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Agroforestry options for Ghana - Land use planning with integrated bio-physical and multiple objective models. Part 1

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Agroforestry Options for Ghana - land use planning with integrated bio-physical and multiple objective models.

(ODA/NRI R6517 - ZE0016)

Revised Final Technical Report

February 1999

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1 Executive Summary

1.1 Purpose

Non-adoption of agroforestry interventions has been a set back for agroforestry R&D. This project was set up to develop a model building sequence which incorporates a range of farmer goals and constraints in order to aid decision makers and extension workers analyse a range of alternative land-use activities and select combinations to meet specified objectives, enhance food production/security, and maintain ecological stability through improved land-use practices.

1.2 Research activities.

1. Collation of existing information to build up a background picture of small-holder farming in Ghana.
2. Field visit – March/April 1996 – Kenneth Nkowani – to carry out the collation of existing data on tree farming systems in Ghana, consultations with a variety of pertinent institutions and organisations, and to select field sites for the farmer survey in collaboration with the IRNR and MoFA.
3. Questionnaire survey – in collaboration with MoFA, clusters of 50+ farmers were surveyed in each of the three agro-ecological zones – Forest, forest-savanna transition and guinea-savanna.
4. Field visit – October 1996 - Kenneth Nkowani – to co-ordinate the primary input of the questionnaire survey and to hold meetings with selected farmers to elicit information about farmers objectives.
5. Database construction –tables of information were entered into an MS Access database such that relational and cross tabulation queries could be run.
6. Database analysis – key information was extracted from the database and used to derive the input/output coefficients for the modelling phase of the programme.
7. Field visits – April 1997 – Julian Smith –Geo -referenced the study villages and carried out a participatory survey of the spatial allocation of plots around seven villages. May - July 1997 -David Young- surveyed the reasons why farmers retain the trees that they do, on their farms.
8. Workshop – July/August 1997 –validated key results from the database with Ghanaian Professionals. Areas of missing data were identified and participatory exercises were designed to close the information gaps through 'round table' discussions and presentations.
9. Ideas for adapting the skeletal structure of the models to fit with current practice were developed. Model runs and refinement are an on going process providing the key productivity benchmarks and output for publications on systems design.

1.3 Outputs.

1. Database analysis – key results from the database are presented covering a wide range of information; crop production practices; livestock keeping; tree management; wild resources; labour; income & expenditure; and constraints.
2. Geo-referencing – survey points were entered into a GIS providing an exact mapping of the location of the villages.
3. Farmer objectives – results of the discussions feature a wide range of objectives from subsistence to income generation, planning for the future, improving the standard of living and feeding the nation as a whole.
4. Spatial aspect of land use – participatory maps are presented showing the allocation of land and other resources around the villages.
5. Participatory Workshop – key data were elicited in the form of time lines of labour activities by crop and region to be owned and maintained by user groups. Farmers reasons for keeping the trees that they do and professionals views on non-adoption of agroforestry techniques are presented.
6. Financial appraisal of interventions -
7. System models – show how the local farming system can be compared competitively with the implementation of an agroforestry practice and perennial crop system.
8. Compromise programming – whilst satisfying subsistence targets, the conflicting objectives of maximising expectations and minimising the associated risk are traded to allow the optimal compromise activity mix suitable for risk-averse farmers to be computed.

9. Regional models – present the application of the XPRESS technology to aggregate the household level information to the regional level such that analyses of the carrying capacity, production surplus and marginal value products of scarce resources can be estimated and compared.

1.4 Contribution to Goals.

Our published results from the models herein demonstrate the power to discriminate between agroforestry options beyond the capabilities of financial (e.g. spreadsheet) appraisals. Incorporation of farmers' goals and constraints into planning models is identified as the mechanism for rejecting, at the design stage, options ranked superior by financial appraisal techniques (NPV, IRR etc.) which prove to be inferior in meeting the expressed needs of farmers under practical constraints. The information gathered and disseminated is directed towards improving the sustainability of commodity production systems on land previously under natural forest.

1.5 Concluding Remarks

The survey of existing practice reveals that current farming systems are diverse and complex. Greater understanding of existing practice is a precondition for development of an advisory tool by **user groups**.

The data base derived from the survey serves as a platform for running simulation models of field work practice. Templates of biophysical input output coefficients are complemented with household data to complete an integrated model of a farm household.

System models have been used for comparison against existing cost benefit analysis (**CBA**) in which day to day activities are costed but not planned. The level of planning detail in the **system models** reveals the reasons why existing cost benefit software packages are unable to make legitimate comparisons of real systems for decisions on the adoptability of alternative agroforestry practices for smallholders and provides a new standard for comparison of alternatives.

Models at the farm level can be aggregated to a local district level to reveal the carrying capacity of the system, the extent of marketable surpluses of produce and the marginal value productivity of scarce resources. At a regional level, a limited range of crude supply and demand balance predictions could be made in the context of adequate census data.

The workshop revealed the full extent of the lack of information flow monitoring current agricultural productivity and pricing, particularly in the livestock sector. The workshop also identified the need for improved standards of information reporting in respect of date and location, so that the spatial and temporal dimensions can be fully utilised in future work. Particularly if this can be linked to the interpretation of satellite imagery and prediction of environmental and micro climatic impacts arising from the scale effects in the practice of farming systems.

The workshop calls for the establishment of ***user groups*** (one in each agro ecological zone) to take ownership, develop and disseminate planning information to all potential beneficiaries in farming practice, through extension workers, NGOs, as well as government and commerce.

2 Background to the Project.-

Non-adoption of agroforestry interventions is a set back for agroforestry research and extension services to West African farmers. Reasons for non-adoption were identified by Bayliss-Smith *et al.* (1993). This work would seem to point out that the incorporation of farm family objectives into farming systems research should provide a mechanism for rejecting options at the system design stage where conflicts with family seasonal labour supply, life style, gender issues, tastes and preferences are significant.

Discussions between ODA's Forestry Research Programme, Plant Sciences Research Programme and Agronomy and Cropping Systems Programme led to a desk study in 1992 which identified agroforestry research priorities and modelling opportunities (Anderson *et al.*, 1992). In July 1993, the Forestry Research Programme commissioned ITE Edinburgh to undertake the 'Agroforestry Modelling and Research Co-ordination Project (AMP)'. Part of this project sought (with funding from the Agronomy and Cropping and Resource Assessment Programmes of ODA) to couple process-based growth models of individual trees (between MAESTRO - Edinburgh University), forest canopies (HYBRID, ITE, Edinburgh) and tropical crops (PARCH - Nottingham University). Subsequent improvements will incorporate microclimate interactions (ERIN - Institute of Hydrology) and root growth models (University of Reading).

Bio-physical crop and agroforestry models have developed to a stage where they can provide insight into land use planning choices for smallholder farming systems. They can simulate production from alternative cropping regimes, and provide information on likely variability of yields (Fawcett, 1995). However, bio-physical models provide only part of the picture, and mean outputs of grain or timber may not be the dominant influence on a farmers' decision to plant and nurture a tree or crop in a risky environment.

The effect of low agricultural productivity and poverty make it exceedingly difficult for a smallholder farmer to think beyond mere survival and exploitation of land: increasing pressure on land through unsustainable farming practices (caused in the main by population pressure) continues to provoke environmental deterioration. In addition, considerations of food security, long-term sustainability, labour-minimisation, food palatability and social customs may conflict with a desire to maximise cash output. Farmers have 'satisficing' strategies, which allows conflicts between multiple goals to be resolved (Dent and McGregor, 1993; Nkowani *et al.*, 1995). The challenge faced by decision makers is to find ways to feed an increasing population, without irreparably damaging the natural resource base on which agricultural production depends.

The farmers' land-use decision-making process is driven by a number of objectives which include minimising risk, improving food security, involvement in community, fulfilling cultural obligations and concerns about income. Decision-making by farm households is complex. This complexity can be, however, represented on model format by embedding the output from biophysical models (MAESTRO, HYBRID, ERIN, and HYPAR) into the socio-economic framework established at farm level which sets out the resource constraints under which smallholder farmers operate. Representative multiple objective farm level models have been used to investigate land/resource use options open to smallholder farmers (for instance see Flinn *et al.*, 1992; Maino *et al.*, 1993). The modeled farm-level outputs which define the results of the decisions taken by the farmers in their daily lives provide a major source of data for the regional level model.

2.1 *Linear Programming – its links to neo-classical economics*

It can be recognised that any successful farming system has to be set within the environmental, social and economic constraints of the particular locale. Mathematical programming allows us to capture the physical systems of the farm, the environment and the market place. In addition, the range of possible activities represented in the model are not only restricted to 'what is' but also to allow analysis of 'what could be possible'. Modelling of the farming systems allows the researcher to establish quantified links between the inputs and outputs from the processes involved in the farming system. Indeed, the modelling process highlights areas which lack information, increases understanding of the systems as a whole and allows the static data and information to become dynamic and more enlightening.

Linear programming (LP) is the foundation of a set of practical optimising techniques known as mathematical programming methods. It was developed simultaneously in Russia by Kantorovich and in the United States by George B Danzig. The Russians used it for the central planning of the soviet economy and the Americans mainly for logistical planning in the Airforce and Navy. It has been applied in agriculture by Earl O Heady and Wilfred Candler and has become a basic tool in industry. It is commonly used for formulating animal feedstuffs. Dent et al have shown the strength of mathematical programming in agricultural decision support and farm planning. The development of this socio-economic model has shown a system of choice expressed as a matrix of constraints, activity and motivation. Mathematical modelling offers the planner, economist and decision maker the tools to analyse and explore a range of options.

Our purpose in selecting linear programming is to see how it can help with deciding the optimal allocation of resources. It can be linked directly to classical economic theory through two fundamental principles in economic thinking: namely, the law of diminishing returns and the Equi-marginal principle.

This is one of the most useful practical tool known to mankind in helping us to make the best use of scarce resources when faced with complex decision problems, i.e. problems beyond the capacity of the human brain to solve except by instinct. Many problems can not be solved properly because of a fundamental lack of knowledge or information. The distinction between knowledge and information is important but the lack of either is serious when you want answers to problems in a short (finite) time scale.

The fundamental resource classification for economists is into land, labour and capital. Land stands for natural resources and all that is to be found in the environment As individuals our own labour time is limiting and whether we are rich or poor there is a finite limit to our borrowing capacity or the physical amount of capital we can mobilise.

Whether we are hunter gatherers, pastoral nomads, or sedentary agriculturalists, the fundamental limiting resource that we posses is our own labour time and we become experts in its deployment in the course of our everyday lives. We learn by doing what we think is best for ourselves and those to whom we have responsibilities.

We may have some objective and purpose to our lives whether this be the accumulation of wealth or maximizing happiness. Not until we have defined the purpose in the use of resources, can we say anything about efficiency or be prescriptive and say how it should be used. One way of learning about resource use is to read what others have said about it and we may turn to the moral philosophy of Adam Smith and recall what the law of diminishing returns is about.

If in any productive process we have engaged a group of fixed factors and to them we add successive increments of a variable factor, ultimately we run into diminishing returns: i.e. the increment in output diminishes with successive increments in input. This law is revealed in the shape of the universal production function.

The Equi-Marginal principle states that resource allocation is optimal between competing uses when the marginal value productivity in all uses is identical. The proof of this principle is easy if we simply appeal to the universal law of diminishing returns. If the marginal value productivity in one use is greater than another the allocation is not optimal. All we have to do is take some away from the use with low value productivity and apply it to the use with higher value productivity.

The use with high value productivity gets more resource which by the law of diminishing returns reduces the marginal productivity. The activity with low resource productivity has less resource hence marginal value productivity rises. This is a classic gravity model, resources will freely flow between uses until the marginal value productivity is the same in all uses.

The problem with neo-classical economics is that the theory isn't much use when facing the reality of practical resource allocation. Hence, we get into linear programming if want some practical guidance.

1. Neoclassical economics ignores the distribution and ownership of resources
2. Property rights were not an issue in a god given system of inheritance.
3. Neoclassical markets are assumed to function perfectly and resources are infinitely divisible not discrete like persons animals or machines. Scale effects are important here.
4. Neoclassical economics assumes perfect knowledge and ignores the information requirement i.e. information is a resource in its own right. Detailed knowledge or understanding of any process is required before you can manage it properly.
5. Neoclassical economics ignores risk and uncertainty. Risks are reducible if repeatable via the calculus of probabilities. The use of expected values (arithmetic means) as if they were fixed values has some inherent dangers. Uncertainty can not be eliminated since the event is not readily repeatable so you can not calculate probability i.e. Uncertainty implies outwith control. Uncertainty we just have to live with it a fact of life.

The production function or input output relationship:

$Y= f(X1,X2,X3,...Xn)$

describes the physical relationship (dependency) of output per unit time to input per unit time in any production process.

In the real world we often deal with response functions because we are not commencing our observations from a baseline of zero. For example, if we are considering crop response to fertilizer, the initial levels of N, P, K in the soil may be unknown so all we can model is the observed response. A zero input level may have some positive intercept. The productivity of a resource is dy/dx the increment in output per unit input. If we multiply the marginal physical product by the price of output we convert to value productivity. Marginal Value product is the value of the change in output resulting from one more unit of input or one less unit of input.

The single variable production function Y = f(X) has the characteristic sigmoid curve. If the time step in this process is one year as with annual cropping in the northern hemisphere. We usually forget the fact that Y stands for dy/dt and X stands for dx/dt and that these are discrete pulses. All systems are linear over part of the operating range. All curves can be broken into linear segments. Hence we can use linear models to approximate the working of any system. The information requirement is minimal. What we need to know is the set of input output coefficients for a particular production activity.

