# Balancing Livestock Needs and Soil Conservation: Assessment of Opportunities in Intensifying Cereal Legume Livestock Systems in West Africa

**CGIAR Systemwide Livestock Programme**
**Annual (2008) Progress Report**

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# CGIAR Systemwide Livestock Programme
# Annual (2008) Progress Report

## A. Project Information

1. ***Title of project:***
   Balancing Livestock Needs and Soil Conservation: Assessment of Opportunities in Intensifying Cereal Livestock Systems in West Africa

2. ***Project purpose***:

(i) The quantification of tradeoffs between usage of biomass as livestock feed or for maintaining and improving soil fertility in the subhumid and semiarid savannah of West Africa;

(ii) The identification of the key driving forces and areas of intervention and entry points where research and development activities can facilitate and contribute to synergies during the intensification of crop livestock systems;

(iii) The creation of better institutional linkages between the different actors involved in research, extension and policy issues related to mixed farming systems.

3. ***Project Outputs*:**

(i) Conceptual framework to assess interactions and tradeoffs in organic matter management in crop livestock systems and implications for livelihood strategies

(ii) Quantitative information on indicators and processes within this framework analysed and synthesised, including the identification of drivers and modifiers, cross scale interactions and tradeoff indicators

(iii) Lessons learned from project results made available to enhance institutional capacity for R&D and improve institutional linkages.

### *4. Project start and end date*

Start date: 1st October 2005
End date: 30 September 2008
No Cost Extension: 30 September 2009

## B. Investigators and Collaborating Institutions

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## C. Progress Report

## 8. Period Covered by this Report

1$^{st}$ October 2006-30$^{th}$ September, 2008

## 9. Summary of Progress in Reporting Period

A survey was conducted at all the selected sites to gather biophysical information on nutrient inflows and outflows of cereal legume livestock systems. The data collected from the survey will be used to calculate the nutrient balances for farmers of diverse socioeconomic situations. In addition, the nutrient cycling efficiencies of the various components of cereal legume livestock systems will be used to identify entry points for research interventions into the system.

All the field experiments on crop residue uses, manure improvement and integrated nutrient management outlined in the research protocol were successfully carried out at all locations. An extensive literature review coupled with expert advice from biophysical scientists, an economist and sociologist led to the development of tools for validating 'best bet' interventions in cereal legume livestock systems.

Progress was also made on socioeconomic aspects of the project. Farm level cross sectional and community level data were collected from twelve villages in Maradi while the same ranges of data were collected from twenty four villages in Kano State. In total, 180 farm households were sampled in Maradi while 360 farm households were sampled in Kano. Significant progress was made towards the achievement of Output 3 through the interaction of graduate students with their University supervisors, project team members' interaction with other internal and external project teams, joint proposal development and publications.

## 10. Implemented Work Programme and Results per Output and Activity

### Output 1: Improved knowledge of the livelihood strategies of the poorest households in mixed farming systems in W Africa

#### 1.1. Identification of entry points for innovation platforms in cereal legume livestock systems by using nutrient balance and resource flow analysis

***Introduction***

The integration of crop and livestock production systems offers a farmer the unique opportunity to manage crop residues and manure to ensure maximum recycling of the nutrients within the farming system and conserve soil fertility. Indeed, efficient recycling of nutrients has led to sustainable increases in both crop and livestock production for considerable periods (30–40 years) of continuous cropping without land degradation in the Close Settled Zone (CSZ) of Kano in Northern Nigeria (Harris, 1995) and the Machakos system in Kenya (Slingerland 2000).

In sub Saharan Africa, stakeholders and decision makers have progressively recognised depletion of soil nutrients as a major constraint to sustainable agriculture and rural development (Smaling *et al* 1996). In contrast to the annual fertiliser consumption of 0.8 million Mt N, 0.26 million Mt P, and 0.2 million Mt K in Africa (FAO 1995), the continent loses as much as 4.4 million Mt N, 0.5 million Mt P, and 3 million Mt K from its cultivated lands annually (Sanchez *et al* 1997). One of the difficulties in reversing the trend of nutrient depletion is the limited use of fertilisers and the subsequent vicious circle of poverty (Sanginga *et al* 2003).

Quantitative knowledge of nutrient flows in agriculture production systems offers a credible insight into the sustainability of the systems and facilitates the identification of the main losses of nutrients from the system. This can, therefore, serve as a diagnostic tool with which to identify areas of intervention where research could contribute significantly to agricultural productivity.

Many studies of the sustainability of agricultural production in sub Saharan Africa (SSA) in the last decade have focused on the quantification and estimation of nutrients that enter and leave the systems (Smaling *et al* 1996; Van den Bosch *et al* 1998 and Kanmegne *et al* 2006). The conclusions emerging from such studies have widely confirmed the alarming rate of 'nutrient mining' and soil fertility deterioration in SSA.

Most of these studies provided quick balance sheets, based on a short timeframe exercise, and depended on a number of assumptions relating to system dynamics. The validity of such assumptions, their degree of reliability, and capability to provide insight into these dynamic processes are of concern. Scoones and Toulmin (1998) questioned the credibility of nutrient balance analysis in providing reliable directions and support for policy formulation on soil fertility management. On the contrary, Lynam *et al* (1998) provided convincing evidence that nutrient balances formed a template for economic budgeting and, hence, a useful tool for understanding the determinants of soil management practices undertaken by a farmer.

Smallholder farmers in the dry savannahs of West Africa are constantly faced with difficult decisions over the allocation of their limited nutrient inputs in crop livestock systems. These decisions could be refined by presenting farmers with alternative management scenarios that minimise the use of external input while maximising the efficiencies of the available inputs.

A thorough assessment of nutrient gains or losses and judicious manipulation of nutrient flows to either reduce nutrient losses or increase nutrient gains would optimise the efficiencies of the various nutrient carriers. Undoubtedly, nutrient balances and resource flow analysis offer a unique framework for identifying these management options.

The specific objectives of this study are to:

1. Audit the flow of nutrients in small scale cereal legume livestock systems

2. Quantify the nutrient balances in these systems

3. Identify alternative management scenarios to redress the nutrient imbalances in these systems

***Conceptual framework for flow of nutrients in crop livestock systems***

A cereal legume livestock system is conceptualised as a farming system comprising a cereal legume production unit, a livestock production unit and a homestead through which nutrient transfers take place (Fig. 1).

Nutrients may be imported into the farm primarily through feed concentrate, mineral fertilisers, and biological N fixation while exports occur through sales of livestock and crop products (Watson *et al*, 2005). In the savannahs of West Africa deposition of Harmattan dust is another important nutrient input into the farming system (Harris 1999). Additional nutrient losses occur through leaching, erosion and denitrification (de Jager *et al* 1998).

Nutrients in crop livestock systems are cycled in several stages, and losses at each stage may decrease the amount of useful output. Crop residues may be fed to livestock and the manure generated returned to the cropland. Turner and Hiernaux (2002), found rangeland to be an integral component of the daily grazing orbit of ruminant livestock in the dry savannahs as animals are typically free range. As a result, livestock grazing on rangelands may import nutrients onto croplands when the manure deposited in confinement, either through kraaling or night parking, is used in crop production (Harris 2002). Rufino *et al* (2006) observed that the passage of crop residues through the rumen decreases the quantity of organic material for soil amendment, but generally increases the nutrient concentration.

Alternatively, nutrients in crop residues may be taken up by the subsequent crop to produce biomass and grain when left on the field after harvest (Powell *et al* 2004). Nonetheless, in the dry savannahs, a substantial amount of the residues left on the field may be lost as a result of bush fires, strong winds, feeding by termites, free roaming animals, or transhumant herds of Fulani cattle (Schulz *et*

*al* 2001). Carsky and Ndikawa (1998) reported that 4 Mt $ha^{-1}$ of *Mucuna* biomass disappeared during the dry season due to wind and termites activities.

