Agro-Biodiversity Potential Of Smallholder Farms In A Dissected Highland Plateau Of Western Uganda

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Abstract:

Uganda's hilly and mountainous areas have been globally designated as a centre of plant diversity reflected in large number of afromomtane plant species, land use types and crops. Current population densities range between 200-700 persons per square kilometer. And contribute to reduced vegetative cover and loss in biodiversity.

A study was carried out to develop acceptable technologies of biodiversity conservation in agricultural systems. Methods used included community workshops, line and belt transect walks.

Eight main land use types were identified within the landscape each with different field type combinations. The backslope of the landscape had greatest land use stages (23) and shoulders had the least (15). Bushwere alone had 6 land use stages and 194 field types and was selected as PLEC demonstration site.

Agricultural diversification contributed about 60% of total income. Diverse plant species were variously used for construction, roofing, granaries, thatching etc. The main incentive to conserve agro-biodiversity on farms was food security. Others were cash income and socio-cultural and economic benefits. Overall 7 modules for sustainable agrobiodiversity conservation were developed.

Introduction

Agro-biodiversity is a fundamental component of biodiversity, particularly important in Uganda where 21 % of her total land area is under agricultural land use (UNEP, 1990) and 43 % of the national Gross Domestic Product (GDP) comes from agriculture. While humans depend on agro-biodiversity for food, medicine and industrial use, and other biodiversity units (e.g. forests and gorilla parks) are protected because they are considered aesthetically valuable, only a properly functioning ecosystem provides the most important anthropocentric function -that of supplying air, water and soil.

Uganda's hilly and mountainous areas have been globally designated a "centre of plant diversity" by the IUCN plant conservation program because of their high number of "Afromontane plant species". By definition, these places are considered particularly rich in plant life which, if adequately protected, would assure the survival of the majority of the world's wild plants. The rich natural plant biodiversity of these montane ecosystems is also reflected in the large number of different crops and land use types that these areas are able to support because of the high productivity level of their soils, vegetation and other land resources. These areas include Bundibugyo, Bushenyi, Kabale, Kabarole, Kapchorwa, Karamoja, Kasese, Kisoro, Mbale, southern parts of Mbarara district, much of Ntungamo, and Rukungiri. Although they have extremely steep terrain, farming communities have occupied them. The people have been attracted by the fertile soils and conducive climate (bimodal and high rainfall) which favour high plant growth and crop yields. In addition to the inherently rich biodiversity resources some of which are of global significance, these agroecosystems are well known for their great contribution to national food security and household income mainly, from agro-biodiversity products. The people in these areas are traditionally cultivators and also polygamous in lifestyle. Populations are growing rapidly (2.5% per annum) and land clearing for farming is widespread. Population densities are over 200-700 persons per square kilometer (Statistics, 1992). Agriculture and population growth in these steeply sloping lands reduces vegetative cover of soil surface, destroys soil structure and exposes the inherently very friable soils to the strong and desiccating winds characteristic of such mountainous regions. All these render the ecosystem fragile and thus vulnerable to degradation.

Due to the fragility of these important agro-ecosystems that have been exposed to intensive agriculture, there is need to reduce and /or halt loss of biodiversity resources, if the ecosystems are to remain sustainably functional. This will require integrating biodiversity conservation efforts into the farming practices of small holders' who are the daily managers of the resources. In this paper, PLEC-Uganda gives its experiences in trying to promote this integration with the aim and objectives outlined below.

Aim

- To identify, develop and promote acceptable technologies for integrating biodiversity conservation into small holder farm units with a net benefit of improved household income and welfare.

Objectives

- To establish the status of agrobiodiversity

- To work with small holder farmers to develop sustainable technologies to biodiversity conservation on agricultural lands on rugged highlands.

Methodology

Participatory methods were used throughout the study as summarized below.