2.2 Agroecological Zones of Ghana

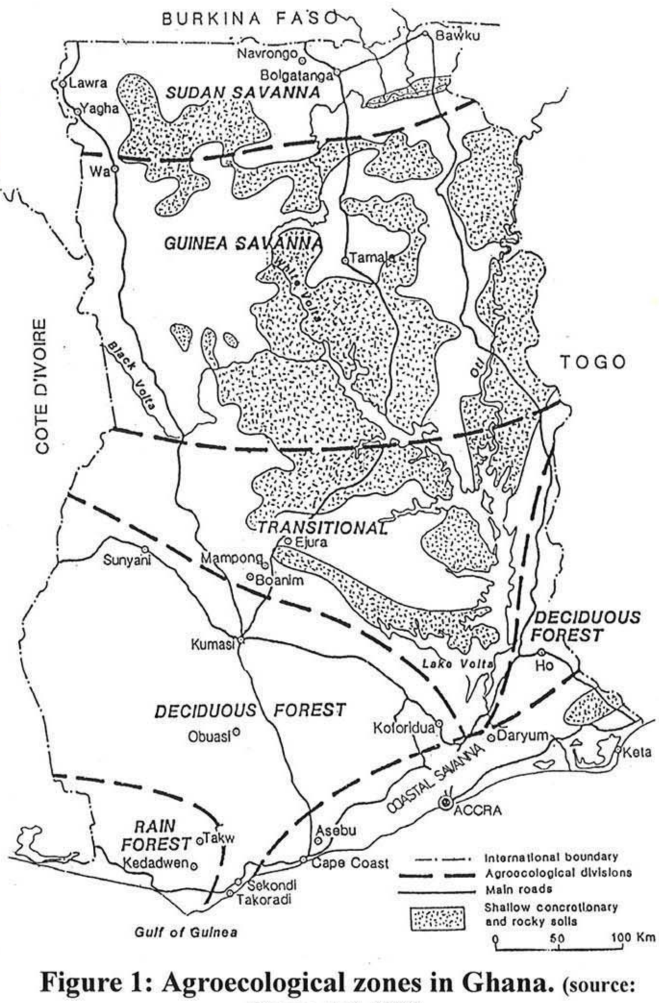

Figure 1: Agroecological zones in Ghana. (source: Owusu *et al.*, 1993)

The worlds agroecological zones are largely determined by temperature and precipitation. In West Africa there is a unique transition over a relatively short distance from rain forest to the Sahara desert, only 600 km north (Beets, 1990). The vegetation zones which run approximately parallel to the coast represents the reaction of the tropical flora to the climatic gradient (Baker, 1962). The country is divided into 6 main vegetation zones: Rainforest, Deciduous Forest, Forest-Savannah Transition, Coastal Savannah, Guinea Savannah and Sudan Savannah.

In the forest zones and coastal savanna zone the rainfall is bimodal peaking in May-June and October while the northern savanna zones the rainfall is unimodal lasting from May to October. The transition zone encompasses the area were the climate becomes drier and the forest merges into savanna vegetation. Surveys were carried out in three of the agroecological zones, namely the guinea savanna zone (Ecozone 1), transition zone (Ecozone 2), and the deciduous forest zone (Ecozone 3) whose main characteristics are summarised in Table 1.

Table 1: Data characterising the three ecozones in which the survey was carried out

	Moist Semi -Deciduous Forest	**Forest -Savannah Transitional Zone**	**Guinea Savannah**
Rainfall (mm)	1800-1500	1200-1500	1000-1200
Kind of Wet Season	Bimodal	Bimodal	Unimodal
Temperature (°C)			
Mean Max	30.6	32.5	33.6
Mean Min	21.1	22.6	22.3
% of Total Land Area of Ghana	21%	11%	57%
Population Density 1984 (persons per km^2)	86	31	17

Sources: Owusu *et al* 1993, Sarris & Shams, 1991; Amanor, 1995

2.3 Agricultural Household Systems in Ghana

Agriculture in Ghana is predominantly on a smallholder basis, although there are some large farms and plantations of cocoa, rubber, oil-palm, coconut, rice, and maize (Sarris & Shams, 1991). In a 1986 survey carried out by the Ministry of Agriculture (Geri & Oku, 1988 cited in Amanor, 1995) 69% of farm holdings were under 2 acres. In the south 80% of holdings were under 2 acres while in the northern savanna areas only 31% of farms were under 2 acres suggesting that small holdings are particularly characteristic of the forest zone. The greatest agricultural production in Ghana emanates from root and tuber crops encompassing cassava, yam, and cocoyam. These contribute 46% of the Agricultural Gross Domestic Product (Owusu *et al*, 1993).

Farming in many areas is still practiced using the traditional hand tools of hoe and cutlass although some farmers hire tractors for ploughing. Intercropping is widely practiced together with bush-fallowing and crop rotations. Over the past decades, bush fallowing strategies have undergone change in their management of land, cropping system, and duration of fallowing. In the savanna-forest mosaic areas of the northern transitional zone many farmers have moved toward ploughing, permanent cultivation and use of chemical fertilizers. However, most forest farmers continue to use low inputs within a cycle of bush farming. Even though the modern forest bush fallow system is built on past traditions, it has evolved in relation to pressures of land scarcity and intensification. The intensification of cultivation has been achieved by more rapid cycling of land between cropping and fallowing and by experimenting with intercropping systems and integrating these into the cycles of fallow regeneration (Amanor, 1995). One of the most popular modern intercropping systems of the forest zone is that of maize and cassava. Maize is harvested at the end of the first season while cassava is left to be harvested when needed in the second or third year. The cassava plants out-compete the regenerating vegetation, requiring little weeding. By the time the farmer finishes harvesting and the plot enters its fallow period, the natural vegetation is released and regenerates quickly.

Historically, agriculture has been more developed in the transition zone and dry semi-deciduous forest areas than in the wet forest areas (Amanor, 1995). In general, these areas have more fertile soils and less dense tree cover, reducing land clearance times. The transition zone can thus be regarded as the major commercial food crop area. In the wet forest zone, problems of low soil fertility, soil leaching and erosion have hindered the development of intensive high yielding agriculture. The focus in this high rainfall climate has been on planting perennial trees such as cocoa, banana, oil palm and citrus which thrive in moist conditions and protect the soil from erosion.

Farming systems in the savanna are often composed of two spatially dis-aggregated components: the compound farm and the bush farm. Distinctly different cropping patterns are found on these two farm types (Diehl, 1992). While the farms near to the homestead are permanently cropped and fertilized with animal manure and household wastes, the bush plots are rarely fertilized but allowed to regenerate under periodical fallow. The first year after fallow, demanding crops like yam are grown; followed by maize crop combinations for two to three years and lastly crops with low demand on soil fertility such as millet and groundnuts may be grown before returning to fallow (Norton, 1990).

3 Project Purpose.-

The overall aim of the project is to develop a model sequence which will aid decision makers and extension workers in analysing a range of alternative land use management scenarios and in developing a land use mix which meets social objectives, enhances food production and/or food security, and at the same time maintains ecological stability through improved land use - specifically but not only by the incorporation of trees into farming systems.

4 Research Activities

4.1 *Collation of information*

Most socio-economic data was collated with the assistance of the main collaborating partner, the Institute of Renewable Natural Resources (IRNR), University of Science and Technology, Kumasi. Other equally important institutions that were visited and consulted include: MOFA-AFU, FORIG, CRI, FD, EPA, FC, NARMSAP, BIRD and NGO'S.

4.1.1 Institute of Renewable Natural Resources (IRNR).

IRNR is comprised of five departments namely; Agroforestry, Fisheries and Aquaculture, Silviculture and Forest Management, Wildlife and Range Management, and Wood Science and Technology. IRNR has close links with other University faculties, and has conducted a number of agroforestry trials (for instance Osafor, 1992; Quashie-Sam *et al.,* 1993). The institute in general offers Diploma, Undergraduate and Postgraduate Courses in the fields prescribed above.

4.1.2 Ministry of Food and Agriculture - Agroforestry Unit (MOFA-AU).

The Agroforestry Unit (AU) an arm of Crop Services Division, was formed in 1990 to co-ordinate and encourage Ghanaian farmers to adopt agroforestry techniques. The AFU co-ordinates the National Agroforestry Committee. The AFU has good linkages with IRNR, FORIG, CRI, SRI, FD, FC and NGO's involved in agroforestry. Detailed work carried out by the Unit can be seen in reports (for instance. Anane, 1994,1995; Anane & Twumasi-Ankrah, 1996). Mr. Twumasi-Ankrah was requested to play a leading role in fine-tuning the farmer survey questionnaire designed to suit the Ghanaian local conditions based on his past experience with the farmers. He was also asked to work closely with the IRNR in processing survey data into appropriate statistical entities.

4.1.3 Other institutions consulted:

- Forest Research Institute of Ghana (FoRIG).
- Bureau of Integrated Rural Development (BIRD).
- Environmental Protection Agency (EPA).
- World Vision International - Ghana - NARMSAP.
- Forestry Department. (FD)
- Forestry Commission. (FC)
- Other NGO'S, The World Bank, UNDP, EU.

4.2 *The Questionnaire Survey*

The survey was carried out in 1996 in collaboration with the Ministry of Food and Agriculture in Ghana. A total of 155 rural farms households were surveyed in three ecozones. Of these 50 households were located in the forest zone, 55 in the transition zone and 50 in the savanna zone. The distribution of study sites can be seen in Figure 19. Contact was established with the farmers at the local market by MOFA. (i.e. new farmers were selected without previous established contact).

The survey aimed to cover all important aspects of farm household production with emphasis on crop production and tree products. Despite being a very comprehensive survey, the cropping system section was initially designed to record 11 crop species. This was found to be inadequate and revised after the survey had been carried out to include other crop species, noted by the interviewers. The initial restriction of crop species, is likely to have resulted in considerable under reporting of crop diversity. Particularly legumes, vegetables and indigenous crops seem to have been left out. This also means that intercropping practices may not have been recorded adequately. Another major omission in this farming systems survey was the failure to record livestock productivity parameters.

Socio-economic surveys in developing counties rely on information provided by farmers who rarely keep any records of their activities. Farmers were asked to estimate yields of crops harvested during the last year, the expenditures and inputs on specific farm plots. This assumes that the farmers have a good memory of these factors. It is often particularly difficult for farmers to estimate yields of intercropped plots on which not all crops are harvested at once. Perennial crops such as cassava and plantain are often harvested continuously over several month or years. Crops are often sold intermittently, when there is need to raise money to buy essential items, rather than all at one time. Furthermore, it has been found that farmers tend to underestimate their maize yields, calculating the quantity they have sold but not accounting for the proportion they have eaten (Amanor, 1993).

4.3 Farmer Objectives – Field Visit, October 1996

A random sample of between 20 to 30 farmers was chosen from among the districts in the selected agro-ecological zones in consultation with the Institute of Renewable Natural Resources, Regional Agroforesters and the District Extension Officers. Where ethnic and gender differences were not captured in the samples, deliberate effort was made to address this bias.

Farmers were then sub-divided into small groups of between three to four to encourage full participation of individuals. Women formed their own groups allowing an assessment of gender differences and to prevent gender inhibition. Each group prepared and exhaustive list of farm and household objectives. In larger groups, results were compared, duplicates removed, additional objectives were included and a comprehensive list for presentation to the whole research group was prepared. This information was discussed at length and a final draft of group objectives was prepared and presented to each of the farmers.

Control objective statements elicited from researchers and extension officers were introduced to the farmers at this stage to: (a) obtain the farmers' reactions and compare notes and (b) to examine the representativeness of the sample when compared to expert opinion. Objectives which the farmers found important but which had not been identified in earlier discussion were added to the compiled lists. Finally, the farmers were asked to rank the objectives by order of importance. Ranking was carried out through extensive discussion followed by majority voting. Output is presented in Section 5.4.

4.4 Database Construction

Initially, the data from the questionnaires was entered into Excel spreadsheets by Margaret Palchinski. At a later date, the excel spreadsheets were imported into MS Access to allow more complicated queries of the database to be made.

4.5 Database analysis

The data was analysed (in the main by Kathrin Broetz) in a variety of ways to cover the key topics within the survey information: cropping, livestock, household demographics, labour, system constraints, tree management, income and expenditure and use of 'wild' resources.

4.5.1 Secular decline in yield

In order to be able to estimate the per hectare yields in multi-crop scenarios it is necessary to know the proportion of land area allocated to each crop type. These data were not collected during the survey. Thus, a methodology for estimating the proportion of land area to each crop is presented. The exogenous data are expressing the monocrop equivalent yield per hectare for a multiple cropping situation.

Data available

m	Plot size (ha)	A_j	$j \in (1, m)$
p	Crop yields observed (kg)	C_{ij}	$i \in (1, p)$
(p, m)	Observed yields per ha (kg/ha)	$Y_{ij} = \frac{C_{ij}}{A_j}$	
p	Monocrop Yields (kg/ha)	ψ_i	$i \in (1, p)$

Calculating the monocrop equivalent yield.

for all $j \in (1, m)$

Minimax K_j

s.t.

$$i \in (1, p)$$
$$a_{ij}\psi_i + N_{ij} - P_{ij} = Y_{ij}$$
$$N_{ij} + P_{ij} - K_j < 0$$
$$\sum_{i=1}^{p} a_{ij} = 1$$
$$a_{ij}, N_{ij}, P_{ij}, K_j > 0$$

Monocrop equivalent yields can then be calculated.-

$$\phi_{ij} = \frac{Y_{ij}}{a_{ij}}$$

4.6 *Field visit in April 1997*

A survey of the study villages was carried out such that the exact location would be identified. In addition, a preliminary participatory survey of spatial allocation of land was also carried out.

4.6.1 Methodology.-

Each village was visited by the team. At a central point in the village, the location was found using a Geographical Positioning Systems (GPS). Two villages were selected in the Northern Region, two in the Wenchi area and three in the Ashante Region. The farmers (who had been interviewed previously) were invited to join the team at a later date (usually the next day) such that a more in depth analysis of where their plots were and their land use systems could be carried out. Utilising a participatory approach, the team engaged the farmers in a mapping exercise. These sketch maps allowed an overview of the location of the farms and also served as a focus for an informal but semi-structured discussion.