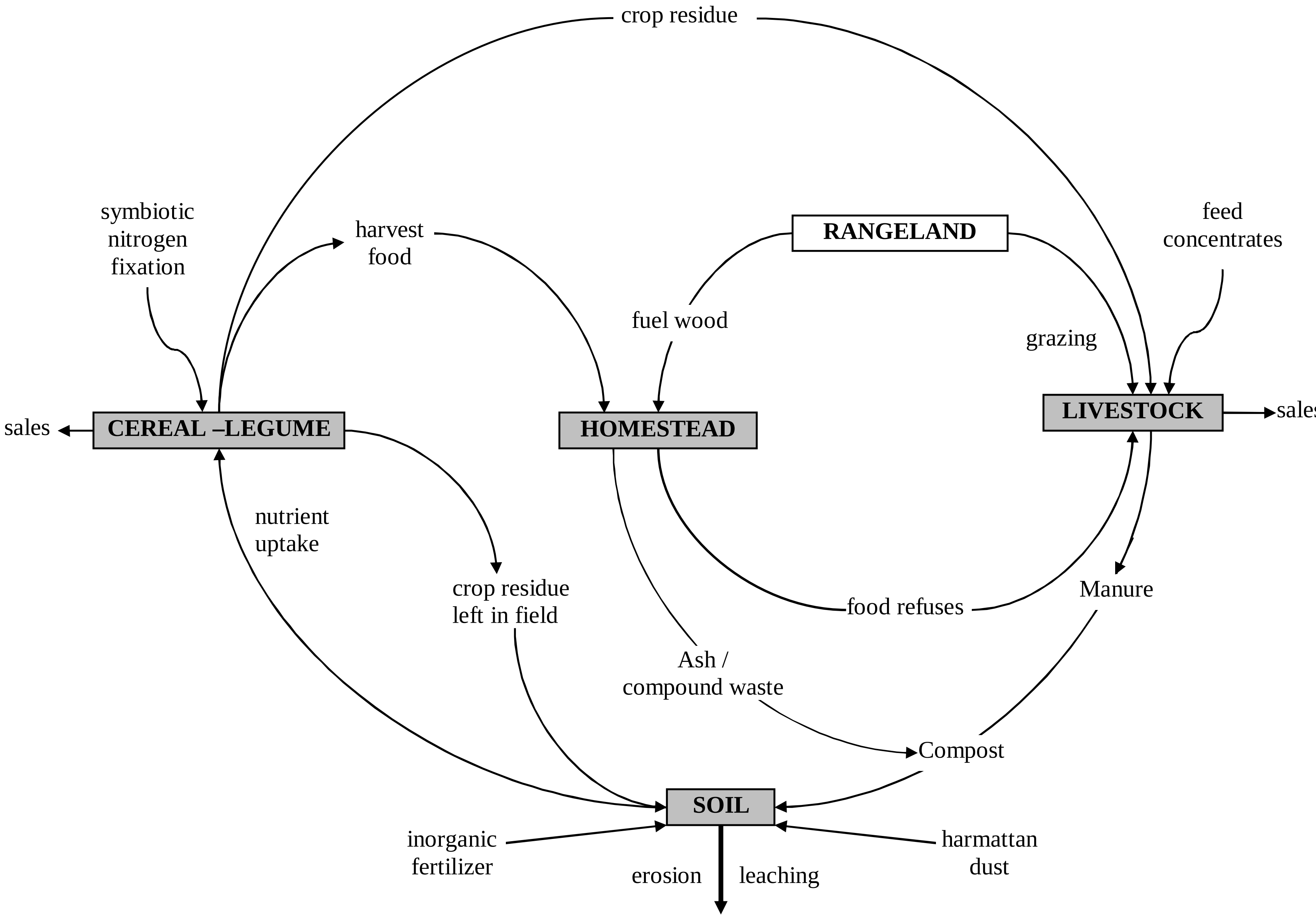



**Figure 1 Nutrient cycling in smallholder cereal legume livestock system**

## ***Methodology***

*Characterisation of households*

Nine case study farms were selected in Garin Labo in Southern Niger representing three socioeconomic groups of farmers: resource rich, medium, and poor. Three farmers in each group were selected for a detailed study of nutrient flows. The sample farmers were selected on the basis of their resource endowment, interest in learning and capacity to exchange information with their peers. Categorisation of households into socioeconomic groups was done by representatives of the zonal farmers union based on a local wealth ranking exercise centred on ownership of draught oxen, donkey, livestock herd and cultivated crop land. Differentiation of households into the socioeconomic group or farm typologies was undertaken before data collection and the three groups were defined as follows:

Resource Rich: This refers to a crop livestock farmer who is equipped with draught animals and tillage implements

Resource Medium: This refers to a crop livestock farmer who owns neither draught animals nor tillage implements but has a number of other livestock exceeding one tropical livestock unit (TLU)

Resource Poor: This refers to a farmer who is essentially into crop production but may keep a number of livestock but not exceeding 1TLU.

The various wealth ranking indicators used for the characterisation of households are shown in Table (1).

**Table 1 Resource profile of the three categories of households distinguished in Garin Labo**

| Criteria | Rich (n =3) | Medium (n =3) | Poor (n =3) |
|---|---|---|---|
| Draught Oxen (number) | 2 | 0 | 0 |
| Cattle (number) | >1 | 0-1 | 0 |
| Donkey (number) | $\geq$1 | 0 | 0 |
| Small ruminants (number) | >20 | 11-20 | 0-10 |
| Total herd size (TLU) | >2 | 1-2 | <1 |
| Ploughs (number) | $\geq$1 | 0 | 0 |
| Carts (number) | $\geq$ 1 | 0 | 0 |
| Total land holding (ha) | $\geq$ 2 | 0.9-2 | 0.1-0.8 |

*Quantification of nutrient flows*

A survey was conducted from March to October 2007 of the 15 selected households to gather information on nutrient flows managed by farmers. Farmers gave information on the different production units, land uses, major farm products and their destinations. The inflows investigated by asking farmers were: the quantities and types of mineral fertilisers (IN 1) and manure (IN 2), feedstuffs and concentrates entering the farm annually. The outflows included crops products (OUT 1) and residues (OUT 2) leaving the farm annually for homestead use, sold or given as gifts. Farmers generally gave quantities in their own units, such as sacks, bags and buckets, which were converted to standard metric amounts. The different inputs and products were sampled and are being analysed for their NPK content.

Environmental nutrient inflows such as atmospheric deposition and biological nitrogen fixation would be estimated from transfer functions using site, climate and soil data.

The combined wet and dry atmospheric deposition (IN 3), would be calculated using the transfer function developed by Stoorvogel and Smaling (1990), in which IN $3_N$, IN $3_P$, IN $3_K$ is the input of N, P and K (kg $ha^{-1}$ $yr^{-1}$) and p is the mean annual precipitation (mm $yr^{-1}$).

IN $3_N$ = $0.14 p^{1/2}$

IN $3_P$ = $0.023 p^{1/2}$

IN $3_K$ = $0.092 p^{1/2}$

Biological nitrogen fixation (IN4) in production systems would be estimated from the general equation:

IN 4 (N) = $\left[(A_L \times IN4a) + (A_F \times IN4b)\right] \times \left[A_F\right]^{-1}$

Where $A_L$ is the area of legume field, $A_F$ is the farm size, IN4a is the symbiotically fixed and IN4b the non symbiotically fixed nitrogen. It is assumed that 60% of

the total N demands of groundnuts and cowpeas are supplied through symbiotic nitrogen fixation (Stoorvogel and Smaling 1990).

$$IN4a = [\{(N_G \times Y_G) + (N_H \times Y_H)\} \times 0.6 + \{2 + (p - 1350) \times 0.005\}]$$

Non symbiotic nitrogen fixation would be estimated from the function (Smaling *et al* 1993):

$$IN4b = [\{2 + (p - 1350) \times 0.005\}]$$

Where $N_G$ and $N_H$ are quantities of N accumulated in grain and haulm, respectively with $Y_G$ and $Y_H$ being grain yield and haulm yield, respectively.

Environmental nutrient outflows such as leaching of soil nutrients below the root zone (OUT 3) would be calculated for N and K. In tropical soils, P is tightly bound to soil particles; P outflow due to leaching is assumed to negligible. The quantities of N lost annually through leaching (kg $ha^{-1}$ $yr^{-1}$) would be estimated from the transfer function by developed by De Willigen (2000):

$$\text{OUT } 3_N = 21.37 + \left(\tfrac{p}{C} \times L\right) \times (0.0037 \times Nf + 0.0000601 \times Oc - 0.00362 \times Nu)$$

Where *p* is annual precipitation (mm/year), *C* is the clay content of the topsoil (%), *L* is rooting depth (m), *Nf* is N derived from the application of mineral and organic fertilisers (kg/ha), *Oc is* organic carbon content of the top soil (%) and *Nu* = N uptake by the crop (kg/ha/year).

The amount of K lost annually through leaching (kg $ha^{-1}$ $yr^{-1}$) would be calculated using the transfer function by developed by Smaling (1993):

$$\text{OUT } 3_K = (Ke + Kf) \times (0.00029 \times p + 0.41)$$

Where Ke is the exchangeable K (cmol/kg) in the top soil and Kf is the amount derived of K derived from mineral fertiliser.

In addition, the annual loss of gaseous N from the soil (OUT 4) by denitrification or volatilisation (kg $ha^{-1}$ $yr^{-1}$) is related to Nmin, Nf and the percentage of denitrified N (DN).

OUT 4 = $\left(N\min + Nf\right)\times DN$

$N\min = 20\times Ntot\times M$

Where Nmin is mineralised N in the root zone (kg/ha), Nf is N applied mineral and organic fertiliser (kg/ha). Nmin is determined from soil total N and the annual relative mineralisation rate (M) estimated at 3% (Nye and Greenland 1960).

DN is a function of clay content of the top soil, C (%), and the annual rainfall p (mm/year), through the transfer function (Smaling *et al* 1993):

DN = $-9.4 + 0.13\times C + 0.01p$

Partial nutrient balances would be determined at farm level comprising flows through the farm gate:

*Partial nutrient balance = IN1 + IN2 – OUT1 + OUT2*

The full nutrient balance would be calculated without nutrient input through sedimentation (IN 5) since the cropping system in study did not employ irrigation. Also, nutrient losses through erosion (OUT 5) will not be included as slope angles measured on the test farms were less than 0.5%.