- A mega-transect
- Of 5 km x 30 km was established stretching from Rubingo parish in Bugamba to Kamuli parish in Kabingo.
- Activities included

a) Community workshops

b) Line and belt transects of 2 km cutting across different landuses that are representative of particular areas within the mega transect.

- Selection of demonstration site
- With the knowledge of different transected parishes; 10 and 7 in agroecological zone A and B respectively.
- Selection of a demonstration site involved ranking the parishes by 6 criteria below:

(1) Agroecological zone (agro); (2) Receptability of the people (R); (3) Ethnic diversity (E); (4) Accessibility (AC); (5) Level of landuse types (L); (6) Level of crop combinations (C).

- Selection of sample areas and plots was based on:

a) Variations in field types; b) Cooperation of field owners; c) Replication and spread over different villages of the parish

- Selection of demonstration farmers:

Included initially identification by fellow collaborating farmers. These were later on confirmed or revised by the PLEC scientists visiting the fields of individual candidates to ascertain the following basic criteria:

a) Innovativeness in conserving several plant species or varieties in the cropping system; b) Innovativeness in good management of the system including spatial arrangement, soil management, timeliness in planting, weeding and other crop agronomy; c) Knowledge on what he/she does and why; d) Willingness to seek or take-up more information and skills; e) Ability to learn, work with PLEC scientists, change where necessary; and f) Willingness to demonstrate and train other farmers and other stakeholders.

- Demonstration activities involved
- Participatory evaluation of innovations of the selected expert farmer initially by the scientists-Expert farmer and the latter's household members.

- Expert farmers adopting the necessary improvements
- Sharing experiences and knowledge thorough field visits by or to other collaborating farmers.
- Demonstrating to other farmers, local leaders and other stakeholders during field workshops.
- Farmer experimentation of models or their components that required testing.

  Participants of farmer field exchange visits were selected by the hosting farmer in collaboration with the field extension worker and PLEC scientists. Emphasis was on representation from each village and also inclusion of at least one of the village level leaders in each case. PLEC management facilitated the organization logistics like transport, refreshments, part of the lunch costs, and the publicity.

➢ **Dissemination of good approaches was through**

- Farmer to farmer field visits either individually or in groups
- Field training sessions led by "expert" farmers with PLEC scientists providing technical and logistical back up.

Formation of common interest groups, formation or revival of which were encouraged by PLEC scientists around the expert farmers and their technologies. PLEC scientists facilitated the groups/associations with technical guidance in constitution making, registration and banking as well as logistics for initial meetings, logo, letterhead and project proposal translation and typing. The groups defined their memberships, objectives and activities and also manage their regular activities including meetings and monitoring of individual members' translation of the set goals and objectives.

Results And Discussion

Status of Agrobiodiversity

Reconnaissance surveys of mega transect resulted into identification of eight main land use systems as shown in Table 1. They consisted mainly grassland (livestock) based system, perennial crop based system, annual crops based system and integrated livestock-perennial -annual crops based system.

Table 1 Land use systems and their main characteristics

Transect Name	**Parish**	**Main characteristics**
1. Rubingo	Rweibogo	Banana /coffee /Cattle System Settlements in valley and food slopes.
2. Bushwere	Bushwere	Intensive annual cropping, a lot of intercropping with scattered small banana plantations. Few coffee fields mostly intercropped with bananas. Cultivation and settlements on all landscape types.
3. Ngoma	Ngoma	Intensive cropping with banana and annuals seemingly in equal proportions. Some livestock and woodlots. Settlements mostly on ridge tops. Relatively good banana management.
4. Kashojwa	Rukarabo	Expansive banana plantations in valleys, annuals on hill slopes and tops. Grasslands on steep back slopes. Settlements variable for different hills.
5. Kigaaga	Kigaaga	Predominantly annuals cropping on ally landscape types. Some bushes in valleys, very little bananas and more pure stand cropping practices.
6. Butenga	Kisuro	Mostly grasslands in wide valleys and plains. Paddocked pastures, lots of livestock and few cropping systems.
7. Kagando	Kamuri	Grasslands and scrublands with fairly large banana, plantations in valleys, un cultivatable slopes with poor grasses and widespread bush burning practices.
8. Byaruha	Nyakigyera	Annual crop on hill tops and pediment, steep uncultivable slopes with grasslands and extensive banana plantations in both narrow and wide valleys. Settlements in Foot slopes.