The team was shown to a variety of the plots identified by the mapping exercise - these were described and geo-referenced. As the walk proceeded, discussion points were expanded and further items of interest (often identified in the field) were discussed. The mapping and walk gave the team an insight into, and a good overview of, the local farming system and the land use pattern of the local area.

4.7 *Workshop held at IRNR, Kumasi, Ghana (28th July to 1st August, 1997)*

A five day workshop was held at IRNR, Kumasi at the end of July, 1997. Twenty-five professionals from different government departments and regions of Ghana were invited to comment on the main findings of the research and their implications for agroforestry interventions.

4.7.1 Objectives

The first objective was to establish the basic performance characteristics of current practice against which agroforestry workers can screen alternate "agroforestry practices" before moving into promotion of best practice by investment in research and extension activities. Agroforestry practices traditionally take a long time to evolve through experimentation. Simulation and model building techniques have been developed such that suitable and stable system designs can be identified and set within the socio-economic and environmental opportunities and constraints of a particular locale. The selected systems can then be tested in farm trials on farmers' plots and in research centers simultaneously. Key results from the survey were presented for critical discussion.

The second objective of the workshop was to demonstrate a range of modelling techniques which not only simulate the biophysical growth and development of plants and animals but also facilitates the definition and selection of systems which can be regarded as optimal for the groups of decision makers and stake-holders concerned. The integration of these techniques has been developed to the stage where those involved in agroforestry in Ghana can evaluate the tools provided and assistance can be provided with practical application in decision support.

The third objective was a preliminary assessment of the tools in terms of suitability for the purposes intended and of any modifications that should be introduced. Finally, it was considered how best such tools might be used in the local Ghanaian context. The pertinent test of relevance for all such modelling activity is whether or not it can and does influence the practice of natural resource management.

4.7.2 Programme

Each day was split into four workshop sessions, comprising some form of presentation followed by an open discussion forum. This allowed the participants to share and air their views on the presentations. Some of the discussion sessions were set aside for participatory exercises which gathered information on allocation of labour throughout the year to the different crops which are commonly grown in each region of the study.

In addition, Julian Smith and Roy Fawcett ran tutorials in mathematical programming with MS Excel to allow interested participants a chance to have some 'hands-on' experience with using computer-based modelling tools. About 12 participants joined these sessions and progressed very rapidly to being able to set up and run simple farm models.

5 Outputs

5.1 Data Analysis

The data collected was used to estimate parameters of farming systems in Ghana, with the eventual aim of linear models construction for farms of each ecozones. The survey data was entered into excel database wherein it could be summarised and analysed for trends. It was of particular interest to analyse the data with regard to differences in farming strategies between the three ecozones.

In order to work with the data successfully, conversions of yields from volume units to weight units (kg) had to be made. In the absence of accurate crop volume to weight data approximate conversions were made using the below conversion rates (see Table 2). The kg yields obtained were further converted into energy (MJ) and protein (g) units using Platt's (1962) tables of food values. This was done in order to be able to directly compare per hectare output of different crops and crop mixtures.

Table 2: Volume to weight conversion rates

Original Measurement	Assumed Weight
1 Bag	50 kg
1 Maxi Bag	90 kg
1 Mini Bag	30 kg
1 Bail	90 kg
1 Basket	25 kg
1 Bucket	20 kg
1 Bowl	2.25 kg
1 Box	25 kg
1 Crate	25 kg
1 Tractor Load	1000 kg
1 Yam Tuber	0.5 kg
1 Plantain Bunch	25 kg
1 Pineapple Fruit	1 kg

Source: personal communication with Nkowani & Bodi (1997)

5.2 SURVEY RESULTS

5.2.1 Survey Population

The total population surveyed consisted of 1154 household members. Household size ranged form 1 to 16 members with an average of 7.45 ±0.26 S.E. members per household. At the time of survey 4.5% of the heads of households were single, 71% were living with one spouse, 22% had 2 wives, and 2.5% had up to five wives. 37% of households had one or more relatives living with them.

When analysing the age/sex composition of the survey population (seen in Figure 2), 52% of all household members were found to be below the age of 20 years. This represents the typical age distribution found in many developing countries with high population growth rates.

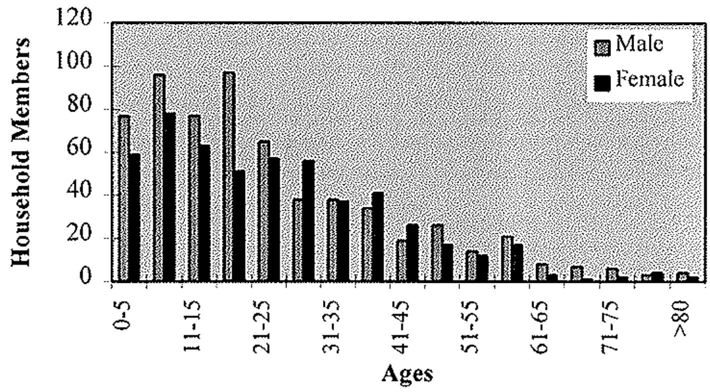

Figure 2: Age and Sex composition of Survey population

Examination of household composition in relation to ecozones reveals a clear trend of decreasing household size from north to south. There is a significant difference ($P<0.05$) between number of spouses in the savanna and transition zone. A significant difference also exists ($P<0.05$) between number of offspring per household in transition zone and the forest zone (see Table 3).

Table 3: Average household composition in the three ecozones

		Household Members	Spouses	Offspring	Relatives
Savannah	Ecozone 1	8.5^{a}	1.58	4.96^{a}	0.98^{ab}
Transition	Ecozone 2	7.38^{ab}	1.11^{a}	4.35^{a}	0.65^{ab}
Forest	Ecozone 3	6.36^{b}	0.94^{a}	3.28	0.96^{ab}

Numbers with the same subscript letters are not significantly different at the 0.05 level

5.2.2 Crop Production Practices

5.2.2.1 Crop species grown by survey farmers

Maize and cassava were found to be the most important food crops of small holder farmers in Ghana. Maize was the most frequently grown crop species of households in the savanna (92% of Hh) and transition zone (84% of Hh). In the forest zone cassava (96% of Hh) was most popular, closely followed by maize (84% of Hh). Cassava has seen a steady growth in popularity over the past decades. It is increasingly displacing yam, cocoyams and plantain (Amanor, 1993).

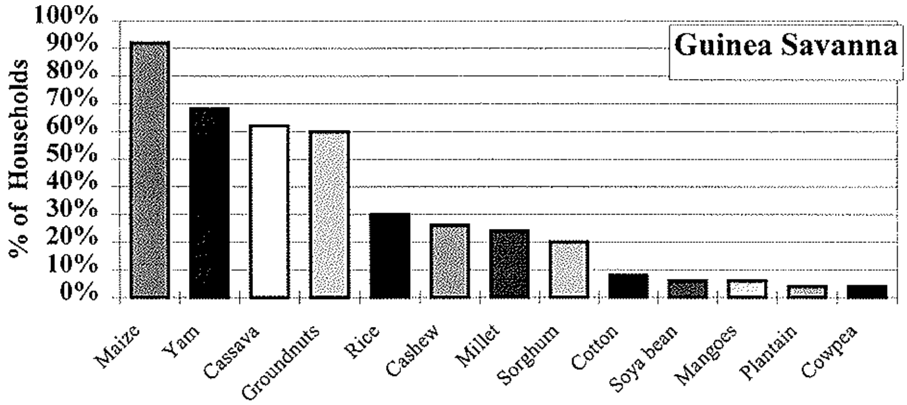

Figure 3: Percentage of households growing named crops in ecozone 1

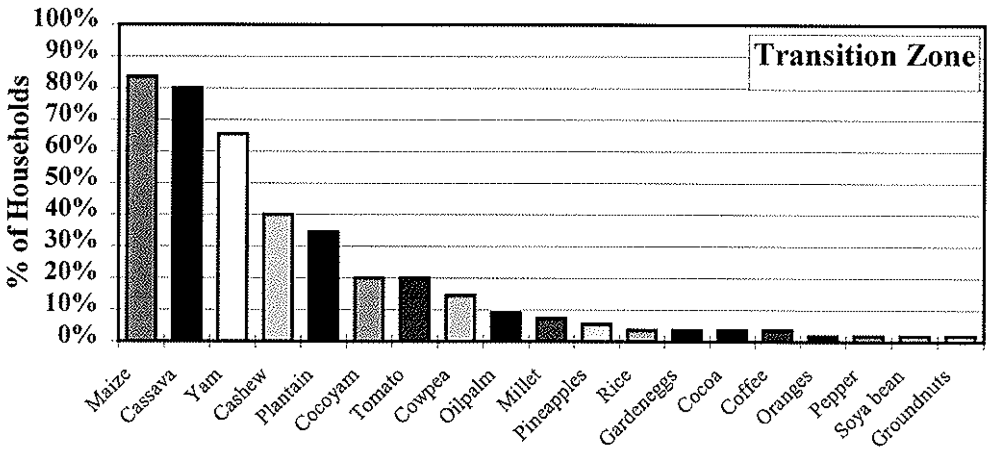

Figure 4: Percentage of households growing named crops in ecozone 2

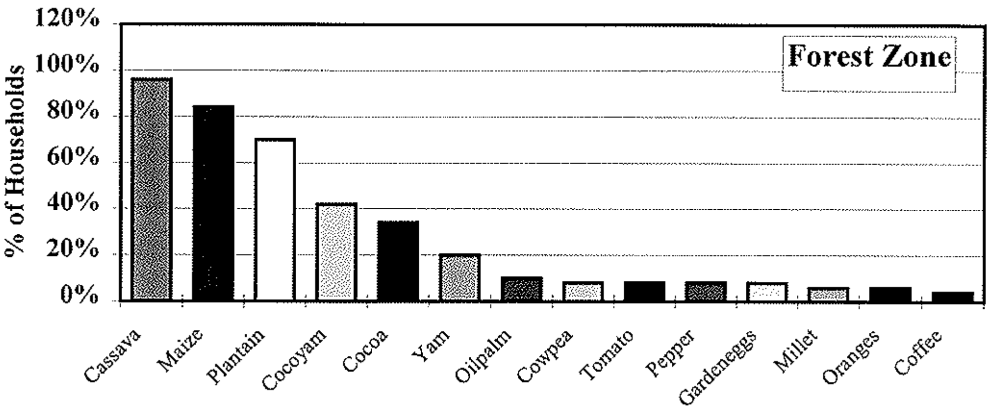

Figure 5: Percentage of households growing named crop species in ecozone3

Yams remain an important crop in the drier ecozones. The greatest crop diversity was found in the transition zone (19 crop species), where crops from both savanna and forest zone could be grown.

Survey farms grew an average of 4 crop species per annum in each ecozone. Farmers usually have around three plots under crop in each season with others under fallow. A decrease in the median area under crop form north to south was detected (see Table 4). More than 90% of farmers in each ecozone were aiming at subsistence production. While only 14% of farmers felt they often failed to achieve this goal in the forest zone, 35% of farmers in the transition zone and 33% in the savanna zone, felt the same. This indicates that seasonal food shortages are perceived to be a much bigger problem in the dryer ecozones than in the forest zone. In the northern savanna zone around 40% of households did not grow enough crops to fulfil their energy requirements, equally, 20% of households in the transition and forest zone. It has been confirmed in other studies that under-nutrition has higher prevalence in savanna zones than in other agro-ecological zones (Van den Boom, 1996).

Table 4: Parameters of survey farms in each ecozone

Ecozone	Median No of Cropped Plots per Hh	Median Area Cropped per Hh (Ha)	Average No of Crops per Hh	
Ecozone 1	3	3.50	4.10	±0.19 S.E.
Ecozone 2	3	3.20	4.02	±0.21 S.E.
Ecozone 3	3	2.15	4.04	±0.19 S.E.

5.2.2.2 Intercropping and sole cropping

Of the total 703.75 ha cropped by the 155 households in 1996 about 32% was intercropped while 68% was monocropped.

Table 5: The total area and number of plots under specific crop mixtures

Crop 1	Crop 2	Crop 3	Crop 4	No of plots	Total Area (ha)	% of Area under ICT[a]	EZ 1[b] Plots	EZ 2[b] Plots	EZ 3[b] Plots
Maize	*	*	*	132	155.85	70%	27	29	76
Maize	Cassava			33	28.25	13%	4	5	24
Maize	Cassava	*	*	99	99.35	45%	5	24	70
Maize	Cassava	Plantain	*	32	37.95	17%	0	5	27
Maize	Cassava	Cocoyam		17	9.55	4%	0	3	14
Maize	Millet	*	*	9	22	10%	9	0	0
Cassava	*	*	*	119	124.95	56%	11	30	78
Cassava	Plantain	*		8	8.2	4%	0	2	6
Cassava	Yam	*	*	8	14	6%	5	3	0
Plantain	*	*	*	38	36.55	16%	3	10	25
Groundnuts	*	*	*	19	31.9	14%	17	2	0
Yam	*	*	*	34	51.5	23%	11	17	6
Cashew	*	*	*	19	31	14%	8	11	0
Cocoyam	*	*	*	37	28.1	13%	0	10	27
Millet	*	*	*	12	24.6	11%	11	0	1

* = stand for other crops which may be part of the intercrop mixture, ICT = Intercrop Type, EZ 1-3 = Ecozone 1-3,

In all, 57 different crop mixtures were recorded with intercropped maize and cassava as the most common, accounting for 13% of the area devoted to crop mixtures, and 45% when further intercropped with other crop species. Most of the maize-cassava plots were found in the forest ecozone. In the savanna zone, maize was more frequently intercropped with millet or groundnuts.

As seen in Figure 6 intercropped plots were far more common in the forest zone than either the transitional or savanna zone.