*Full nutrient balance = IN1 + IN2 + IN3 + IN4 - OUT1 + OUT2 + OUT3 + OUT4*

*Preliminary Results and Discussion*

<u>Resource inflows and outflows of cereal legume livestock systems</u>

Although the relative sizes of fields and combination of crops grown on different fields varied among the selected farmers, the patterns of land use identified in Garin Labo was remarkably similar among smallholder farming systems in the Sahel savannah. Figure 1 shows the typical pattern of nutrient flows within the selected farm. Three major sub systems identified were arable crop fields, the home garden and the homestead where both people and animals reside.

All farmers, regardless of their of resource endowment, apply farm yard manure to their fields. Resource poor farmers generated and applied the least. In

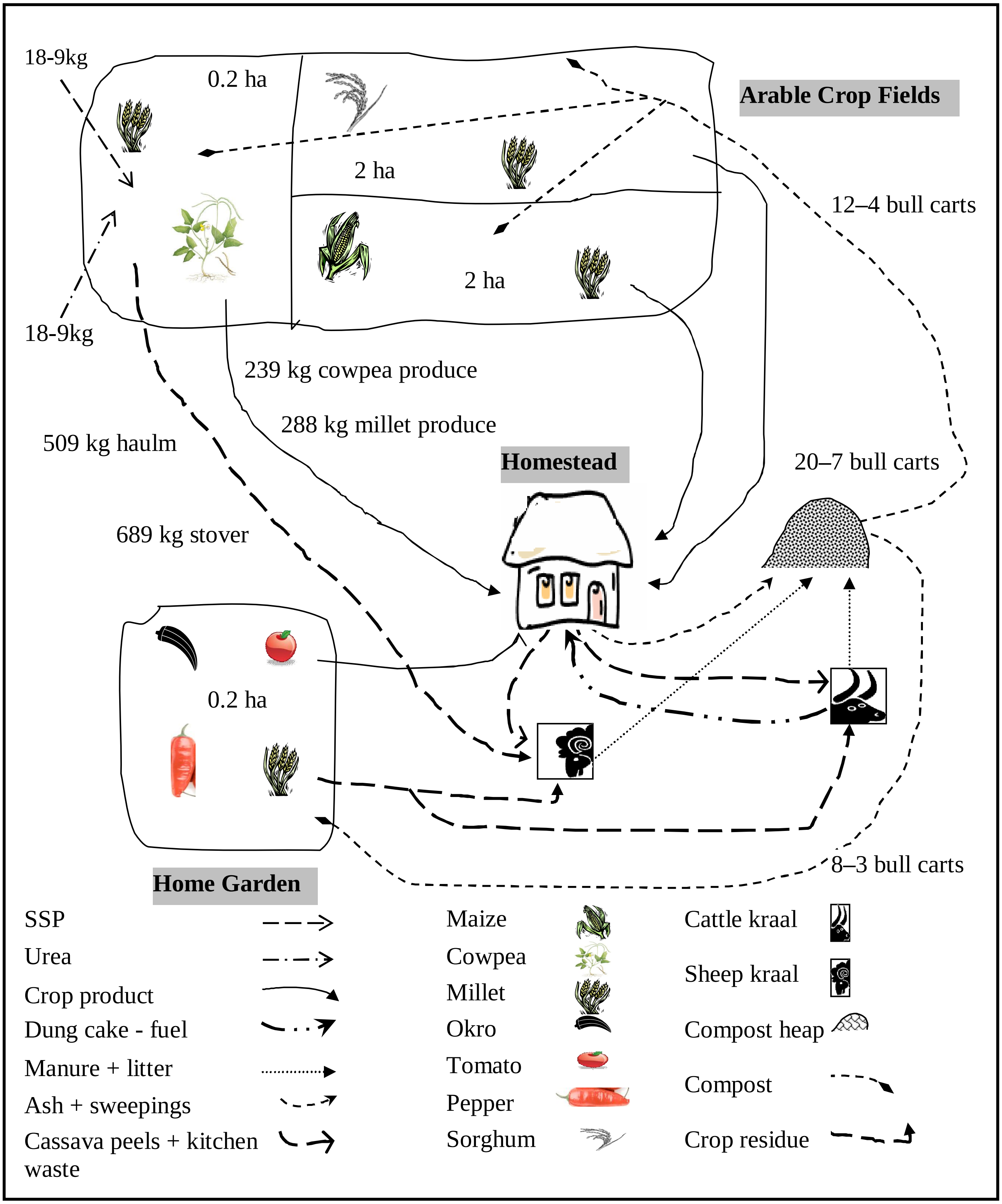
addition, the application of manure was largely influenced by the proximity of fields to the homestead. Farmers applied as much as 2-5 mt $ha^{-1}$ of manure to their home gardens while the arable crop fields received as low as 0,3-1 Mt $ha^{-1}$. The bulky nature of manure and the high labour required input to transport manure to the distant crop field may partly account for the low amounts sent to these fields.

Furthermore, maintaining an area of the farm at optimal soil fertility may be seen as a means of guaranteeing food security for a farmer (Giller *et al* 2006). Besides, crop products of home gardens may be less susceptible to theft.

Wealthier farmers who could afford the recommended amount of mineral fertilisers were able to apply them across the different fields. Resource poor farmers on the other hand had limited access to mineral fertilisers. On the contrary, there were no major differences in grain and crop residue yields obtained from the arable crop field of the various socioeconomic classes. Irregular distribution of rainfall particularly the prolong spell of drought during the grain filling period may account for the poor observed yields.

On average, farmers in Garin Labo consumed 80% of their annual production, and either gave some of the remaining 20% away as gifts or sold it in the market.

All the reuseable crop residues were removed from the field and used as fodder for livestock, fuel and hut construction.




1 bull cart is equivalent to 120 kg of manure or compost

**Figure 2 Generalised resource flow map for cereal legume livestock farm in Garin Labo**

***Expected Output***

It was envisaged that hotspots for research interventions and their entry points would be identified during this phase of the study. This would give clues to improved management options for manure and crop residues in cereal legume livestock systems.

**Output 2. <u>Quantitative information on indicators and processes within this framework analysed and synthesised, including the identification of drivers and modifiers, cross scale interactions and trade off indicators</u>**

**2.1. Implement field trials and surveys to collect qualitative and quantitative data**

***2.1.1. <u>Manure preservation and improvement trial</u>***

The objective of this experiment is to develop an appropriate technology for increasing the nutrient concentration of manure during storage.

The specific objectives are to:

a) Determine the rate of N, P and K depletion or accumulation in manure during storage
b) Determine the effect of cocomposition of manure with oil cakes on N, P and K content of the cured manure
c) Assess the cost effectiveness of manure storage methods

***Methodology***

This study was conducted simultaneously at Animal Research Institute, Tamale (Ghana), National Animal Production Research Institute, Zaria (Nigeria) and Institut National de Recherche Agronomique du Niger (Niger).

The design was a randomised complete block design with three replicates. The storage facilities tested were heap with or without plastic sheet cover and pits with or without plastic sheet lining. Livestock manure with or without oil cake

was stored in these facilities for about six months. Shea butter cake was used in Ghana, while cotton seed and groundnut cakes were used in the Niger and Nigerian studies, respectively.

*Data Collection*

Samples of the stored manure were collected over the storage period and are being analysed for their $NO_3^-$-N, $NH_4^+$-N, organic C, available P and K. Other quality parameters like lignin and cellulose contents will also be assessed. Data on labour cost, market price of inputs, and social acceptability of the interventions on manure storage will be used to appraise the sustainability of these interventions.

***Expected Output***

The study would identify the 'best bet' low input technology for storing and improving manure quality.

### ***2.1.2. Quantification of the tradeoffs in alternative uses of crop residue***

***Introduction***

Crop residues constitute an important source of livestock feed in crop livestock systems. De Leeuw (1996) estimated that crop residues accounted for 40-60% of the total dry matter intake of cattle during the dry season in dry savannah zones of West Africa. The general crop residue management practice in the dry savannahs of West Africa is that legume haulms are high in proteins and are fed to special animals such as oxen, small ruminants, and donkeys (Agyemang *et al* 1993) and cereal stover on the other hand has low nutritive value in terms of digestible energy and is first grazed by cattle and the remaining unused residues are either gathered and burned or allowed to decay on the fields to improve soil fertility (Tarawali 2000). In Niger, hardly any crop residues are left on the field for soil improvement as the entire field is harvested and fed to animals (Tarawali 2000).

Crop residues when used as mulch improve soil fertility and crop yields (Ikpe *et al* 1999). Bationo *et al* (1995) found increases in soil organic matter content

(SOM), P availability, ECEC, and pH following the application of crop residues. Crop residues have enormous potential to ameliorate soil fertility but their efficiency has been limited by constraints such as the keen competition for its use as fodder, the high labour required for its incorporation into the soil, and the large amounts needed to achieve sustainable crop yields.

The observation by Delve *et al* (2001) that returning cereal residues to the soil had delayed benefits and were less attractive to farmers confirms the assertion that cereal stover has a wide C:N (mean of 100:1) ratio that promotes N immobilisation and may even lead to N deficiency in the subsequent crop (FAO 2006). To boost farmer confidence in the use of cereal stover for soil application, FAO (2006) suggested the addition of 1 % mineral N to the stover prior to incorporation. Alternatively, due to the high concentration of N in legume haulms, appropriate mixtures of stover and haulms for soil application could provide immediate benefits to crops.