Each land use systems was found to have various lands uses as published by Nkwiine, Tumuhairwe and Zake (1999).

The highest number of landuse types was on backslope (23) followed by footslopes (21), hilltops (16), and the least number was on the shoulder (15). Farmers attributed the higher number of land uses found on backslope to the fact that backslopes are exposed to many ecological stresses like shallow soils, steep slope, drying winds, high loss of soil and moisture. Due to land shortage farmers try to use the marginal backslopes, by trying to grow there all types of crops and crop combinations. They are not sure which crops can perform well and so they grow many as an insurance against any crop failure, to avoid total economic loss.

While banana, maize and fallow are grown on all landscape types, banana growing dominates all the valleys and ravines. Several crop combinations were recorded in the study area. The practice of growing more than one crop in the some field promotes agro-biodiversity conservation. It is important to note that Bushwere had the highest number (4) of crop combinations or intercrops (16) compared to the others (4-8). At the same time Bushwere and Ngoma also had more pure stand fields (7) than the rest of transects which had 4-6 only. Using the above results scientists working together with farmers came up with criteria for selecting a demonstration site out of 17 parishes studied as indicated in the methodology.

Table 2 shows scores for each parish according the criteria. Bushwere had the highest scores (28) followed by Kamuri and Nyakigyera (24 each). Consequently Bushwere was taken up as a PLEC demonstration site for Uganda.

Table 2: ***Parish Scores by criteria for selection of a demonstration site.***

PARISHES	(Agro)	(R)	(E)	(Ac)	(L)	(C)	TOTAL
Rweimbogo	A	3	2	1	3	5	14
Kabarama	A	3	2	1	3	5	12
Bushwere*	A	3	4	2	3	16	28
Kigaaga	A	3	2	1	3	6	18
Rwamiyonga	A	3	2	1	3	6	18
Rukarobo	A	3	4	3	3	8	21
Ngoma	A	2	4	2	4	8	18
Ibumba	A	3	4	2	2	6	18

Kigyendwa	A	3	4	2	2	5	17
Nyamuyanja	A	1	4	2	2	5	19
Katanoga	B	2	7	1	2	5	19
Kisuro	B	2	7	1	1	3	13
Nyakigyera	B	3	7	1	4	8	24
Kaharo	B	3	7	3	2	4	19
Katembe	B	3	7	2	2	3	16
Kagarama	B	3	8	2	3	3	18
Kamuri*	B	3	8	4	5	4	24

NB: The higher the scores the greater the agro diversity and acceptability.

Influence of ethnicity on land use and management diversity

Discussions with local communities revealed that different ethnic groups had different biodiversity and land management approaches. For example, there were two sub-groups among the Banyankole, according to their occupation and origin. One group, the Bahima are traditionally nomadic cattle keepers while the other group, the Bairu are traditionally settled cultivators. The Bahima used to depend almost entirely on their cattle, and traded with the Bairu to get some carbohydrate and other foods into their diet. They utilized the drier plains and hills especially in agro-ecological zone II marked B in Table 2 for cattle grazing and temporary homes. They moved from place to place in search of pasture and water for livestock. The transhumance patterns were associated with climatic seasons

In this way, wild plant diversity was managed through rough rotational grazing and was thus protected from degradation since the system reduced chances of over-grazing. As the livestock grazed and moved, they also spread manure over the grazing areas, and this acted as fertilizer and dispersal mechanisms to maintain vascular wild biodiversity. The herdsmen also lit bush fires towards the end of the dry season, a traditional practice for pasture management. This was a method of managing biodiversity such that useful pasture species were facilitated to sprout at the beginning of the rains. Plants that could not survive bush fires however, were eliminated. The cattle keepers thus had very little Agro-biodiversity