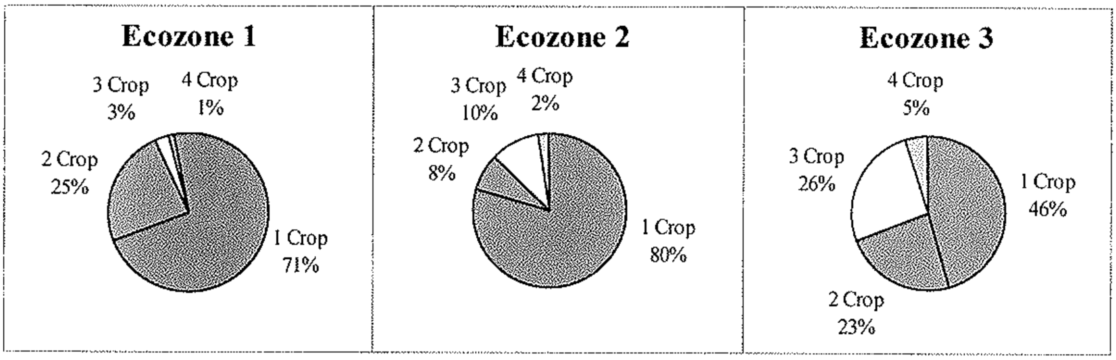

Figure 6: Percentage of farm plots in each ecozone in relation to the number of simultaneously grown crops

Food crops are the predominant crop type of the savanna zone. Food crops in the savanna zone may or may not be intercropped and little difference between the average size of mono or intercropped plot size can be determined. Figure 7 shows that cash crops occupy more than half of all the sole cropped land in the forest zone, while they occupy only 6.4% of the sole cropped area in the savanna zone. In the savanna zone almost all the sole cropped land is occupied by food crops.

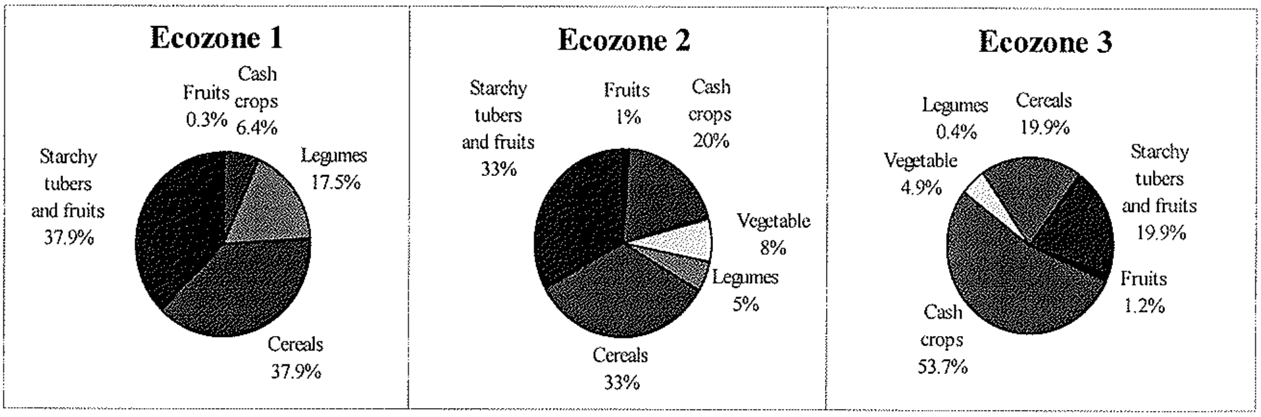

Figure 7: Percentage of monocropped land used for different crop type

5.2.2.3 Monocropped yields in terms of energy and protein

Yields were converted into MJ of energy and grams of protein such that a comparison between mono and intercropped plots could be achieved. Processing and storage losses were deducted from the field yield before converting it into MJ and protein of edible yield in order to reflect the consumable output. The resultant values were used to calculate per hectare, per MJ, and per gram protein inputs of labour and costs. In order to have enough replicates of different cropping activities the data was compiled from all households. Yields of sole cropped yam and millet were found to be exceptionally low - perhaps the environmental conditions of 1996 were not ideal for yam and millet growth.

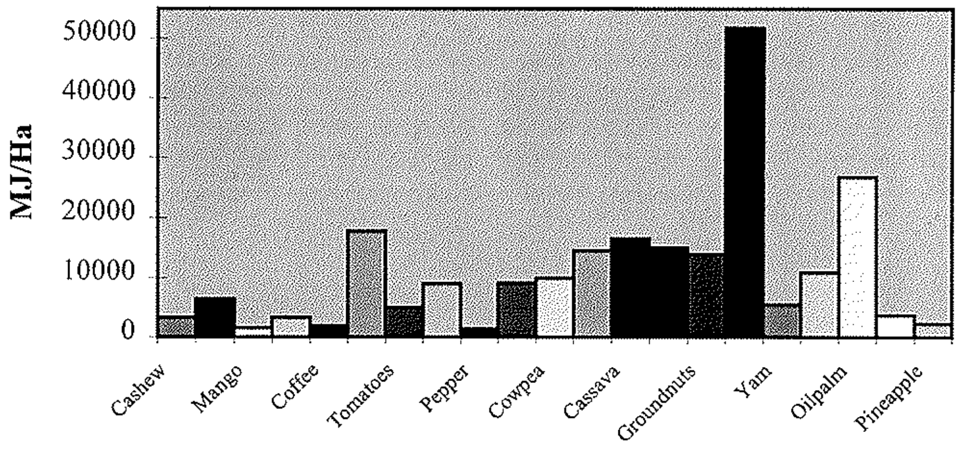

Figure 8: Energy yields (MJ/ha) of crops grown by small holder farmers in Ghana

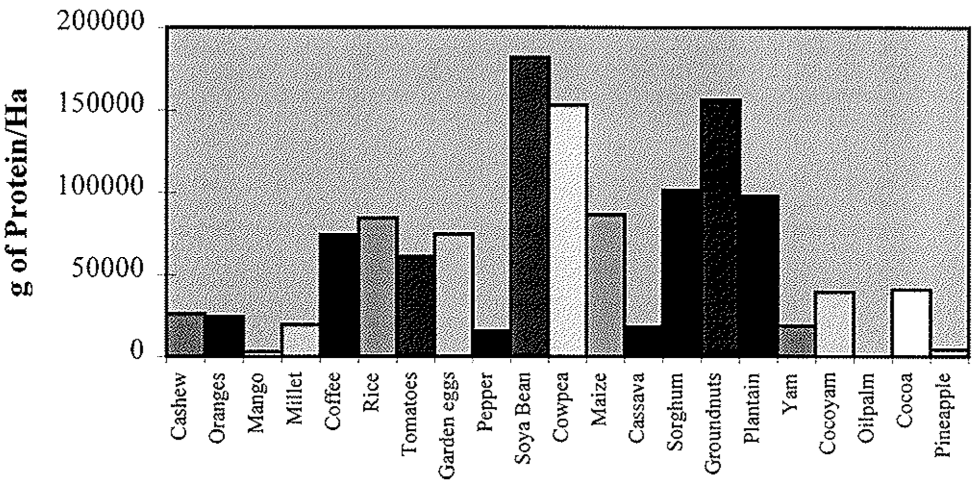

Figure 9: Protein yields (g/ha) of crops grown by small holder farmers in Ghana

Yields of protein per hectare (Figure 9) were found to be highest for legumes such as soya beans, cowpeas, and groundnuts. Soya beans had the highest total output in protein per hectare and the lowest cost per gram of protein grown.

The analysis of on farm crop yield in terms of protein and energy output has great scope to be further explored especially in the context of farmers with subsistence goals. In the subsistence situation, the price fetched for a crop is often of secondary importance. When food output is one of the main objectives the energy and nutritional quality of the food output are perhaps the main determining factors in the crop selection. Therefore the energy and protein efficiency measurements in terms of labour and cost may be the most appropriate factors taken into consideration when advising farmers in developing countries on crop decision making.

5.2.2.4 The efficiency of intercropping

Comparisons of yields from monocropped and intercropped plots revealed that intercropping seems to be more efficient in terms of total energy and protein yield as well as returns to labour and cost inputs. On average, a plot with two crops was found to yield twice the amount of energy and protein compared to the equivalent sole cropped area ($P < 0.001$) (see Table 6 & Table 7). The output was further increased (but not significantly so) when three crops were intercropped but the average output decreased at four crops. Outputs per unit of labour also increased with increasing number of crops, while costs decreased. All these factors support the proposition that multiple cropping represents a more efficient use of resources than sole cropping. Sole cropping which has evolved mainly in relation to mechanised agriculture, is less efficient in agricultural production based on hand labour.

Table 6: Average energy and protein yields of fields with different numbers of crops

No of crops	Total No of Plots	Ave. Manhr per Ha	Average Cost per Ha	Average Total Yield MJ/Ha	Average Total Protein Yield (g/Ha)	Ave. MJ per Manhr	Average Cost per MJ	Average g of Pro. per Manhr	Average Cost per g of Protein
1	345	73.9	219284	12306	53578	307.0	61.6	1300.5	12.5
2	97	75.2	180989	27671	98889	410.8	17.5	1587.7	4.1
3	71	90.1	170534	32885	106850	446.9	11.9	1429.1	3.8
4	15	90.8	162515	26400	93162	298.6	13.6	1033.2	3.2

Table 7: Median energy and protein yields of fields with different numbers of crops

No of crops	Total No of Plots	Median Manhr per Ha	Median Cost per Ha	Median Total Yield MJ/Ha	Median Total Protein Yield (g/Ha)	Median MJ per Manhr	Median Cost per MJ	Median g of Pro. per Manhr	Median Cost per g of Protein
1	345	70	84,000	7,650	25,000	104	12	407	3
2	97	75	110500	17,010	63,461.3	264.5	5.8	900.2	1.4
3	71	90	135000	22,520.6	86,634.4	280.6	4.6	1128.2	1.4
4	15	100	100000	25837.1	84168.8	316.9	4.5	978.6	1.7

Intercropping may take place within a time frame extending over several seasons and may thus not always be easily compared to sole cropped plots. Thus the most frequent crop combinations recorded in the survey involve the combination of annual with perennial crops. Essentially almost any crop can be found in mixtures of intercropped plots. But some of the most productive mixtures are based on maize intercropped with cassava, plantain and yam. The advantages of maize and cassava intercropping have been reviewed by Rao (1986). Studies show that maize yields are unaffected. Cassava growth undergoes an initial setback, but its yield is unaffected as it matures after the maize has been harvested. A similar scenario is likely to be the case when maize and plantain are intercropped.

In the literature there is a lot of discussion about the types of multiple cropping systems (Francis, 1986, Beets, 1982) and the concepts of competitive and facilitative interaction of crops (Vandermeer, 1989). Most detailed studies of intercropping are carried out on research stations. Very little information on indigenous intercropping practices and comparative yields of on farm inter- and monocropping has been published. One study which has been published was done by Norman (1974) in Nigeria. He found that the profitability of crop mixtures was about 60% higher than for sole crops. Furthermore, growing crops in mixtures was found to spread out the work load. The gross return per man-hour was however only higher during the period when labour was a limiting factor. In a study carried out in northern Ghana (Runge-Metzger, 1987) outputs of mixtures were also found to yield substantially higher yields of energy than sole cropped plots. In this case yam based mixtures significantly exceeded yields of other crop mixtures, and the highest returns to labour were achieved by maize-tobacco mixtures.

Considering the continued importance of multiple cropping in developing countries, and its considerable yield advantages, it seems that relatively little attention has been paid to this phenomena. Extension systems in Africa are usually moulded on extending crop improvement packages which are based on sole cropping. The promotion of sole cropping may not only lead to lower yield potential as shown in our results but may also lead in a decline of nutritional adequacy of a farming population in which 90% have subsistence objectives.

5.2.2.5 Distribution of monocrop equivalent yields

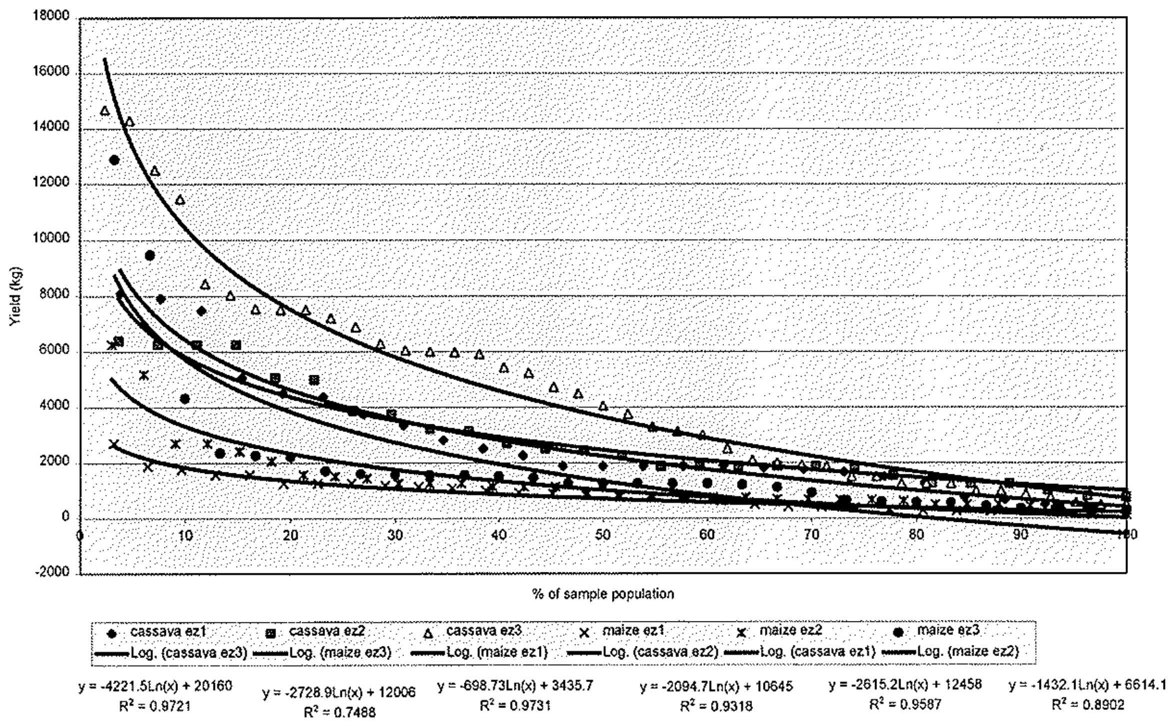

Figure 10: Distribution of monocrop equivalent yields of Maize and Cassava in three ecozones.