Crop residue management is a major issue affecting the sustainability of crop livestock systems in West Africa, yet reports on the exact proportion of cereal legume residue produced from a unit area to be used for soil application (SA) or as livestock feed (LF) to maximise the productivity of the system have been conflicting. Whereas Larbi *et al* (2002) advocated the use of 25 - 50 % of the total cereal stover as fodder and 50- 75 % of it as mulch, Olaf (2002) warned of significant yield reduction in the next crop following the application of 50 % or more of the total cereal stover as a result of pronounced immobilisation. Apparently, the discrepancies in these results may be due to differences in the endogenous N content of soils and the quality of crop residues used in these studies.

In sum, due to the variable nutrient composition of crop residues, an holistic approach is required to quantify the impact of using crop residues as fodder or mulch on the productivity of crop livestock systems in relation to the quality of the crop residue. In two separate but concurrent field experiments the following scenarios are being tested on farmers fields and their tradeoffs i.e. impact on the farm outputs and incomes, being quantified.

Scenario 1: 0% SA (0% M[1], 0% C[2]) versus 100% LF (100% M, 100% C)

Scenario 2: 50% SA (25% M, 75% C) versus 50% LF (75% M, 25% C)

Scenario 3: 50% SA (50% M, 50% C) versus 50% LF (50% M, 50% C)

Scenario 4: 50% SA (75% M, 25% C) versus 50% LF (25% M, 75% C)

Scenario 5: 100% SA (100% M, 100% C) versus 0% LF (0% M, 0% C)

#### 2.1.2.1. ***Effect of crop residue incorporation on growth and yield of cereals and legumes***

The objective of the crop residue incorporation experiment is to determine the amount of crop residue to be incorporated into soil for optimum dry matter and grain yield of maize or millet and cowpeas or groundnuts.

The specific objectives are to:

a) Assess the effect of crop residue incorporation on growth and yield of maize or millet and cowpeas or groundnuts
b) Evaluate the effect of crop residue incorporation on soil physical and chemical and microbial properties
c) Appraise the economic benefits of incorporating crop residues into the soil.

***Methodology***

This on farm experiment was conducted on two farms each at Chiyohi (Ghana), Saraunya (Nigeria) ad Garin Labo (Niger) simultaneously. The design was a randomised complete block design with three replicates. The treatments were 0, 25, 50, 75, 100% of maize or millet stover combined with 0, 25, 50, 75, 100% of cowpea and groundnut haulms.

Crop residues were gathered, weighed and the appropriate proportion spread evenly on the designated plots at the end of the 2007 cropping season (Fig. 3a and b). Crop residues were then incorporated into the soil to prevent them from free range grazing animals (Fig 3c).

[1] Maize stover
[2] Cowpea residue (haulm)

**Figure 3 (a) Determination of cowpea haulm yield**

**Figure 3 (b) Spreading of crop residues on the field**

**Figure 3 (c) Ridges made to incorporate crop residues into the soil**

Maize or millet was planted on these test fields during the major rainy season in 2008. These cereals were then intercropped with cowpea or groundnut. Mineral fertiliser was applied to supplement the nutrients supplied by the crop residues. Weeds were controlled manually by hand hoeing.

*Data collection*

Data will be collected to assess agronomic superiority in terms of crop growth, grain yield, soil physical, chemical and microbial properties.

Data on labour cost, markets prices of inputs and crop produced, social acceptance of crop residue incorporation as well as accessibility of needed inputs to farmers will be used to evaluate the profitability and social responsiveness of crop residue incorporation.

***Expected Output***

This study is currently ongoing. Crops will be harvested in October / November this year. Optimum amounts of crop residues to be incorporated into the soil for sustainable crop production will be determined. In addition, any reduction in crop yields as a result of inadequate or excessive application of crop residue would be quantified and used in the tradeoff analysis.

***Effect of maize and cowpea residue intake on livestock productivity (Liveweight)***

The objective of this experiment is to determine the amount of crop residues that could be fed to small ruminants in cereal legume livestock systems for optimum gains in liveweight.

The specific objectives are to:

a) Assess the effect of crop residue intake on livestock productivity (liveweight)
b) Evaluate the effect of crop residue intake on the quantity and quality of manure produced
c) Appraise the economic benefits of feeding crop residues to livestock.

***Methodology***

This on farm experiment was conducted on two farms each at Chiyohi, Saraunya and Garin Labo simultaneously. The design was a randomised complete block

design with three replicates. The treatments were 0, 25, 50, 75 and 100% of maize or millet stover combined with 0, 25, 50, 75, and 100% of cowpea or groundnut haulm.

On each farm a housing unit consisting of 15 compartments with 2 m x 1 m floor space was constructed to accommodate 15 male sheep or goats. Animals aged 12-18 months were selected by examining the dentition in their lower jaw as animals within that age bracket have their two central incisors are replaced by two larger permanent ones.

Animals underwent standard quarantine procedures for 21 days to enable them adapt to the feed being tested and to also develop the appropriate rumen microbes for degradation of the feed. During this period, animals were identified with plastic ear tags, vaccinated, dewormed and treated with acaricide. The crop residues to be fed to livestock were weighed into the appropriate daily amounts and supplied to the designated test animals.

**Figure 4 (a) Prepacking cowpea haulm**

**Figure 4 (b) Feeding sheep with crop residues**

*Routine husbandry activities*

Animal pens were cleaned daily. Test animals on the control ration (0%) were allowed to graze on rangeland from morning to evening. Other test animals were fed with their daily ration. Water and salt lick were supplied *ad libitum.* Feed 'left over' was collected the next morning, weighed and recorded.

*Data collection*

Data was collected on quantities of feed fed daily as well as the refuse fodder to estimate feed intake. Data on live weight and manure production was determined biweekly. Data on labour cost, markets prices of inputs, social acceptance of 'cut and carry' feeding strategy as well as accessibility of needed inputs to farmers will be used to evaluate the profitability and social responsiveness of feeding crop residues to small ruminants.

### ***Preliminary results and discussion***

Increasing the quantity of groundnut haulm gave rise to higher growth rates. Figure 6 shows that goats fed on rangeland (as control animals) gained only 14.3g liveweight per day while those offered 50 g DM $kg^{-1}$ of groundnut haulm and maize stover rations gained weight in the range of 31 to 59g $day^{-1}$. Doubling the amount of feed to 100g DM/kg more than doubled the growth rate to 109g $day^{-1}$.

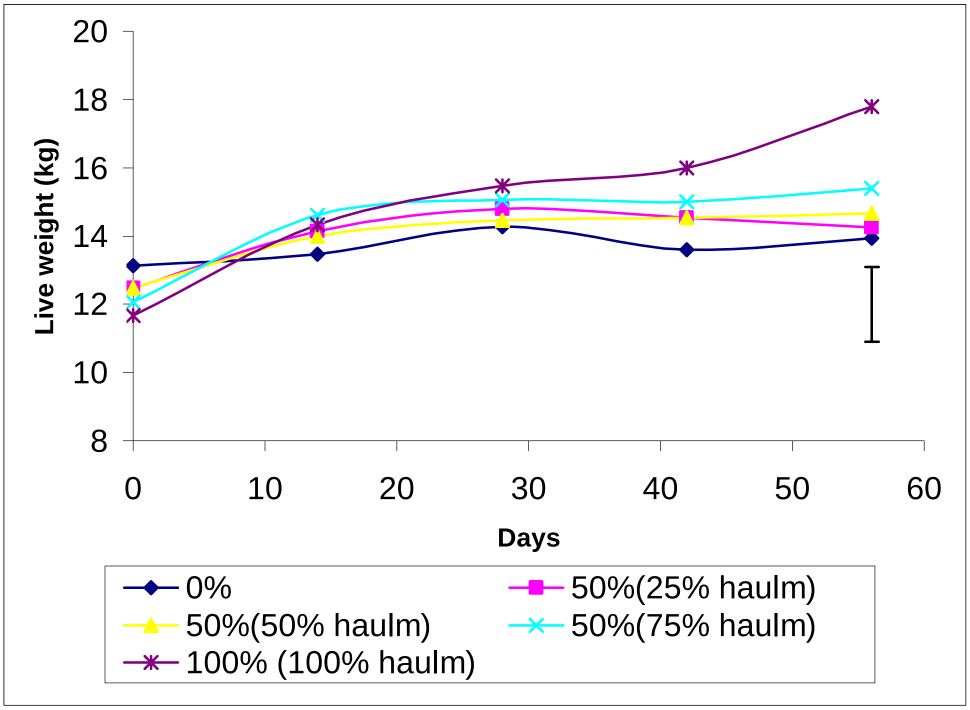



**Figure 5 Effect of groundnut and maize residues on liveweight of goats at Sauranya. Bars indicate LSD at p = 0.05**

The lack of herbage on the rangelands during that phase of the year largely accounted for the poor growth rate observed in animals grazed on the range. Tanner *et al* (1995) and Wahed *et al* (1990) observed similar increases in growth rates when the quantity of forage on offer increased from 25 to 75g DM/kg$^{-1}$. These authors suggested that the higher feeding rates provided the animals with greater opportunity for selective feeding which, in turn, led to improvements in the quality of the diet ingested.