The cattle keepers were interested in cattle numbers for prestige. Cattle were also used for paying dowry. However, new socio-cultural values and changes in attitudes and market

forces have led the cattle keepers into changing focus from cattle numbers to quality. So the cattle keepers are now getting interested in fewer cattle but which give higher milk yields or which grow faster and have a larger carcass weight. This is because of the changing social obligations that require money. For example, getting formal education for children requires school fees, buying medical services, and the need for better housing and consumer goods also require increased income more than prestigious herds of cattle. The market also prefers tender meat from faster growing cattle than the traditional way of butchering only aged and thus lean cattle. A combination of the changes in social values, attitudes, obligations and market preferences have therefore influenced the cattle keepers to either upgrade their livestock through cross breeding or acquire exotic breeds. The management of the livestock and pastures has also changed. The increasing population pressure on land is also forcing the cattle keepers to abandon their nomadic life-styles to settle down. The land available for communal grazing is decreasing as more and more is being opened up for cultivation. Because of the population, pressure, even marginal areas which were reserved for grazing, are also being opened up for cultivation. Also the corridors through which the cattle used to be moved to grazing and watering points are being cultivated. As a result of all these, the cattle keepers are becoming more and more restricted to ranching or paddock grazing and more recently zero-grazing. The cattle keepers were also forced into crop farming to become more self-reliant on food and also to generate more cash by selling crops, including bananas.

Concerning obtaining adequate water supply for their livestock in the drier environments they occupy, the cattle keepers are coping by either constructing valley dams or water tanks for rain water harvesting and storage in their farms, ranches or communal grazing areas. The small herds are watered from springs and wells using water troughs.

In similar manner, the traditional cultivators have also adopted cattle keeping as additional source of livelihood and also for balancing their diets. The Bakiga who never used to grow bananas have also adopted it for similar socio-economic reasons. These transformations and adaptations have converted all the people of Mbarara district into one large banana eating community.

Looking at the landuse types (LUTs) of the region however, besides the perennial banana growing which is almost everywhere and is expanding rapidly, traces of which ethnic

group is dominant are still evident. The major subsistence crop of the sedentary Nkore people was formerly millet, but in the last 50 years millet has been surplanted over large areas by bananas. The Bakiga dominated Mwizi area is intensively cultivated with many annual crops with minimum livestock keeping.

On the other hand as reported by local people, traditions determine how the land is managed but because of integration in settlement pattern, the different ethnic groups have influenced one another and their ways of doing things, including land management practices and eating habits. These in turn influence the general agrodiverstiy. More specifically the seedbed preparation methods have direct effect on soil fertility and soil water status. Some practices like clean tilth and trash burning have degrading effects on soil biological, chemical and physical properties, there by influencing biodiversity and sustainability of agricultural systems.

Demonstration Site Level

During community workshops, Bushwere farmers reported major changes in agro-biodiversity over the past decade. Table 3 summarizes reasons for reported major changes.

Table 3 ***Production trends over the past 10 years for Bushwere, Ryamiyonga and Kigaaga parishes.***

Type of Biodiversity	**Reasons for Decreasing**	**Reasons for Increasing**
Bananas	In the valleys due to the Nyamwenga disease (*Fusarium scoparium*)	1. Increased extension services. 2.Increasedcultivated land 3. Productivity even in areas where there is a high population growth 4. Commercialization of banana farming
Coffee	1. Decreasing due to bacterial wilt 2. Low prices offered by coffee buyers	1. Good banana intercrop

	3. Monopoly of some traders	
Annuals		1. Population increase. 2.Increase market demand 3. Introduction of taungya land use stage 4. Increased extension services 5. Increased feeder roads
Livestock	1. Decreased grazing land with more competing lands uses. 2. Limited/Distant watering plants.	