5.2.3 Livestock-Keeping in the Three Ecozones

The domestic animal population of 4896 was grouped according to livestock type and ecozone as seen in Figure 11. This figure shows that the largest number of animals are small livestock, which includes domestic fowl (chicken, ducks, guinea fowl) as well as rabbits. The numbers of cattle and small ruminant are substantially higher in the north and transition zone than in the southern forest zone. This type of trend along the climatic gradient from moist to drier areas is found in many parts of Africa. People in the semi-arid are usually more reliant on animals to bridge the dry season gap and to guard against crop failure. In the moist climatic zones these pressures do not exist. These areas often lack good grazing land and have a higher predominance of disease such as trypanosomiasis.

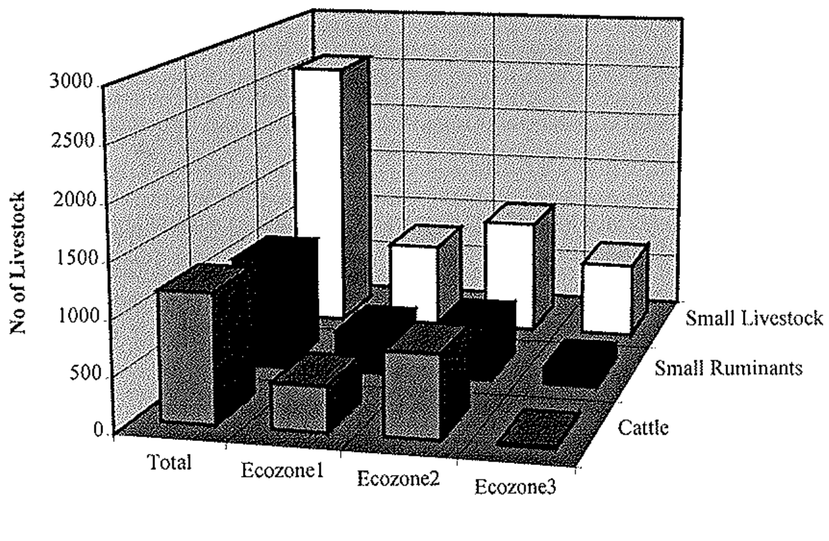

Figure 11: Total livestock numbers of households in three agro-ecological zones of Ghana

Prevalence of livestock keeping ranged from 94% of households in the north to 68 % in of southern households. In the transition zone less farms were involved in cattle keeping compared to the northern zone (see Table 8). Goat and sheep numbers showed a similar pattern to that of cattle. The average heard size was larger in the transition zone but more households were keeping goats and sheep in the savannah zone. In the southern zone sheep keeping was the more prevalent of the two. In all zones chickens were the most frequently reared animals, and flock numbers were similar.

Table 8: Average number of animals per household keeping named livestock type

Ecozone	cows	bulls	calves	chickens	Ducks	guinea fowl	pigs	goats	sheep	Ave No of Animals per Hh
Ecozone 1	15	4.43	4.75	20.82	4.00	22.25	7.3	6.90	8.14	34.6±43.6 S.D.
Ecozone 2	22.2	5.4	20.7	23.0	23.8	0	8.3	12.6	14.5	34.1±30.0 S.D.
Ecozone 3	4	2	2	23.50	7.40	1	6.33	4.86	10.55	26.09±28.8 S.D.
% of households with different livestock types										% of Hh with Livestock
Ecozone 1	48%	14%	8%	66%	2%	8%	6%	58%	44%	94%
Ecozone 2	13%	11%	7%	47%	9%	0%	13%	31%	20%	71%
Ecozone 3	4%	2%	2%	56%	10%	2%	6%	14%	22%	68%

5.2.4 Tree Management

The most common reason given for planting trees was the provision of fruits. The second most common reason recorded was classified as "other" which in most cases refers to cash income. Ghana has a strong tradition of tree cash crops originating from the cocoa and oil-palm production. Cashew has become a popular new tree cash crop product, which is planted mainly in the drier savanna and transition zone. The most planted timber tree is *Tectona grandis,* which fetches a good price on the world market. A few typical agroforestry trees such as *Leuceana* have been planted for soil fertility purposes and to provide poles.

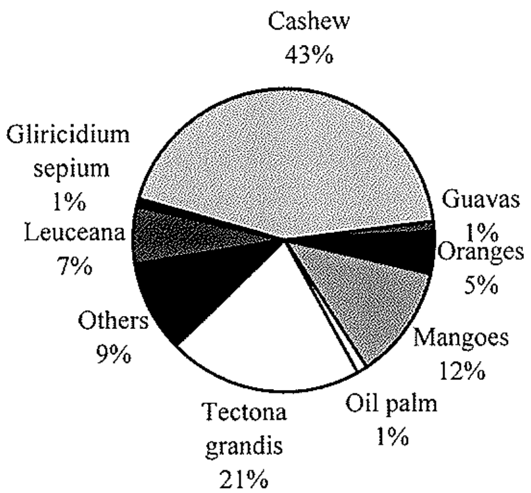

Figure 12: The proportions of different tree species planted

Most of the trees actively planted are exotic species (Figure 12). This may at least in part be due to ownership traditions. The chiefs are recognised to hold rights to ownership of indigenous trees and often receive part of the royalties for timber extraction (Norton, 1990). In the past the farmers have had little rights and benefits from indigenous farm trees. Indiscriminate activity of loggers has lead to the alienation of farmers. The result is that farmers are now destroying species which they previously preserved (Amanor, 1995). Ownership can only be guaranteed to farmers if they plant certain exotic tree species (Norton, 1990). Therefore farmers are mainly interested in actively planting exotic trees species which ensure them benefits.

The data collected indicates that tree planting is more common in the transition zone compared to the forest as well as the savanna zone (see Table 9). The transition zone is more intensively cultivated than either forest or savanna zone. This and the high incidence of natural fires means deforestation in this zone is high and tree regeneration slow (Amanor, 1994). Amanor (1995) found that that the moister forest districts are more self reliant in fuel wood than the drier districts.

Table 9: % of respondents which have been involved in tree planting

Tree Planting	No of Hh	Total	Ecozone 1	Ecozone 2	Ecozone 3
yes	73	47.4%	44%	72%	24%
no	81	52.6%	56%	28%	76%

5.2.5 Use of "Wild" Resources

More than half of all survey households (55.5%) were involved in collecting and processing materials from fallow plots and natural forests. This has been coined "hidden harvest" by the IIED team (1995), and is often neglected in accounting for the survival strategies of smallholder farmers. In all three ecosystems the proportion of households which engage in the use of wild resources is similar. The most popular activities were found to be mushroom collection (carried out by 23.2% of households), collection of medicinal plants and hunting (carried out by 16.8%) (see Figure 13). It is recognised that in many societies wild resource collection is carried out predominantly by women (IIED, 1995). Thirty one percent of households engaged in collection and processing of wild produce, do so purely for home consumption, while the other 69% gain some income from their activities. The annual income of households engaging in the sale of wild products was an average of 225365 cedis. Of the named activities, hand craft produced the most income followed by tapping and brewing. Hunting, fishing and charcoal burning also achieved returns in excess of that received for manual wage labour. As has been documented by Asibey (1974, 1977) there is great demand for bushmeat and cash returns are high. He found that in some parts of Ghana during the 1970's as much as 73% of locally produced meat came from wild animals, particularly from some smaller types such as cane rats, grasscutters, hares and giant rats.

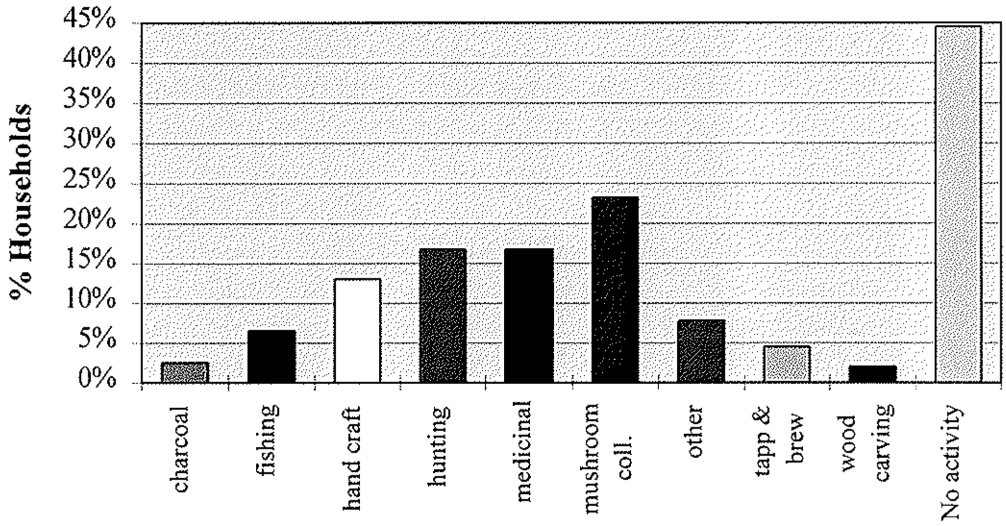

Figure 13: Percentage of households involved in "wild" produce activities

5.2.6 Labour

Most labour in smallholder farming system is provided by the household members. There is only a limited capital available to hire labour. Family size is a major determinant of labour capacity. Families, as previously noted, may be characterised by polygamous marriages and multigenerational extended families. In small families of 1 to 5 members 80% of the labour potential falls on the husband and wife, with an average maximum of 210 hours per family per week available .Around 1/3 of all families surveyed fell in this category. At double the family size (6-10 members) a greater proportion of the available labour time falls on the children and relatives staying in the family. About half of all households belonged to this size category while only 18% of households had between 11 and 15 members. The largest household category had an average maximum of 712 hours per week available. Decisions have to

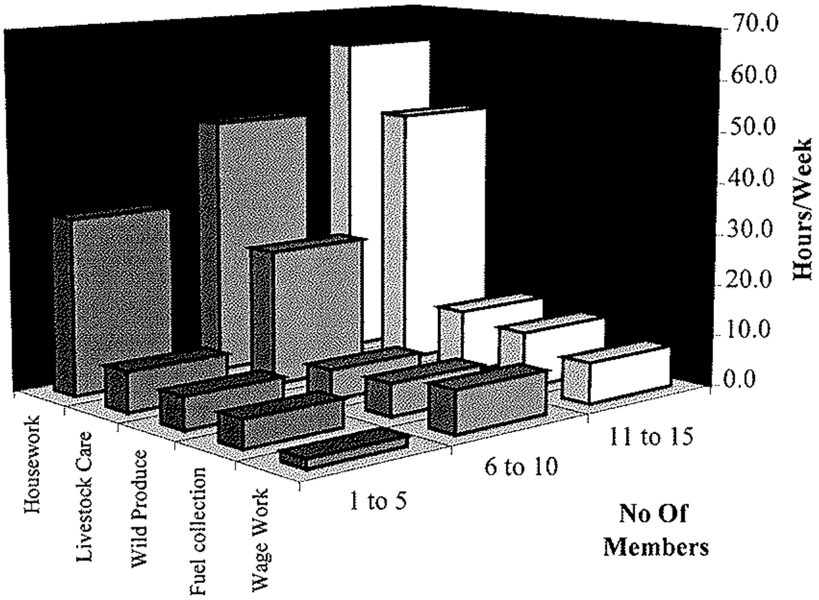

Figure 14: Average number of hours per week spent on named activities in households of different sizes

be made by the household members in which activities and how much of its labour to invest. Certain activities though are compulsory for the household to survive, these include domestic tasks such as food preparation as well as provision of fuel and water.

The number of hours spent on activities tend to go up with increasing household size as can be seen in Figure 14. This is particularly evident in the case of household activities and livestock care. Nevertheless, when examining the relative proportion of labour spent on domestic tasks, small families may typically spend 20% of their time on this while the largest households need only 11% of their labour capacity. The larger households spend more time on livestock care, indicating that they keep larger numbers of livestock. This was confirmed to be the case when comparing livestock numbers with family size. Overall 26% of surveyed households had income from wage labour or piece work. More households in the savanna and forest ecozone engaging in wage labour than in the transition zone.

5.2.7 Income & Expenditure

Food crop sales contribute the largest source of income in all ecozones, which is in agreement with earlier findings (Sarris & Shams 1991). The proportion of food crop income decreases from 60% in the savanna zone to 40% in the forest zone (Figure 15). A corresponding increase in the contribution of cash crops and off farm income sources is noticed.

Table 10: Average and median income from off farm employment in the three different ecozones (000 cedis)

	Savannah Ecozone 1	Transition Ecozone 2	Forest Ecozone 3
Average	322	835	655
Median	220	500	403
Stand. Dev.	308	913	657

The transition zone farming system is characterised by a greater degree of specialisation and commercialisation than the savanna zone. Thus farmers in the transition zone have more choice concerning the farming activities they wish to invest in. Alternatively they may be able to concentrate on off farm work. In the savanna zone farming is less intensive, with higher risks, due to climatic factors as well as lack of marketing opportunities. The farmer in this ecozone is more subsistence oriented and has to be aware of risk factors. Median annual income from food crops in the savanna zone is about half of that found in the transition zone. This means that farming systems in the savanna zone are required to be more diversified.