Data on fodder refuse, faecal voidance and the biochemical characteristics of crop residues fed collected during the study will be used to explore the mechanisms for selective feeding, weight gain and quality of faecal matter voided.

It is expected that at the end of data collection and analysis, the optimum amount of crop residues that could be used to sustain the growth and productivity of livestock the during dry season will be established. In addition, losses in liveweight as result of inadequate or excessive feeding of crop residue will be quantified and used in the tradeoff analysis.

*2.1.3.* ***Optimisation of manure and mineral fertiliser use****:*

The objective of this study is to determine the optimum application rates of manure and mineral fertiliser for the sustainable production of cereals in the dry savannahs of West Africa.

The specific objectives are to:

a) Determine the effect of different combinations of manure and mineral fertiliser inputs on growth and yield of maize

b) Evaluate the effect of the different combinations of manure and mineral fertiliser inputs on soil physical and chemical properties

c) Appraise the economic benefits of the different combinations of manure and mineral fertiliser inputs on maize production.

***Methodology***

This on farm experiment was conducted at Chiyohi (Ghana), Saraunya (Nigeria) and Garin Labo (Niger), simultaneously. The design was a factorial combination of four application rates of inorganic fertiliser (0%, 25%, 50%, and 100% of the NPK application rate recommended for the location) and four application rates of farmyard manure (0, 2.5 DM Mt ha $^{-1}$, 5 DM Mt ha $^{-1}$, and 10 DM Mt ha $^{-1}$).

*Data collection*

Data will be collected to assess agronomic superiority in terms of crop growth, grain yield, soil physical, chemical and microbial properties.

Data on labour cost, markets prices of inputs and crop produced, social acceptance of the various combinations of manure and fertiliser application as well as accessibility of needed inputs to farmers would be used to evaluate the profitability and social responsiveness of these nutrient management regimes.

*Preliminary results and discussion*

This study is ongoing. Crops will be harvested in October and November this year. The study will identify the 'best bet' application rates of manure and mineral fertiliser for maize or millet in the study location.

### 2.1.4. Framework for evaluating the sustainability of best bet interventions

*Introduction*

Improper use of agricultural inputs and poor cultural practices have taxed the resilience of soil to meet the global demand for food and fibre. The has led to calls for adopting sustainable farming practices to address concerns about adverse environmental and economic impacts of conventional agriculture.

Sustainability is a multifaceted concept (Dalal *et al*, 2003). An attempt to derive a precise, operational, and absolute definition of sustainable agriculture is exceptionally problematic, partly because of the multidisciplinary and fuzzy nature of the concept (Pretty and Hine 2001, Rigby and Caceres 2001). However, the general definition propounded by Dalal *et al* (2003) as '*management of an agricultural ecosystem in such a way that its capacity to meet the economic, environmental and social needs of present and future generations does not diminish*' offers a conceptual understanding of the subject. Despite the diversity in conceptualising sustainable agricultural practices, there is a consensus that agricultural sustainability should be assessed from the perspectives of economic viability, environmental stability and social responsiveness (Rasul and Thapa, 2004; Doran, 2002; von Wiren-Lehr 2001; Van Cauwenbergh *et al* 2007).

Agricultural sustainability is not precisely measurable, as the externalities of any agricultural system are very difficult to measure (Pretty, 1995). Several assessment tools have been used to evaluate the sustainability of agricultural systems. These include

Framework for evaluating sustainable land management (FESLM) (FAO 1993); Sustainability assessment of farming and the environment (SAFE) framework (Van Cauwenbergh *et al*. 2007),

Integrated modelling platform for animal crop systems (IMPACT) (Herrero *et al* 2007),

Nutrient balances (Wijnhoud *et al* 2003; De Jager *et al* 2001),

Life cycle assessment (LCA),

Cost–benefit analysis (CBA), Environmental impact assessment (EIA) (Lo´pez-Ridaura *et al* 2005),

Sustainbility index (SI) (Kang *et al* 2005),

Soil quality index (SQI) (Masto *et al* 2008; Andrews *et al* 2003).

These attempts to empirically examine the sustainability of agricultural practices have led to the identification of several indicators of sustainability.

To avert the widespread non adoption that characterised most of the adaptive research interventions on the use of organic materials for crop and livestock production in SSA, all field experiments in this project will be evaluated on the basis of their ecological stability (ie, agronomic superiority and environmental friendliness), economic viability and social responsiveness. A realistic way of achieving such a rigorous format of evaluation is by developing a composite index of sustainability that integrates the ecological, economic and social aspects of the research intervention. As indicated in Figure 9, the construction of a sustainability index involves the identification of the relevant facets and indicators of sustainability, selecting the relevant ones to form a minimum data set (MDS), transformation of these indicators into commensurable units and integrating them into an aggregate index. The index is a decision tool intended to make complex information more accessible to decision makers.

## ***Methodology***

*Selection of appropriate indicators*

Indicators are composite sets of measurable attributes which are derived from functional relationships and can be monitored through field observation, field

sampling, survey or compilation of existing information (Walker and Reuter, 1996). Indicators signal desirable or undesirable changes in land, water and vegetation management that have occurred, or may occur, in the future. Dalal *et al* (2003) argued that a valuable sustainable indicator should be sensitive to changes in management practices; easily measurable and cost effective.

The concept of a minimum data set of sustainability indicators is widely accepted, but relied mostly on expert opinion to select minimum data set components (Doran and Parkin1994; Karlen *et al* 1996). The relevant indicators capable of measuring the ecological, economic and social contributions of each intervention would be selected for a specific location. Table 2 presents a list of sustainability indicators used in previous studies. Soil quality, crop performance and livestock performance data is obtained by collecting soil, crop and manure samples from the various test farms for laboratory analyses.

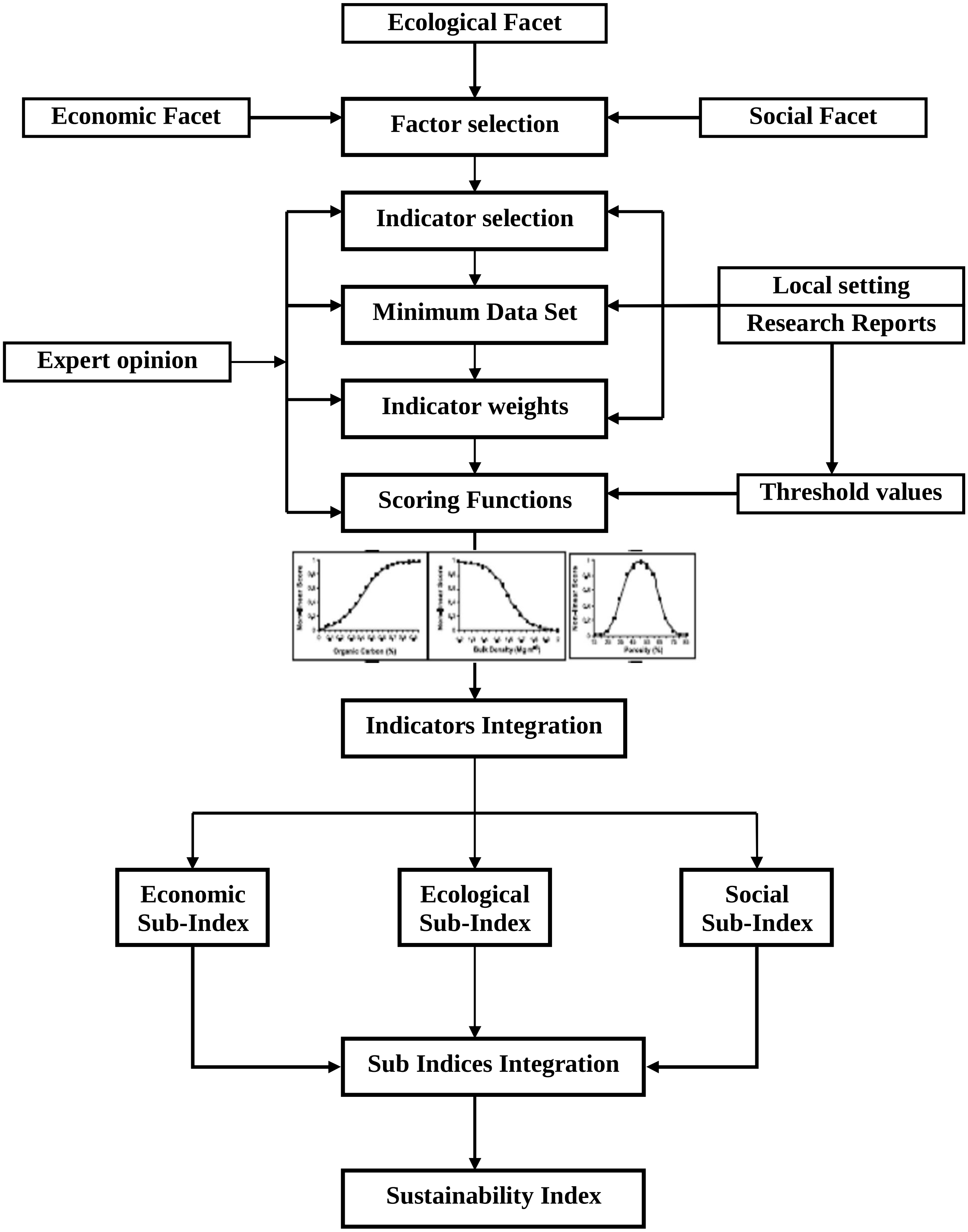



**Figure 6: Framework for agricultural sustainability index**

Other livestock parameters, feed intake, apparent feed digestibility and live weight were determined during the feeding trial. Data on prices and quantities of

inputs, labour and outputs for each experiment will be used to compute the various economic indicators. A semi structured questionnaire is being developed to collect data on the various social indicators.

