot use of the approach in three districts has been tabled.

At the final workshop in Accra the following proposal for piloting use of the approach in Ghana was tabled (Box 6.1).

Box 6.1: An outline pilot proposal for the incorporation of the tools and framework into the NARES in Ghana.

Outline pilot proposal

Title
Capacity building and pilot implementation of methods and procedures to relate agricultural research and extension activity to rural livelihoods in Ghana

Goal
Improved and more sustainable agricultural production and hence rural livelihoods in Ghana

Purpose
More effective targeting of agricultural dissemination and research to the circumstances of rural livelihoods in Ghana

Outputs

1. Sustainable capacity within MOFA to incorporate livelihood analysis in dissemination activity developed and implemented in three districts
2. Sustainable capacity within CSIR and universities to specify technological innovations in terms of the livelihoods for which they are relevant, developed and implemented in four national research institutes and two universities
3. Role of regional aggregation of livelihood data and technology options appraised and recommendations on regional provision of information services made
4. A suite of tools for:
   4.1. livelihood profiling and subsequent aggregation of profile information at larger scales,
   4.2. choosing and specifying appropriate technologies for particular livelihoods,
   4.3. managing local and expert knowledge at district and national scales, and

Box 6.1 (continued)

4.4. facilitating provision of flexible extension advice (as opposed to prefabricated packages) developed, refined and field tested in Ghana.

5. Lessons learnt documented and if appropriate, recommendations on how to scale up to the whole agricultural sector in Ghana (incorporating outcomes from the pilot phase), developed and nationally presented.

Scope of activities

The pilot implementation will be led by MOFA and CSIR nationally, with an initial focus on sustainable improvement of crop production through soil fertility management.

- Capacity building will focus on staff within the Human Resources Development Directorate of MOFA (possibly Kwadaso Agricultural College) who will be trained as the trainers of extension staff. University staff and curricula (at UGL and UST) will also be developed to incorporate livelihood analysis and knowledge-based tools in education in the natural resources sector more generally.
- The dissemination focus will be on MOFA district staff and NGOs in three districts with contrasting agroecology (possibly Atwima, Tano and Wenchi) from more than one region (Brong Ahafo and Ashanti in the case of these districts). The role of MOFA regionally in scaling across districts will also be addressed, alongside direct drawing down of services from national provision, by districts.
- From the national research system, four CSIR research institutes with particular interests in soil fertility will be involved (possibly CRI, SRI, FORIG and ARI).

At the end of the project recommendations for scaling up to the whole agricultural sector (subjectwise and geographically) will be made as appropriate.

7. PUBLICATIONS AND OTHER COMMUNICATIONS MATERIALS

7.1 Books and book chapters

7.2 Journal articles

7.3 Institutional report series

7.4 Symposium, conference, workshop papers and posters

7.5 Newsletter articles

Ghana Organic Agriculture Network 2001 Agroforestry Knowledge Toolkit. The Organic Farmer 6, 1, January to March 2001 pp. 5

7.6 Academic theses

Frost W., 2000. Farmers' knowledge of soil fertility and weed management in Atwima District, Ghana: the implications for participatory technology development. MSc Thesis. School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 91pp.

7.7 Extension-orientated leaflets, brochures and posters

7.8 Manuals and guidelines

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

7.10 Reports and data records

7.10.1 Citation for the project Final Technical Report (FTR)

Moss, C., and Sinclair, F.L., 2001 Final Technical Report "Bridging Knowledge Gaps between Soils Research and Dissemination in Ghana" (DFID Project R7516). School of Agricultural and Forest Sciences University of Wales, Bangor, UK.

7.10.2 Internal project technical reports

Bokor, R., 2000. The effectiveness of farmer field schools in disseminating soil fertility interventions. Ghana Organic Agriculture Network, Kumasi, Ghana. 7pp.

Bokor, R., 2001. Farmer Field School Evaluation: part two. Ghana Organic Agriculture Network, Kumasi, Ghana. 7pp.

Moss, C., 2001a. A case study of cover crop knowledge storage and information flow. School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 17pp.