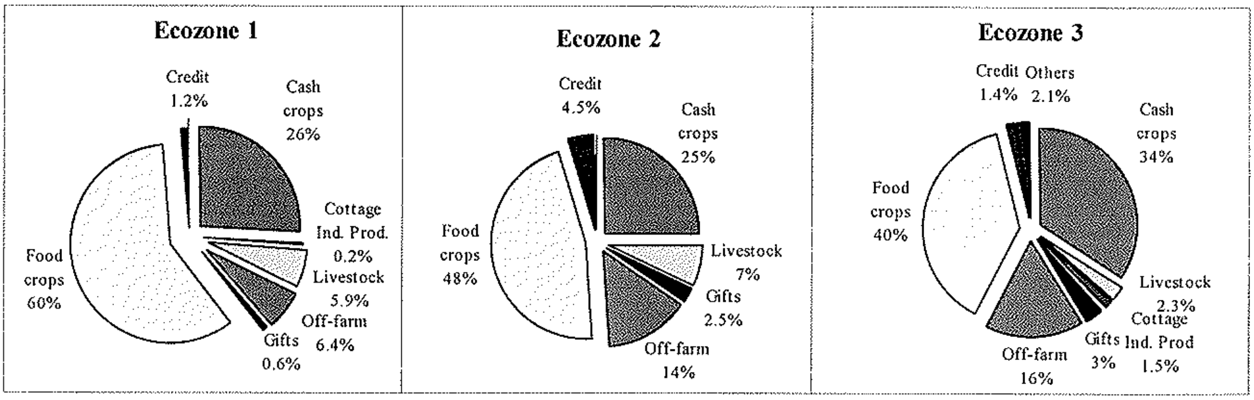

Figure 15: Average proportional income from different sources in the three ecozones

In the forest zone farmers also have a lower median income than in the transition zone despite being close to the urban areas and therefore marketing outlets. The farmers in this ecozone are heavily dependent on the traditional cash crops of cocoa and oil palm which have experienced continued drop in world market price.

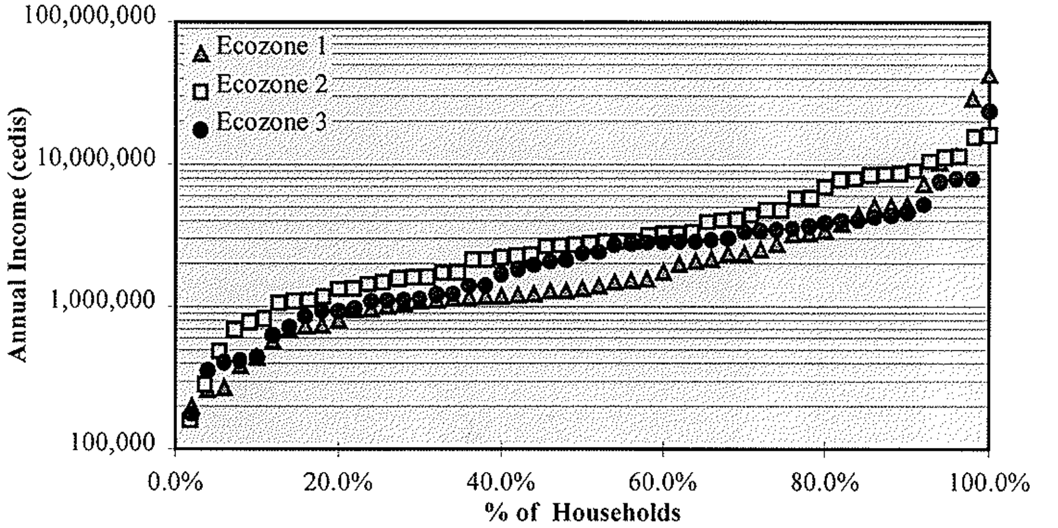

Figure 16: Households ranked according to their income in each of the three ecozones

As seen in Figure 16, households of the transition zone command the highest income, with the forest ecozone slightly less well off, and savanna households among the poorest.

Average and median expenditure was highest in the transition zone. The distribution of expenditure among different commodities can be seen in Figure 17. Overall hired labour, minor foods , building material, clothing and crop inputs were the commodities which commanded highest expenditure. In this survey less than one fifth of expenditure was found to be spent on foods, rather than half of all cash expenditure as reported by Sarris & Shams (1991).

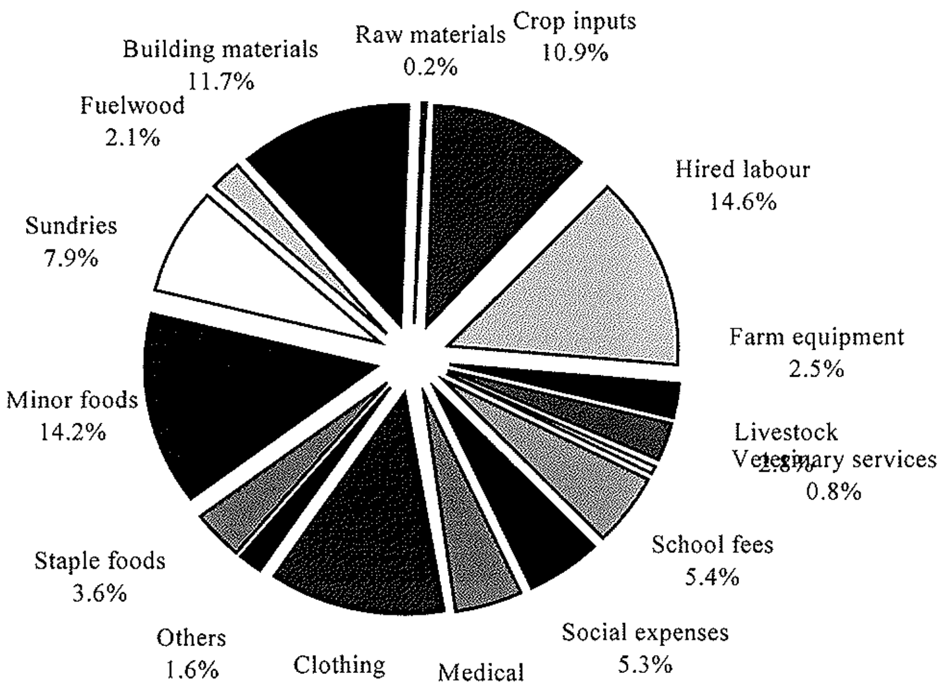

Figure 17: Average proportional expenditure of survey households on different commodities

In the savanna ecozone the largest proportion of income was spent on crop inputs and hired labour, with less than average being spent on minor foods and building material. In the transition zone most money was spent on building material, minor foods and clothing. A substantially lower proportion of income than in the savanna zone goes into farm inputs. The items that income is spent on can be taken as indicators of wealth. The savanna zone farmers invest their money mainly into the farming activities which sustain them. In contrast farmers in the transition zone spend money on non relative luxury items such as building materials and clothing. Interestingly the transition zone farmers also spent the comparatively largest proportion of income on school fees (6.9%), with savanna zone households spending 2.6% and forest zone households 5.5%. In the southern area farms spent most money on minor foods. Above average spending on sundries is noticed, with near average spending on most other commodities.

5.2.8 Constraints

Perception of constraints varied according to ecozone (see Figure 18). In the savanna zone "costs" were regarded as the single most important constraint. This is verified by the high proportion of income spent on hired labour and crop inputs by farmers in this zone. The cost constraints are compounded by the unavailability of credit and problems with marketing of crops. In the transition zone costs constraints were still perceived to be important by 69% of farmers. In addition, land and tenure were also classified as very important by more than half the respondents. This points towards more intensive agriculture and land scarcity. Land scarcity problems arise due to discrepancies between traditional customs of communal land ownership ruled over by the chief and the more modern monetary purchase or renting of land by migrant farmers. Large tracts of land have thus been allocated to rich landowners, leaving insufficient land for less powerful small holders relying on the traditional system of land distribution (Amanor, 1995). Land tenure was already seen as the fundamental problem of agricultural production in Ghana more than 30 year ago (La Anyane, 1962), and is destined to continue to be problematic.

Problems of land and tenure are also perceived to be prominent in the forest zone, which has a higher population density than the other two zones. Perhaps paradoxically the availability of markets was here seen as one of the main constraints, despite being relatively close to the two largest urban areas of Accra and Kumasi, and the ports of Ghana. It is likely that these market constraints refer to the recent price drops in major cash crops such as cocoa, which has made tree cash cropping a less profitable enterprise.

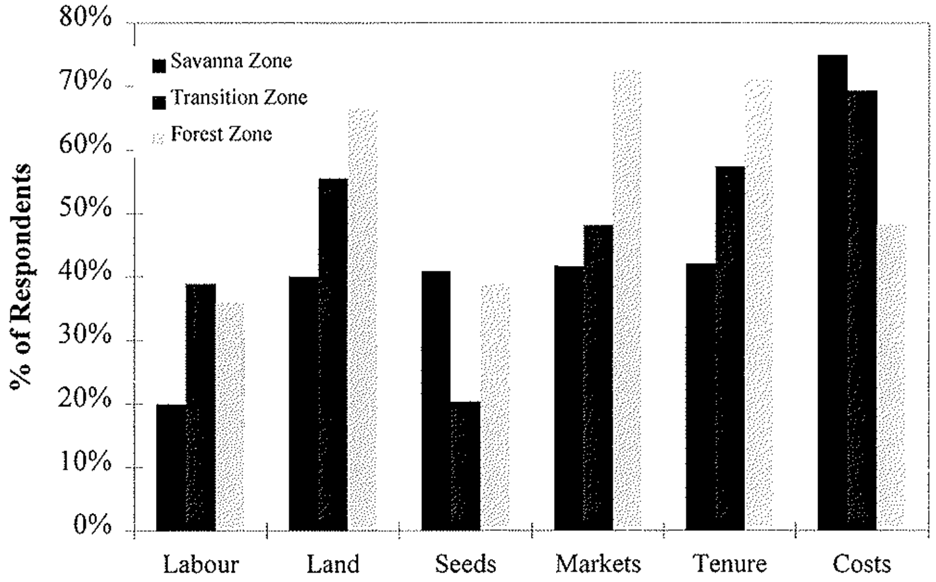

Figure 18: Percent of respondents from different ecozones who regard named constraints as "very important"

5.3 Geo-referencing

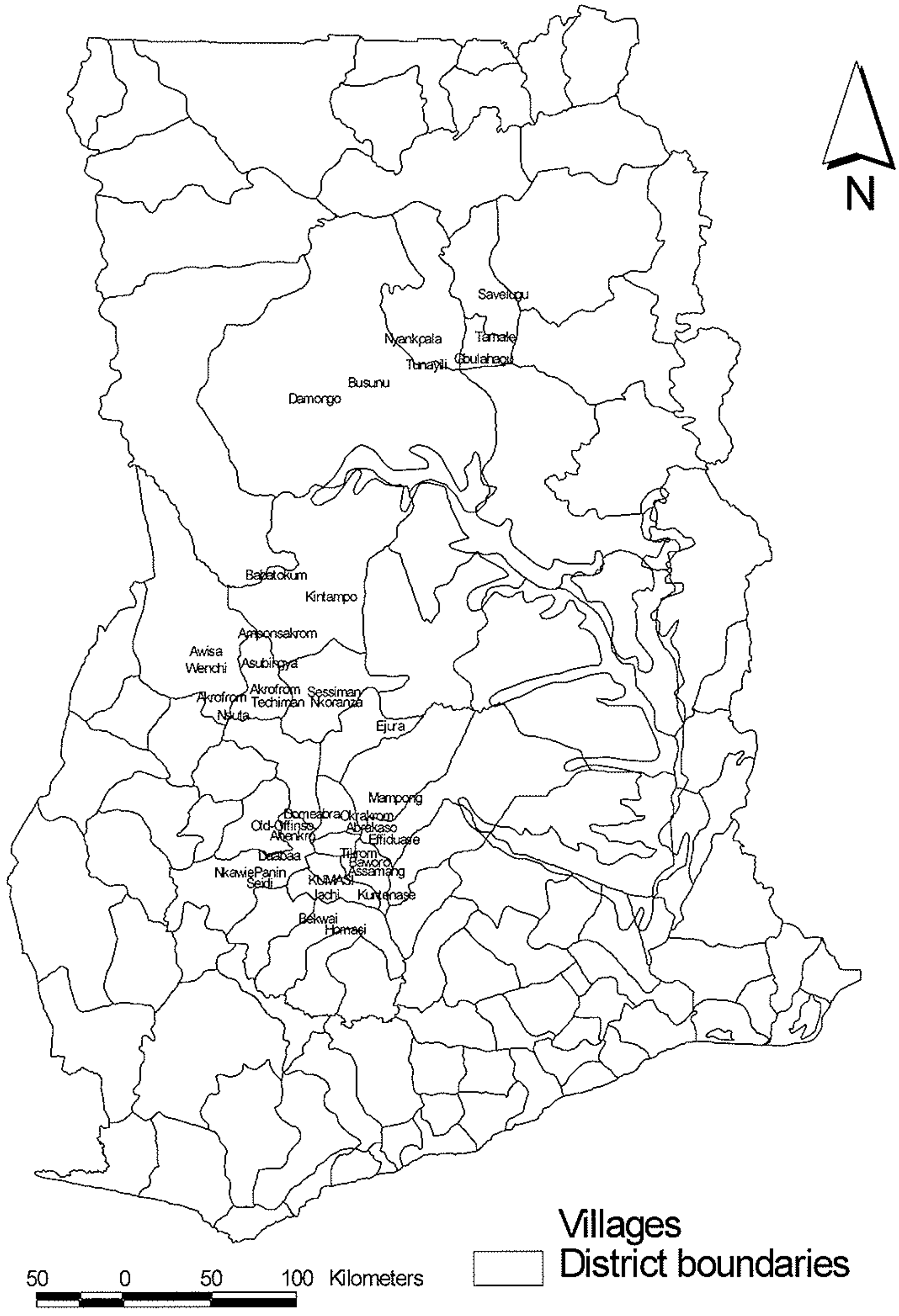

Figure 19: Map of study villages.