*Transformation of indicators*

Measured values of the selected indicators are transformed into unitless values in a number of ways. Diack and Stott (2000) tried a linear scoring technique; Karlen and Stott (1994), Andrews and Carroll (2001) and Andrews *et al* (2001) demonstrated non linear scores. Andrews *et al* (2002) compared two scoring methods and found that the non linear scoring method was more representative of system function than the linear method. The use of scoring curves allows the transformation of an indicator to reflect the relationship between the indicator and its associated ecosystem (Schiller *et al* 2001). An indicator may be transformed by ‘more is better’, ‘less is better’ or threshold value criteria. These criteria are associated with relationships where a higher, lower or threshold value for an indicator is indicative of enhanced performance within a specified ecosystem function.

*Aggregation of sub indices*

The integration of transformed indicators into ecological or economic or social sustainability indices could be multiplicative (Singh *et al* 1992), simply additive (Andrews and Carroll 2001), or weighted additive (Karlen *et al* 1998). However since Andrews *et al* (2002) found few differences between the various integration techniques when used to combine nonlinearly scored indicator values, the simplest alternative, additive, will be used to calculate the sub indices of sustainability. This step would be accomplished by summing the scores for each indicator and dividing by the total number of indicators as shown below:

$$SSI = \left( \frac{\sum_{t=i}^{n} S_i}{n} \right)$$

Where SSI is sustainability sub index, S represents the scored indicator value and n is the number of indicators in the MDS for a specified dimension of sustainability.

**Table 2 Indicators for agricultural sustainability evaluation**

| Facet | Factor | Indicator | Source |
|---|---|---|---|
| Ecological | Soil quality | | |
| | | *Soil pH* | Dalal et al. (1999) |
| | | Electrical conductivity (mS/cm) | Nambiar et al. ( 2001) |
| | | Clay content (%) | Masto et al. (2008) |
| | | Aggregate stability | Nambiar et al. ( 2001) |
| | | Bulk density(kg/ dm3) | Nambiar et al. ( 2001) |
| | | Organic matter content (%) | Masto et al. (2008) |
| | | Nutrient stock (kg/ha) | Kang et al. (2005) |
| | | Nutrient balance (kg/ha) | Nambiar et al. ( 2001) |
| | | Soil microbial biomass (mg/kg) | Kang et al. (2005) |
| | | Mycoharizal infection (%) | Kang et al. (2005) |
| | | Rhizobium count (log count/g soil) | Kang et al. (2005) |
| | Crop performance | | |
| | | Crop produce yield (kg/ha) | Dalal et al. (1999) |
| | | Crop residue yield (kg/ha) | Dalal et al. (1999) |
| | | Percentage of potential yield (%) | Walker and Reuter (1996) |
| | | Grain protein (%) | Dalal et al. (1999) |
| | | Crop residue quality (% N, P and K) | Dalal et al. (1999) |
| | | Nutrient use efficiency (%) | Kang et al. (2005) |
| | Livestock performance | | |
| | | Herd size (head/farm) | Ogle (2001) |
| | | Live weight (kg/head) | Ogle (2001) |
| | | Milk yield | Ogle (2001) |
| | | Livestock feed balance (kg DM/year) | Kassa et al. (2003) |
| Economic | | | |
| | | Net farm income ($/farm) | De Jager et al. (1998) |
| | | Gross income/total assets | Dalal et al. (1999) |
| | | Gross margin ($/ha) | De Jager et al. (1998) |
| | | Labour intensity (days/ha) | De Jager et al. (1998) |
| | | Farm income sustainability quotient | De Jager et al. (1998) |
| Social | | | |
| | | Access to required inputs | Zhen and Routary (2003) |
| | | Access to supporting services | Zhen and Routary (2003) |
| | | Knowledge and awareness | Zhen and Routary (2003 |
| | | Perception | Assefa and Frostell (2007) |
| | | Social acceptance | Dalal et al. (1999) |
| | | Physical and metal stress | Sydorovych and Wossink (2008) |

*Integration of subindices*

Agricultural sustainability as a three dimensional concept is analogous to a triangle with ecological sustainability, economical sustainability and social sustainability at its vertices (Fig. 7). The overall sustainability index could be calculated as the area the triangle ABC.

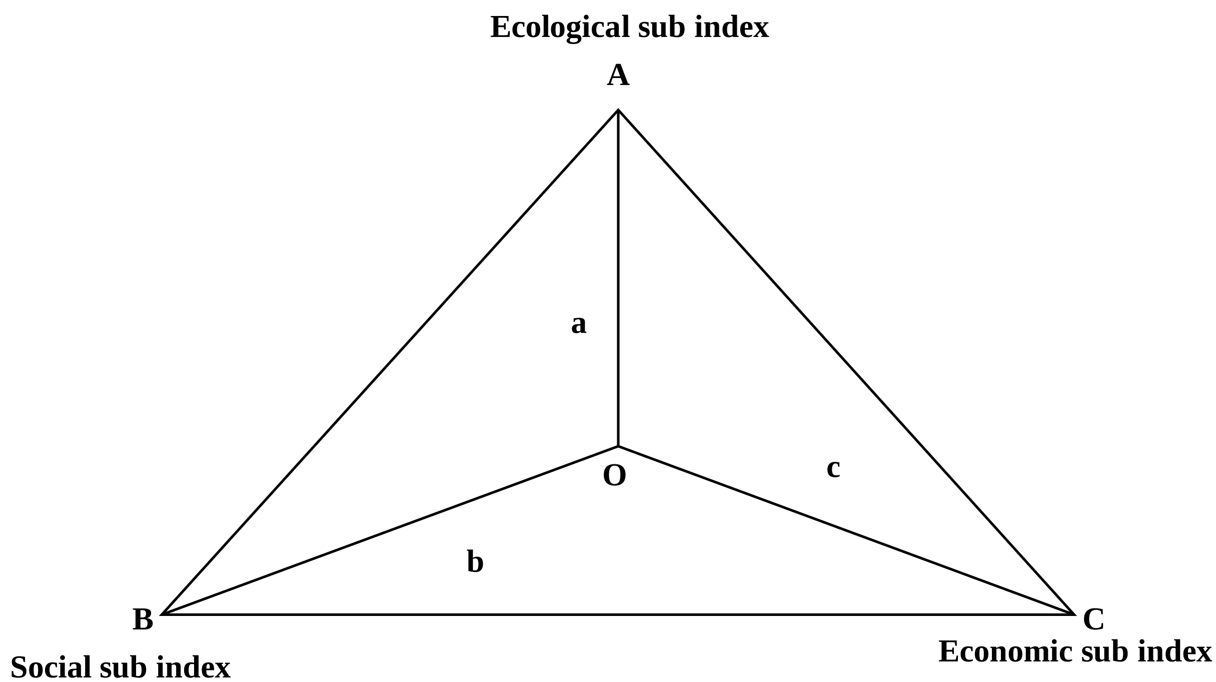



**Figure 7 sustainability triangle indicating subindices of sustainability**

$$SI = \Delta ABC = \Delta AoB + \Delta BoC + \Delta CoA$$

$$= \tfrac{1}{2} ab \sin(120^\circ) + \tfrac{1}{2} bc \sin(120^\circ) + \tfrac{1}{2} ca \sin(120^\circ)$$

$$= \frac{\sqrt{3}}{4} (ab + bc + ca)$$

Where SI is the sustainability index; and a, b, and c are the ecological, social and economic subindices of sustainability, respectively.

## 2.2. Development of economic models for the different farm typologies

### *2.2.1. Review PhD Thesis proposal(Socioeconomics student)*

. The initial topic for this socioeconomic aspect of the project was 'Bioeconomic Modelling of Farmers Livelihood Strategies in Crop Livestock Farming Systems of the Subhumid and Semiarid Savannahs of West Africa' with the following specific objectives:

1. Determine the profitability of crop livestock enterprises under different farming systems
2. Investigate the resource use efficiency among the different farming systems
3. Determine the tradeoffs between alternative uses of crop residues.
4. Develop models (biophysical, economic or bioeconomic) for identifying entry points and opportunities in crop livestock systems
5. Identify the biophysical, socioeconomic (and market) factors influencing intensification of crop livestock systems along the natural resource gradient.

Attempts made to collect data with a set of survey questionnaires based on project objectives revealed serious constraints regarding data collection on biosphysical information required for the development of the bioeconomic model. Consequently, a review was made by the supervisory committee and project team leading to the modification of the PhD Thesis topic to read "Socioeconomic and Risk Factors influencing Intensification of Crop Residues among Farm Households in Crop Livestock Farming Systems in the Subhumid and Semiarid Savannahs of West Africa'. This revised study has the following objectives:

The major objective of this study is to determine the socioeconomic factors that influence intensification and allocation of crop residues between alternative uses in crop livestock farming systems in the savannah agroecological zones in Ghana, Niger, and Nigeria.