Moss, C., 2001c. Livelihoods and local knowledge of soil fertility management in peri-urban Kumasi, Ghana. School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 24pp.

Moss, C., 2001d. Livelihoods and local knowledge of soil fertility management at Oda-Kotoamso, Wassa-Amenfi District, Western Region, Ghana. School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 38pp.

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7.10.3 Literature reviews

7.10.4 Scoping studies

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9. PROJECT LOGFRAME

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	ASSUMPTIONS
GOAL: Benefits for poor people in target countries generated by application of new knowledge to natural resource management in the forest/agriculture interface	By 2005 evidence of application of research products to benefit target communities by achieving one or more of: - sustainable production increase. - less variable production. - productivity increase. - improved employment - (numbers, income, quality). - improved access by poor people to RNR Output.	DFID commissioned reviews. Monitoring against relevant baseline data collated by the programme. Reports of in-country institutions. National statistics.	Enabling environment (policies, institutions, markets, incentives) for widespread adoption of new strategies and practices exists. Climatic conditions are favourable.
PURPOSE: Strategies to secure the livelihoods of poor people dependent on agricultural systems near the receding forest margin developed and promoted.	By 2003 integrated natural resource management strategies validated in relevant systems in three target countries and adopted by target institutions.	Data collected and collated by the programme manager.	Sustainable sedentary systems for poor and fragile soils can be devised. Land ownership issues can be overcome.
OUTPUTS: 1. Information on success and failure in adoption of soil fertility research outputs collated and disseminated. 2. Reasons for low adoption of soil fertility research outputs in Ghana identified and documented. 3. A rigorous framework for designing soil fertility research and dissemination strategies developed and promoted.	1. Results of review reported after 4 months and subsequent records of dissemination of articles. 2. Results of field work surveys and case studies reported after 16 months and subsequent records of dissemination of articles. 3. Methodology set out in handbook after 18 months and subsequently in use by collaborators.	Project reports FAI evaluations and reports Journal papers Popular articles Web site linked to UWB and partner institution pages	Target institutions take up and use research outputs
ACTIVITIES: Desk study (3 months, Bangor) 1.1 Initial in-country workshop 1.2 Review of information available on soil fertility research outputs, farmer recommendations, their adoption and adaptation 1.3 Production and analysis of evaluation matrix Field survey (12 months, Ghana)	PROJECT MILESTONES: After 3 months Initial workshop completed Literature review & evaluation matrix completed	Quarterly, calendar and annual reports	Availability of comparative information on adoption for review Uptake decisions can be adequately modelled using a Bayesian approach. Dissemination is a more fundamental constraint to adoption

2.1 Analysis of generation and knowledge flows 2.2 Existing baseline information collated 2.3 Analysis of dissemination penetration. Method development and dissemination (3 months) 3.1 Requirements for design of research and dissemination strategies presented. 3.2 A methodological framework and appropriate tools produced. 3.3 Dissemination of methods including evaluation workshop in Ghana.	After 12 months Knowledge analysis completed Baseline data collected Dissemination penetration survey completed After 18 months Requirements for design produced (3.1) Method and tools produced (3.2) Final workshop held (3.3)	BUDGET: Staff £41 138 Overheads £22 625 Equipment £ 3 000 Travel £ 9 840 Consumables £20 475 TOTAL £97 078	than technical knowledge of soil fertility. Absence of political or climatic extremes in Ghana during fieldwork.

10. KEYWORDS

Ghana
Local knowledge
Technology adoption
Soil fertility
West Africa

11. ANNEXES

Annex A: *Moss, C. Frost, F. Obiri-Darko, B. Jatango, J. Dixon, H. and. Sinclair, F.L. 2001* ***Local knowledge and livelihoods: tools for soils research and dissemination in Ghana. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK.***

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Annex E: *Bokor, R., 2000.* ***The effectiveness of farmer field schools in disseminating soil fertility interventions. Ghana Organic Agriculture Network, Kumasi, Ghana. 7pp.***

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