5.4 Farmer Objectives

Farmer objectives – a ranked list of the objectives is shown in Table 11. This shows that subsistence and income generation objectives are the two most important objectives to the small-holders.

Table 11: Ranked farmer objectives in the three ecozones

Rank	Guinea-Savannah Zone	Transition Zone	Forest Zone
1	Food to feed the families	Food to feed the family and non-farmers	Income generation
2	Income generation	Income generation	To feed family/nation and eliminate hunger
3	To feed the nation	Improve the standard of living	To secure a permanent name/legacy for the family by catering for the family/elderly/community
4	To satisfy family health needs	To build houses/ family homes	Self-employed/ independent/ self-reliant
5	Payment of school fees	To provide savings and/or security	Provide raw materials for local food industries
6	Provision of vocation for children in future	Provide raw materials for local food industries	To protect the environment/ deforestation by retaining old traditions which have stood the test of time
7	To obtain fuel wood, fodder, rafters for household	To raise capital to make off-farm investments	To earn respect in the community
8	Improve quality of life	Source of employment	To make off-farm investments
9	To reduce food importation	Livestock farming to supplement protein requirements	Send farm family members into employment for remittances
10	To assist husbands in getting food and income to cater for our children	To maintain and/or protect the environment	Sustain farming under prevailing conditions

5.5 Spatial aspects of land-use.-

The farming systems in Ghana are typified by a complex spatial and temporal allocation of resources. Most of the systems rely on some form of temporal agroforestry system – the 'bush-fallow'. That is an area of secondary forest, thicket or forb re-growth vegetation is cleared and the resulting land planted with a crop. After 2-5 years, the area is left fallow for 10-15 years in which time, the nutrients levels in the soil have recovered.

As well as the major cropping and tree plantations, there are a variety of sub-systems. These include the planting of vegetables (peppers, tomatoes, garden eggs etc.) to supplement the diet and cash incomes, and the growing of rice (seen mostly in paddy fields in the northern regions). One map and table of associated information from each agro-ecozone are presented to allow the reader to gain an understanding of how much and what type of information can be gathered from these participatory exercises.

5.5.1 Jachie

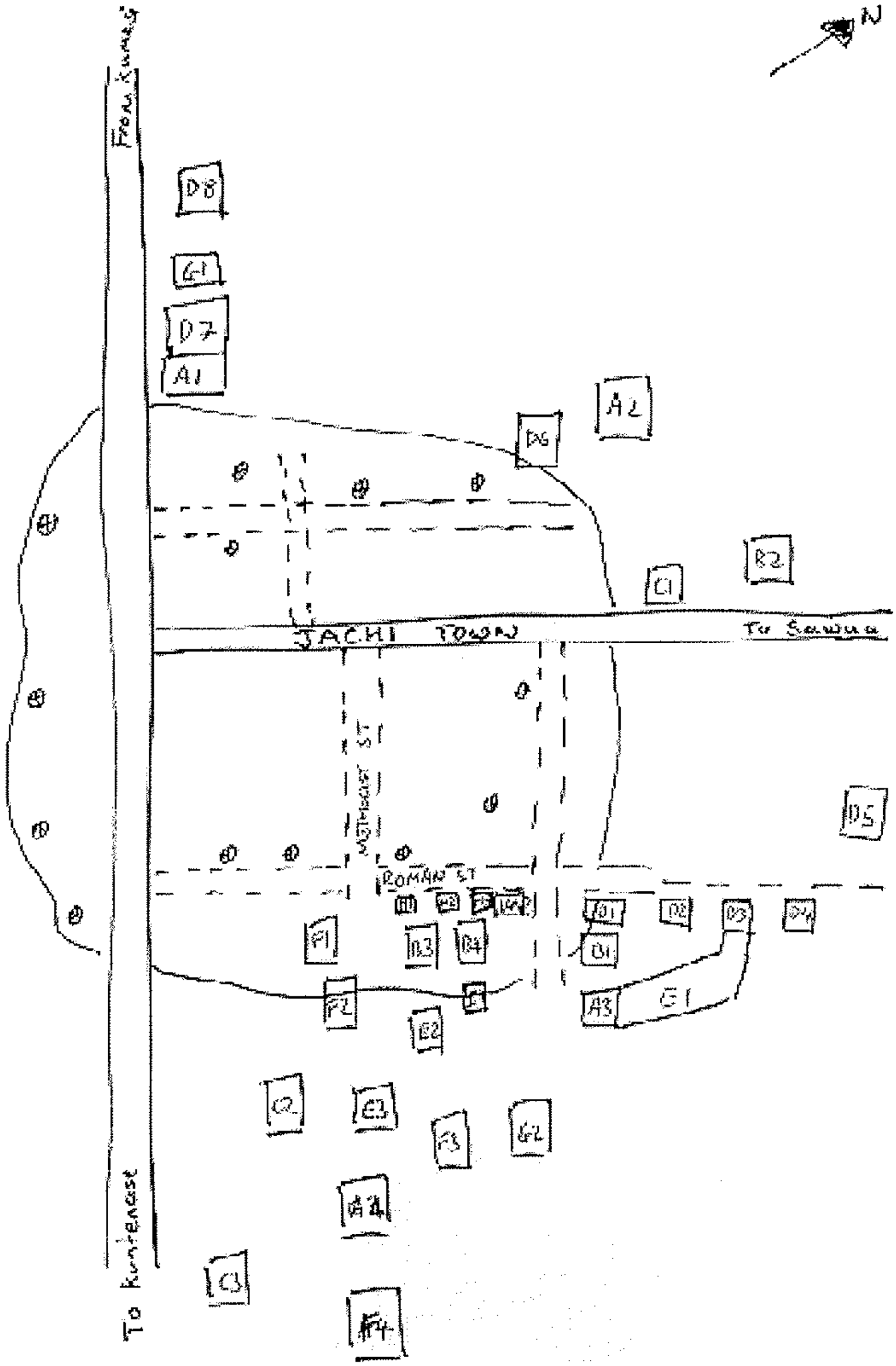

Figure 20: Copy of participatory map of Jachie, Ashanti Region.

Table 12: Key and further information for Jachie

FARMER	FIELD NO.	DISTANCE	UNITS	TIME (mins)	SIZE (acres)	CROPS	LIVESTOCK
ADWOA ADJEINAA	A1	1	MILES	80	3	Cassava.Maize	
	A2	0.5	MILES	40	4	Cassava.Cocoayam. Maize.Plantain	
	A3	2	MILES	240	5	Cassava.Cocoayam. Plantain	
	A4	8	MILES	360	2	Cassava.Cocoayam. Plantain	
VERONICA SERWAA	B1	1	MILES	60	2	Cassava.Cocoayam. Maize	
	B2	2	MILES	240	1	Cassava.Maize.Yam	
	B3	0.5	MILES	40	0.5	Cassava.Cocoayam. Maize	
	B4	3	MILES	300	1	Cassava.Cocoayam. Maize	
YAA ADOMA	C1	0.5	MILES	60	1.5	Cassava.Maize.Yam	
	C2				3	Fallow	
	C3	7	MILES	600	3	Maize.Plantain.Yam	
MARTHA ADJEI	D1	1.5	MILES	120	1	Cassava.Maize	
	D2	1.5	MILES	120	1.5	Cassava.Maize	
	D3	1.5	MILES	120	0.5	Cassava.Maize	
	D4	2	MILES	180	1	Cassava.Maize	
	D5				1	Cassava.Maize	
	D6	1.5	MILES	60	0.5	Cassava.Maize	
	D7	1	MILES	120	1	Cassava.Maize	
	D8	1.5	MILES	120	0.5	Cassava.Maize	
AKNA NKUMNAH	E1	2	MILES	240	1	Cassava.Cocoayam	
	E2	3	MILES	240	2	Cassava.Plantain.Yam	
	E3	4	MILES	300	1	Cassava.Plantain.Yam	
AFNA DANKWE	F1	4.5	MILES	480	4	Cassava.Cocoayam Maize.Plantain	
	F2	3	MILES	180	3	Cassava.Cocoayam Maize.Plantain	
	F3	5	MILES	300	5	Cocoayam.Maize.Pepper Plantain.Shallots	
	F4	8	MILES	600	6	Cassava.Cocoayam. Plantain.Yam	
AKNA GYANFNAH	G1	1	MILES	90	2	Cassava.Maize	
	G2	2.5	MILES	60	1.5	Cassava.Cocoayam Pepper.Plantain	
AGYEMANG DUAH DICKSON	H1	3	MILES	180	1	Cassava.Maize Plantain	
	H2	0.5	MILES	30	0.5	Cassava.Maize Plantain	
	H3	0.5	MILES	30	0.5	Cassava.Maize Plantain	
AGYEMANG DUAH RICKSON	I	3	MILES	80	6	Cocoa.Maize Plantain	

5.5.2 Nsuta

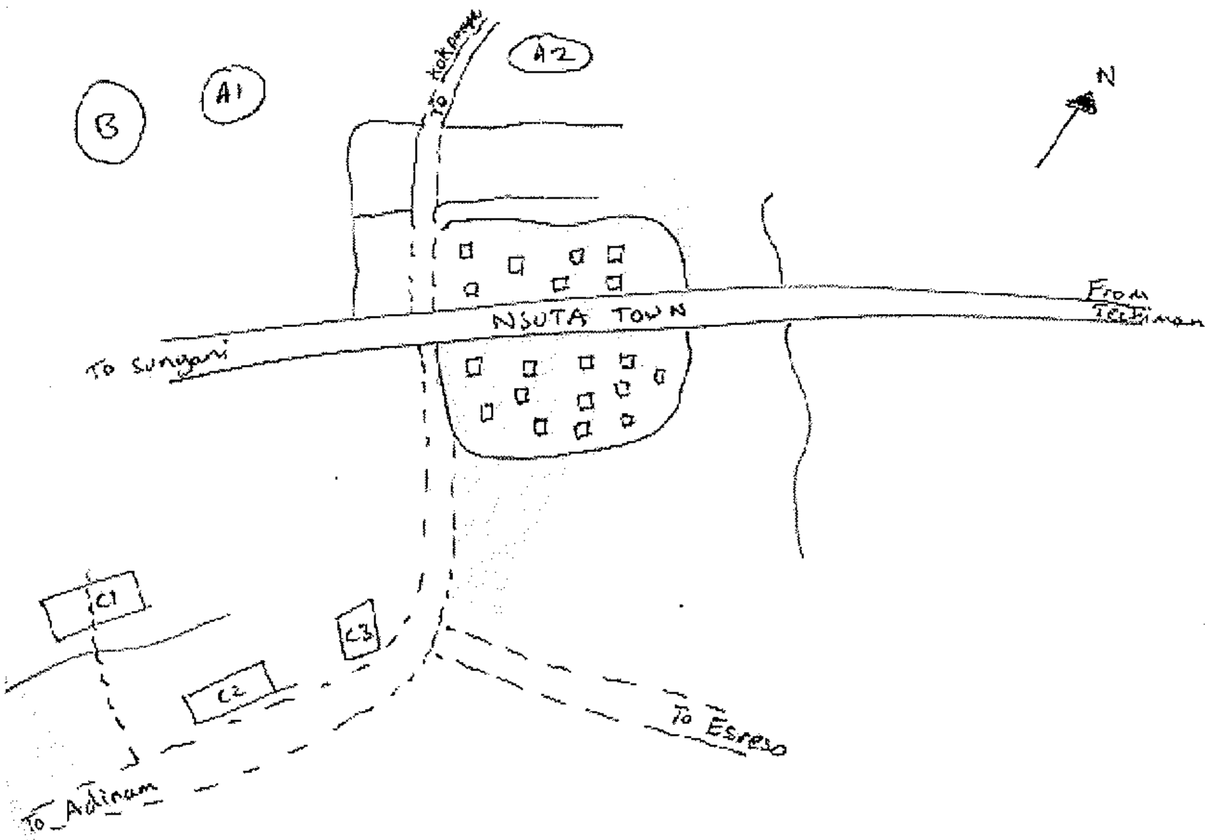

Figure 21: Participatory map of Nsuta, Brong Ahafo Region

Table 13: Further information and key from Nsuta map

FARMER	FIELD NO.	DISTANCE	UNITS	TIME (mins)	SIZE (acres)	CROPS	LIVESTOCK
KINGSFORD OBENG	A1	3	MILES	50	6	Cocoa.Cocoayam. Plantain	
	A2	0.2	KM	3	5.5	Cassava.Cocoa.Cocoayam. Maize.Plantain	
VICTORY ASAA	B	3	MILES	60	8	Maize.Plantain	6 sheep
DANIEL ADUO	C1	2	MILES	50	4	Cassava.Cocoa.Cocoayam. Maize.Plantain	7 sheep
	C2	1.25	MILES	30	4	Cassava.Groundnuts. Yam	
	C3	0.28	KM	5	1.5	Orange Plantain	