The specific objectives are to:

1. Assess the current farming systems including the tradeoffs in benefits as a result of the alternative uses of crop residues in Ghana, Niger, and Nigeria;
2. Estimate risks associated with of different sources of crop residues based on farmers' perception and compare risks across household groups in the study areas;
3. Determine the resource use efficiency (technical, allocative and economic efficiency), in crop and livestock production, by households within crop livestock farming systems in the three study areas (resources are crop residues, labour, manure, fertiliser, agricultural wastes and animal traction); and
4. Estimate the profitability of new crop residue intensification technology by farm households in the farming systems.

In view of this, changes have been made to reflect model formulation, expected outputs, the hypotheses, and questionnaire design as follows:

***Model Development***

Objective 1 is based on hypothesis 1 which states that there are significant differences in the profitability of different enterprises within and among the typologies, and hypothesis 2, which states that there are significant trade-off effects between the usage of crop residues for alternative purposes among the farm typologies.

Parameters needed for testing hypothesis 1 will be generated using the budgetary technique where the gross margin for each farmer under each enterprise will be computed as follows:

$GM_{ij} = TR_{ij} - TVC_{ij}$

Where GM = Gross Margin

TR = Total Revenue

TVC = Total Variable Costs

i = Enterprise

j = Farmer

The profitability index will be determined by adjusting the crop enterprise to one Hectare (Ha) and livestock enterprise to one Tropical Livestock Unit (TLU).

Profitability index, K = $GM_{ij}$ / Ha or $GM_{ij}$ / TLU

Parameters needed for the testing of Hypothesis 2 will be generated using the compromise programming (CP) method. In this method the first step is to determine a set of efficient solutions through multi-objective programming. The optimal solutions will then be identified among the efficient solutions by compromise programming. The first step in CP is to establish the ideal point. The coordinates are given by the optimum values of the different objectives. When the ideal point is not feasible, the efficient solution closest to the ideal point is defined by the CP as the optimum (or best compromise) solution. The tradeoffs will be estimated between the gross margin from livestock (including milk and manure) production and gross margin from crop (including residue) production,

The mathematical programming software (AIMMS) will be used to analyse and quantify the tradeoffs between the uses of crop residues and determine the optimal resource levels.

The models were mathematically represented as:

$$EffZ = \left[Z_1(x_j), Z_2(x_j), \ldots Zq(x_j)\right]$$

$$subjectto:$$

$$x \in F$$

$$\sum_{j=1}^{k} (a_{ij}x_j) \leq G_i$$

$$x_j \geq 0$$

$$where$$

$$x_j = activity / enterprisej$$

$$G_i = \text{Re}\, sourcelevel$$

where Eff means to search for the efficient solutions and F represents the feasible set of solutions, Z means total benefit from the use of crop residues, $Z_1(x_1)$, $Z_2(x_2)$, ...$Z_q(x_q)$ mean benefits from alternative uses of crop residues (input) ie, gross margin from crops (and their residues), gross margin from

livestock (including milk and manure), crop residues required for crop production and crop residue required for livestock production.

Models were developed for three farm typologies in each of the agroecological zones. In general, benefits from the use of crop residues for livestock activities (cattle, sheep, goat, donkey, camel, horse, cattle milk, goat milk and sheep milk, draft power from cattle, donkey, camel), livestock wastes activity (livestock manure), crop production activities (maize, millet, sorghum, cowpeas, soyabeans, groundnuts, maize-cowpeas, millet-cowpeas, sorghum-cowpeas, maize-soyabeans, millet-soyabeans, sorghum-soyabeans, maize-groundnuts, millet-groundnuts, sorghum-groundnuts and vegetables), and crop residues yield activities (maize stover, millet stover, and sorghum stover, cowpea haulms, groundnut haulms, soybean haulms) were specified and the following restrictions were included:

G1 = Crop land available (Ha)

G2 = Seed

G3 = Amount of manure available (kg)

G4 = Amount of fertiliser available (kg)

G5 = Amount of crop residues available (kg)

G6 = Family labour (Man days) available

G7 = Total hired labour available (Man days).

G8 = Amount of capital available (Naira).

G9 = Own Traction (TLU days)

G10 = Hired Traction (TLU days)

G11 = Grazing/range land (Ha) available or grazing time (Hr)

G12 = Agricultural byproducts (feeds)

G13 = Animal health (Naira)

G14 = Concentrate

Objective 2 is derived based on the Hypothesis (3) that the identified factors have significant effects on the farmers' perception of production risk. This will be achieved by the estimation of farmer's risk perception index and regressing this against the farm household characteristics. The risk perception of farmers will be determined through the Variance Mean Ratio (VMR) of the farmers' expected yield estimates. A value of VMR that is close to one will indicate a high risk perception while a value close to zero will indicate low risk perception. This index will then be regressed against the farm household characteristics and the significant factors will be explained.

Since historical farm level data are often lacking in developing countries, especially in the study area, and probabilities for alternative events in decision making may not be quantifiable, the individual decision maker's opinion on crop yield variations associated with rainfall fluctuation will be taken as an indictor of the level of uncertainty that farmers assume. It is important to point out that this methodology relies on farmers' own judgments and experiences on the range of variation in their production activities, rather than on hypothetical preferences for uncertain opportunities. It is an appropriate approach for generating such information in farm communities with a low level of education (Huijsman 1986). It is considered as a proxy for the level of uncertainty that decision makers

assume in their actual practices. A decision maker's risk perception can be characterised by the pattern of the mean and variance of the expected yield variations.

The mean and variance for the expected yield estimates for each crop will be computed using the triangular probability distribution based on a three point yield estimate given by farmers (Hardaker *et al* 1997). The mean, E(Y), will be computed as follows:

$$E(Y) = \frac{L + M + H}{3}$$

Where, L stands for the lowest, M for the most likely and H for the highest yield estimates for 'poor', 'most likely' and 'good' rainfall scenarios respectively, that will be given by farmers. The variance, V(Y), will be computed as follows:

$$V(Y) = \frac{\{(H - L)^2 + (M - L)(M - H)\}}{18}.$$

Small mean and high variance values represent a high level of yield uncertainty or production risk. The Ratio of the Variance to the Mean (VMR), {V(Y)/E(Y)}, will be considered as an indicator of the decision maker's perception of risk. Values close to zero will indicate a low risk perception and close to one a high risk perception. This variable will then be used as the dependent variable in the econometric analysis of the determinants of decision makers' risk perceptions.

In the econometric analysis, socioeconomic and biophysical factors (rainfall, temperature, humidity, and soil type) will be hypothesised to influence the disparities in risk perceptions among decision makers and these will be considered as explanatory factors. The hypotheses regarding the impact of

socioeconomic factors on the risk perceptions of decision makers will then be tested.

VMR = f($X_i$) for each crop.

Where

VMR = Mean Variance Ratio.

$X_i$ = gender, age, experience, education, whether the HHH has marketable skill (dummy), dependency ratio (consumer/producer), membership of farmers organisation, extension visit, institutional credit (dummy), cultivable land holding size, livestock endowment, value of farm assets, off farm income, non farm income, rainfall, humidity, temperature and soil type.

Objective 3 is based on Hypothesis 4 which states that the efficiency of resource use significantly differs from one typology to the other within and across the agroecological zones. Parameters will be determined through use of a stochastic frontier production function.

To determine the efficiency of production, the crop and livestock production functions will be estimated through models of stochastic frontier production function, for the three typologies in each agroecological zone. The model will be implicitly stated as:

$Y_{ij}=f(X_{ij};\beta)\exp(v_{ij}-u_{ij})$; i=1,2, 3,...N

(1)

Where i = observation or individual farm household and j = farming enterprise.

The functional form adopted will be a variant of the stochastic frontier production function proposed by Battese and Coelli (1995), which builds hypothesised efficiency determinants into the inefficiency error component so that one can identify focal points for consideration in order to increase the efficiency levels.

$\log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + V - U$

(2)

Where X is a column vector of input variables; $\beta_{0\text{-}6}$ are unknown parameters; V is the error component representing statistical noise and is assumed to be normally distributed with mean zero and variance $\sigma_v^2$; $U \geq 0$ is the error component representing the effect of technical inefficiency and is assumed to arise from normal distribution with mean μ and variance $\sigma_u^2$; which is truncated at zero. The inefficiency effects are defined as a function of the farm specific factors: $m = \delta_0 + \delta_i Z_i$ where $\delta_0$ is the intercept and i = 1…n (3)

They will be incorporated directly into the MLE. $Z_i$ is a column vector of hypothesised efficiency determinants, and $\delta_n$ are unknown parameters to be estimated.

Objective 4 is based on Hypothesis 5 which states that there are significant differences in the profitability of the new technology among the typologies and across the agroecological zones. Parameters will be derived using the farm household model. Mathematically, the farm household model will be specified as:

Max $\sum \sum \sum prob_k(P_{sik}Q_{sik} - c_{ij}X_{ij} - P_{sik}B_{sik})$ ………………………………..(1)

Lexicographic goal 1: Satisfy the harvest income objective:

$$\sum \sum P_{hik} Q_{hik} \geq I_k \text{ ....................................................................}(2)$$

Lexicographic goal 2: Satisfy the household food subsistence objective:

$$\sum (Q_{cik} + B_{ik}) F_i \geq C_k \text{ .............................................................}(3)$$

These objectives are pursued subject to the following crop and livestock production accounting, supply identity, resource constraints, and resource availability for food expenditures:

$$Q_{pik} = \sum Yi_{jk} Xi_j \text{ ..............................................................}(5)$$

$$Q_{pik} = Q_{hik} + Q_{sik} + Q_{cik} \text{ .....................................................}(6)$$

$$\sum \sum ai_{jl} Xi_j \leq RES_l \text{ .......................................................}(7)$$

$$P_{sik} B_{sik} \leq M^{e}_{kr} \text{ ..............................................................}(8)$$

Where

$X_{ij}$ = the decision variable for quantity of crop or livestock i produced with technology j

$Y_{ij}$ = the yield or output of crop or livestock i produced with technology j

$P_{hik}$= price of crop or livestock i during harvest period h is state k

$P_{sik}$= price of crop or livestock i during the hungry season s in state k

$Q_{hik}$= quantity of crop or livestock i sold at harvest is state k

$Q_{cik}$= quantity of crop or livestock i consumed on farm in state k

$Q_{sik}$= quantity of crop or livestock i sold during the hungry season s in state k

$Q_{pik}$ = total quantity of crop or livestock i produced in state k

$Prob_k$ = probability that state k occurs

$I_k$ = farmer harvest income target

$C_k$ = household crop or livestock subsistence target

$F_i$ = present contributrion of crop or livestock i toward satisfying crop or livestock subsistence target

$c_{ij}$ = unit production cost of crop or livestock i using technology j

$B_{sik}$ = quantity of crop or livestock i purchased in the market in state k during hungry seasons

$a_{ijl}$ = demand of crop or livestock i produced with technology j for resource $l$

$RES_i$ = availability of resource i

$M^{e}_{kr}$ = resource expected to be available for food in rainfall state k and in income state r.

Design of *Questionnaire*

A new set of 26 page questionnaires was developed for data collection in Nigeria and Ghana and the translation of the English version into French was done for data collection in Niger. A set of community level questionnaires was also developed to collect village level data through focus group discussion. These data include prices of and access to inputs and outputs markets in the community, agroecological data, government and Non Government Organisation (NGOs) developmental projects in the rural communities and risks and shocks experienced in the community which might influence village level production and marketing decisions.

*Sampling and Data Collection*

Kano State was stratified into three zones based on the Kano State Agricultural and Rural Development Authority's (KNARDA) Division. Two Local Govermnent Areas (LGA) were randomly selected from each zone and four villages were selected at random from each LGA. A total of 24 villages was, therefore, selected in Kano State. Fifteen farm households were selected within each village as in Table 3.

**Table 3 : Characteristics of farmer typologies**

| Typology 1<br><br>(Crop Farmers with less than 1 TLU of Livestock) | Typology 2<br><br>(Crop Farmers with between 1 TLU and 2 TLU of Livestock) | Typology 3<br><br>(Crop Farmers with more than 1 TLU of Livestock) | Total |
|---|---|---|---|
| 5 | 5 | 5 | 15 |

A total of 360 respondents were interviewed in Kano. Focus group discussion was also conducted in each of the six Local Government Areas in order to collect relevant information at the community level. Table 4 shows the distribution of the villages in Kano State.

**Table 4 : Surveyed villages Kano State, Nigeria**

| **Zone** | **LGA** | **Villages** |
|---|---|---|
| 1 | Kumbotzo | Danbare<br>Zawachiki<br>Danmaliki<br>Yanguza |
| | Rano | Rurum<br>Saji<br>Ruwan Kanya<br>Yalwa |
| 2 | Tofa | Tofa<br>Langel<br>Janguza<br>Lambu |

| | | |
|---|---|---|
| | Dawakin Tofa | Sarauniya<br>Tattarawa<br>Tumfafi<br>Dandalama |
| 3 | Gezawa | Gezawa<br>Jogana<br>Ketawa<br>Dansaki |
| | Wudil | Utai<br>Indabo<br>Dagumawa<br>Kausani |

Maradi (in Niger) consists of six Departments. Three Departments were selected at random from the six Departments. Four villages were selected from each Department and fifteen farm households were selected from each village (ie, five farm households per typology) as in Table 5.

**Table 5: Surveyed villages in Maradi, Niger**

| Department | Village |
|---|---|
| Aguie | Bini<br>Guidan Mousa<br>Maijan Gero<br>Dan Gamji |
| Madarounfa | Garin Labo<br>Gade<br>Garin Maigari<br>Kankare |
| Guidanromji | Jaujouna Dantanin<br>Kumbola<br>Baramaka<br>Baoura |

A total of 180 farm households was, therefore, interviewed in Maradi District (Niger). Focus group discussion was also carried out in only one of the Departments.

*Data collection*

In Nigeria (Kano State), 360 farm households were interviewed, while in Maradi (Niger), 160 farm households were interviewed. The information in the questionnaire includes the socioeconomic, input and output data, production and market risks assessment data and GPS data.

*Data collection*

The data collected from Kano (Nigeria) and Maradi (Niger) are currently being inputted for further management and analysis. The Northern Region of Ghana is divided into 18 Districts namely: Bole, Bunkpurugu-Yunyoo, Central Gonja, East Gonja, East Mamprusi, Gushiegu, Karaga, Nanumba North, Nanumba South, Saboba/Chereponi, Savelugu/Nanton, Sawla-Tuna-Kalba, Tamele Municipal, Tolon/Kumbungu, West Gonja, West Mamprusi, Yendi and Zabzugu/Tatale. Tolon/Kumbungu will be purposively selected based on decision of the project team and two other Districts will be randomly selected. Four villages will be randomly selected within each District. Finally, five farm households will be selected at random, per typology, within each village.

The data collected from the three countries will be analysed using appropriate statistical methods. Results generated from data analysis will be used to develop the desired models. These models are expected to be explanatory and predictive and should contribute to the achievement of project output 2.

**Output 3 Lessons learned from project results made available to enhance institutional capacity for R&D and improve institutional linkages**

### 3.1 Contribution to feed, food and fuel: competition and potential impacts on small crop livestock energy farming systems.

The project leader contributed to a book chapter on "Feed, food, and fuel: competion and potential impacts on small crop livestock farming systems" which was compiled by a team put together by SLP. Specifically, the project leader compiled the section on Oil based diesel crops.

### 3.2 Participation in the workshop on 'Investing in Sustainable Agricultural Intensification: The Case for improving Soil Health'

The project Leader participated in the workshop on "Investing in sustainable agricultural intensification: the case for improving soil health" where the document "Investing in sustainable agricultural intensification: the role of Conservation; A framework for action" was developed. Please see www.fao.org/ag/ca/ for document.

Linkage with BMZ / GTZ Postdoctoral Scientists Soil Conservation in IITA Ibadan

The project, through the leader, prepared a monograph on Soil Conservation in Nigeria: Past and Present On Station and On Farm Initiatives (Junge, Abaidoo and Chikoye, 2008). The publication can be accessed from http://www.swcs.org/en/publications/soil_conservation_in_nigeria/

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## Other Project Information

### 11. Summary of major achievements during the reporting period

1. Installation of all field experiments planned for the reporting period for the collection of biophysical data

2. Project team had a common understanding of socioeconomic inputs to the development of the bioeconomic model and revised the project outputs accordingly. The PhD student now has a better understanding of contributions expected from him towards the achievement of the project outputs

3. Contribution to other project activities through participation at meetings and publication of a monograph that has been placed in the public domain

### 12. Outputs: a) products, b) people trained, c) technology transferred, d) reports and publications, d) presentations in conferences

The following publication has been made;

Monograph on Soil Conservation in Nigeria: Past and Present On Station and On Farm Initiatives (Junge, Abaidoo and Chikoye 2008) The publication can be assessed from

http://www.swcs.org/en/publications/soil_conservation_in_nigeria/

### 13. Implications of research outputs and achievements

The reports provide useful information on the extent of use of crop residues management for reducing soil losses in one of the project areas.

**14. Problems and measures taken**

Problem of late identification of PhD students and unfavourable rainfall patterns disrupted the project time lines. Request was made to the Project Coordinator for aNo Cost Extension which was granted.

**15. Linkages with other research**

The project has worked closely with BMZ / GTZ Postdoctoral Scientist (Soil Conservation Specialists) at IITA Ibadan to compile and publish some information on past soil conservation projects and practices in Nigeria. The data collected from Ghana, and Benin is currently being processed for publication.

D. **Summary of research plans for next reporting period per output and activity**

1) Field data collection from ongoing field studies to assess crop performance and soil quality
2) Laboratory analyses of field samples from the field studies and data analysis
3) Preparation of PhD dissertations and manuscripts (biophysical) for publication
4) Data collection in Ghana will be carried out in November 2008
5) Development of socioeconomic models for different farm typologies
6) Compilation of PhD thesis (socioeconomic)