5.5.3 Savelugu

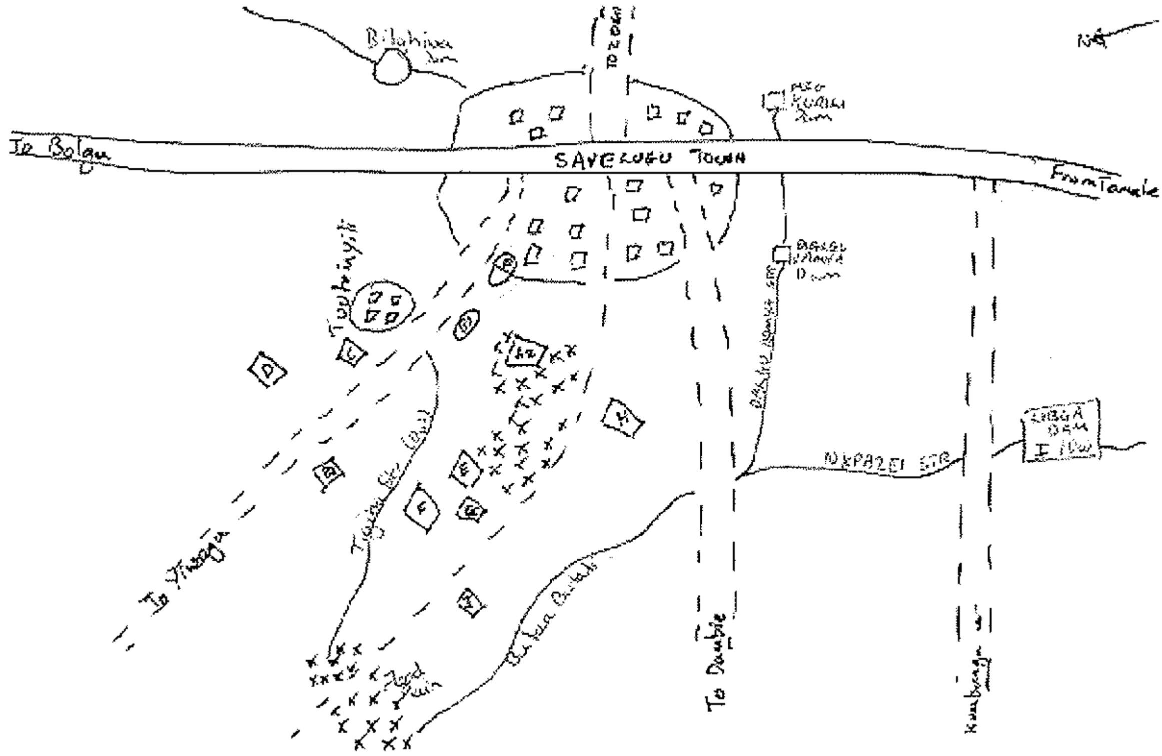

Figure 22: Map of Savelugu, Northern Region

Table 14: Further information from Savelugu

FARMER	FIELD NO.	DISTANCE	UNITS	TIME (mins)	SIZE (acres)	CROPS	LIVESTOCK
ABDULAI ZAKARI	A1	0.5	KM	20	3	Cassava.Cotton Maize.Rice	5 sheep Pair Bullocks
	A2	2	KM	60	2	Rice	
ABDULAI ACHASSAN'S	B1	2.5	KM	40	3	Cassava.Groundnuts Maize	3 sheep 2 goats
	B2	4	KM	60	2.5	Cassava.Groundnuts Maize	
FATI ABDUL-RAHMAN	C	1.5	KM	60	1.5	Groundnuts.Soyabean	
ISSAH YAHAYA	D	2	KM	60	4	Cassava.Groundnuts Maize	4 cows
IDDRISU GNUNYEIWUNI	E	4	KM	240	6.5	Groundnuts.Maize Sorghum	5 sheep
MOHAMADU IDDI	F	4.5	KM	120	4	Cassava.Groundnuts Maize.Sorghum.Yam	5 goats
MAHAMDU MAHMA	G	4	KM	90	2	Cowpea.Maize.Sorghum	none
ABDULAI BABA	H	1.5	KM	30	3	Cotton.Cowpea.Maize	
MOHADMU ZIBLIM	I	4.5	KM	120	3	Cassava.Groundnuts Maize.Yam	4 goats Pair Bullocks

5.6 *Key Results from Workshop*

5.6.1 Time lines of labour activities by crop and region

The time lines show how the labour is distributed by crop and throughout the year to each type of field/marketing operation. These diagrams feed directly into the modelling sequence by allowing the model to be disaggregated into months – capturing the peaks and troughs in the labour demand curves.

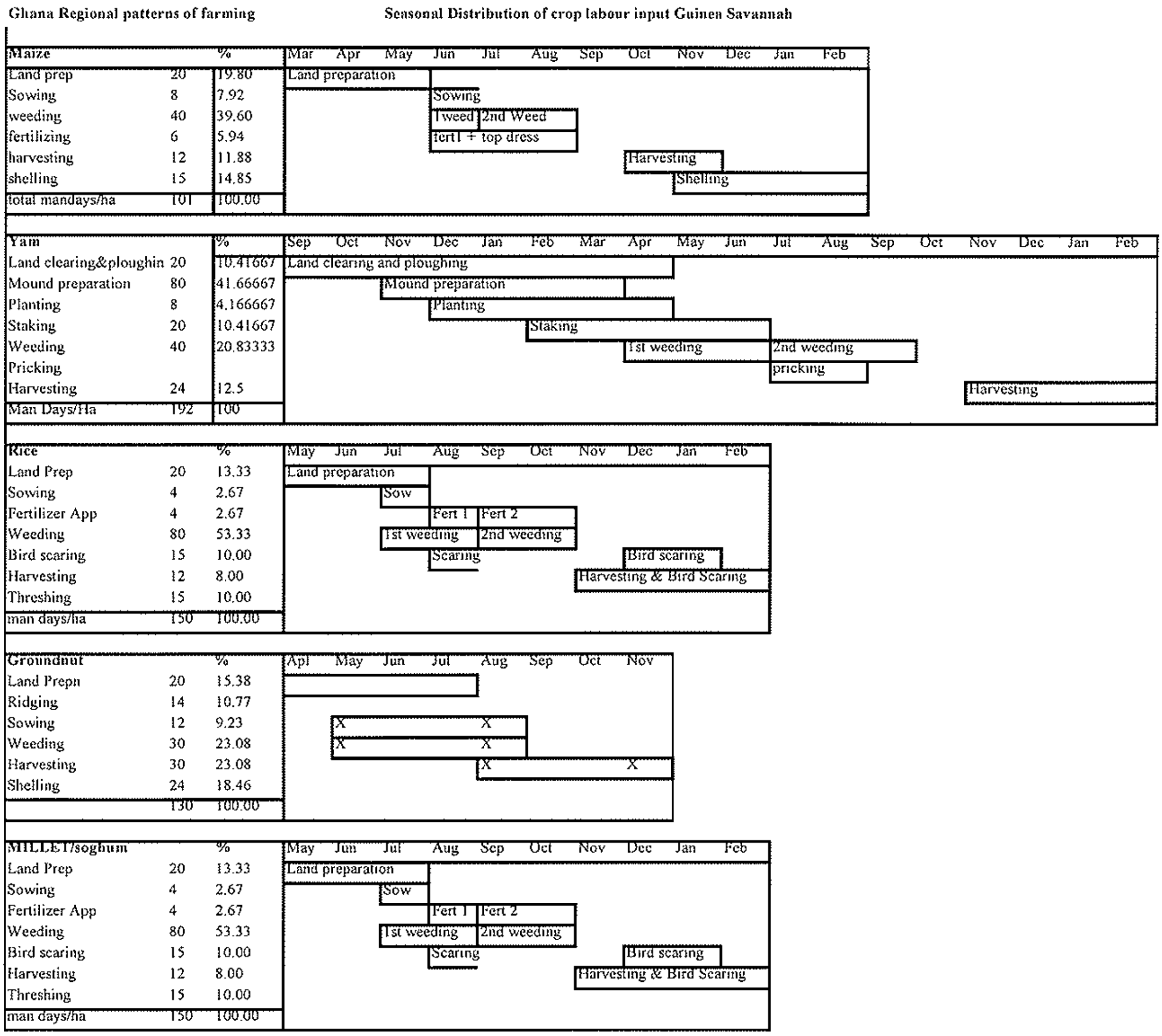

Figure 23: Crop - labour time lines for the Northern Region

Ghana Regional patterns of farming — Seasonal Distribution of crop labour input Transition Zone

Yam	%	Nov Dec Jan Feb Mar Apl May Jun Jul Aug Sep Oct
Clearing	5	Land clearing
Mound preparation	30	Mound preparation
Planting	10	Planting
Staking	15	staking
Weeding	20	weeding
Pricking	5	pricking
Harvesting	15	Harvesting
Man Days/Ha	100	
	Year 2	Nov Dec Jan Feb harvesting into next year

Maize Major	%	Feb Mar Apl May Jun Jul Aug
Land prep	30	Land preparation
Sowing	15	Sowing
weeding	35	1weed / Weed 2
harvesting	20	Harvesting
total mandays/ha	100	

Maize Minor	%	Aug Sep Oct Nov Dec
Land prep	30	Land preparation
Sowing	15	Sow
weeding	35	weeding
harvesting	20	Harvesting
total mandays/ha	100	

Plantain yr1	%	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Land prep	10	Land prep
planting	25	Planting any time between march & sept
weeding	45	Weeding as required continually April to November
Harvest	20	
Total man days/ha	**100**	
	Year 2	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Harvest dependent on planting

Cassava-Cocoyam	%	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Land prep	15	Land prep
Planting	10	Planting any time betweenapril & sept
Weeding	30	
Harvesting	45	Weeding as required continually May to December
Total man days/ha	**100**	
	Year 2	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Harvest dependent on planting (18-24) months

Cow Pea	%	Aug Sep Oct Nov Dec Jan
Land prep	15	land prep
Sowing	15	Sowing
Weeding	15	weeding
Spraying	5	spraying
Harvesting& Threshing	50	harvesting
Total man days/ha	100	threshing

Tomato&Garden Eggs	%	Jul Aug Sept Oct Nov Dec Jan
Nursery	10	Nursery
Land prep	25	Land Prep
Planting	15	Plant
Weeding	20	weeding
Spraying	5	spraying
Harvesting	20	Harvesting&Packing
Packing	5	
Total man days/ha	100	

Figure 24: Crop - labour time lines for the Brong Ahafo Region

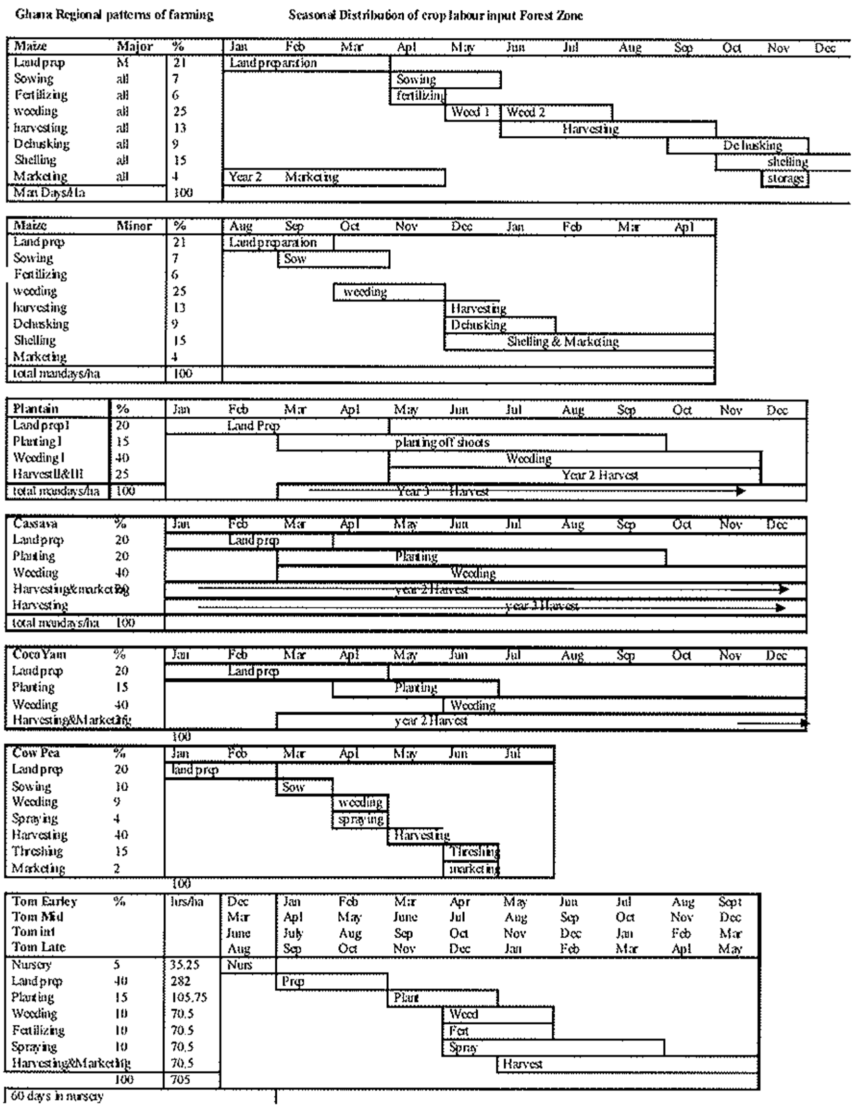

Figure 25: Crop - labour time lines for the Ashanti Region

5.6.2 Reasons for the Non-adoption of currently advocated agroforestry techniques

Participants were asked to give reasons for the non-adoption of accepted agroforestry practices. The list was then subjected to a pairwise ranking activity with the whole group deciding on the more important item in a pair. This was achieved after some discussion and a vote, the majority being the more important reason.

Table 15: Ranked list of reasons for non-adoption of agroforestry systems

Place/ Rank	Reason/issue	Score
1	Land tenure - gender, security, infrastructure	13.5
2	Farmers not involved in planning	12
3	Inadequate farmer education	11.5
4	Under-resourced extension service	11
5	Inadequate research	9.5
6	Benefits too long term	9
7	Bush fires and livestock	7.5
8	Lack of markets for products	7
9	No apparent yield increases	6
10	No incentives or not known incentives	5.5
11 =	Policy and implementation of policy	4
11 =	Too labour intensive	4
13	No basis in indigenous knowledge	2.5
14	Systems too complex	2
15	Against taboos and social/cultural values/traditions	0

During the post ranking discussion of the above list, it was found that many people did not agree that land tenure was as important as it had been found by ranking. This can be attributed to differences in opinion over the definition of land tenure and rights. It can be seen therefore that besides land tenure issues, farmer education and participation in the planning and research are the two most important factors considered by the participants of the workshop.