Bushwere parish was found to have 6 land use stages with many crop combinations distributed on all landscape types as indicated in Appendix 1. The land use stages included:

i) Perennial crop based with 20 crop combinations on the four different landscape types with 70 field types.

ii) Annual crop based with at least 34 crop combinations occurring on different landscape types to make 80 field types. Annual crops are not so common in valleys and ravines, for cabbage, maize, beans and cassava in few combinations.

iii) Home gardens with sixteen field types. These did not occur in ravines since the latter were not habitable, being waterways. The edges field types are normally marking field boundaries (in case of ravines) and also around homesteads as on other landscapes.

iv) Natural grasslands with 9 field types,

v) Natural Bushsland with 8 field types, and

vi) Gazetted land use stage with 10 different field types,

During the biodiversity inventory exercise done in the site at least 194 field types were encountered. However, due to limited resources only 24 field types were studied in detail. They were found rich in species diversity. A total of more than 210 taxa (species) were encountered in the 24 field types. Table 4 shows the field types studied and their average number of species.

Banana-based field types have relatively less species diversity compared to other field types, due to clean culture management that is done in banana gardens. Weeds are normally removed as soon as they appear, and most farmers practice mulching. These practices limit the number and abundance of species in these fields. Naturals had the highest species diversity because normally these field types are not interfered with, apart from grazing and occasional bush fires. Biodiversity is highest on Backslopes and lower on Hilltops which are more intensively grazed (Loudentia grasslands). Following closely to natural is Irish potato/Maize (Backslope) field type. This may be due to the way seedbeds are prepared. There is a lot of soil mixing which encourages germination of weed seeds, hence high diversity.

Household Level

Agricultural diversification support household livelihood and contributes about 62% of their total income. The most important income earnings in Bushwere are from bananas, Irish potatoes, common beans, Maize, Sorghum and Millet. Thirty percent Bushwere farmers reported that they depend on both off-farm and on-farm activities. Still most household's earnings from off-farm activities eg. carpentry, handcrafts and trading in farm produce is dependent on agro-biodiversity products.

Utility

It was observed in all households of Bushwere that people have many different utilities for the different plant species in their lands. Almost all the livelihood of each household depends on use of differet plant parts in one or more ways, starting with construction and roofing the dwelling houses, granaries, furniture, tools and implements. Timber, poles and posts of different tree species are suited to different parts of the construction or products. Specific grasses and fibres of bananas are also suited for thatching houses. Some specific banana varieties and other shrubs are known to give strong fibres used for construction instead of nails or for making strong ropes to tether livestock. In the kitchen, there are lots of utensils, appliance like mortars, pestles mats, baskets of different functions and ornaments made from agro-biodiversity. Leaves of bananas are used for covering foods while cooking and same fibres used to make covers for bottles, calabashes and pots. For the man of the home and elders, special trees or shrubs make their special walking sticks, boats for brewing beer and straw hats. The traditional wooden basins, sandals and stools

are still common in some homes. Carvings and handicraft work in schools and women clubs are also accessible in several homes.

With such diverse and highly valued or necessitated utilities in households, conservation of biodiversity is appreciated by all household members either on farm or in bushlands within or away from the parish. Fortunately farmers still have access to government gazetted land which still have large areas of natural woodlands and grasslands conserved, though it is limited to specified non-destructive parts and quantities.

Factors influencing conservation on farmland

There are several factors underpinning the capacity of households to conserve agro-biodiversity on their farmland. The main incentive is direct food, cash, cultural and other socio – economic benefits. The traditional healers have conserved medicinal plants on their farmland, artisans in construction(carpenters & builders) or granaries, beehives or handicraffs also try to conserve the suitable species where possible or move long distances to purchase form the people that have bushlands or woodlots.

The main constraint, on the other hand is land shortage. A Canonical Correspondence Analysis (CCA) ordination relating biodiversity utlisation with socio-economic categories of collaborating farmers and their access to land is presented in Figure1

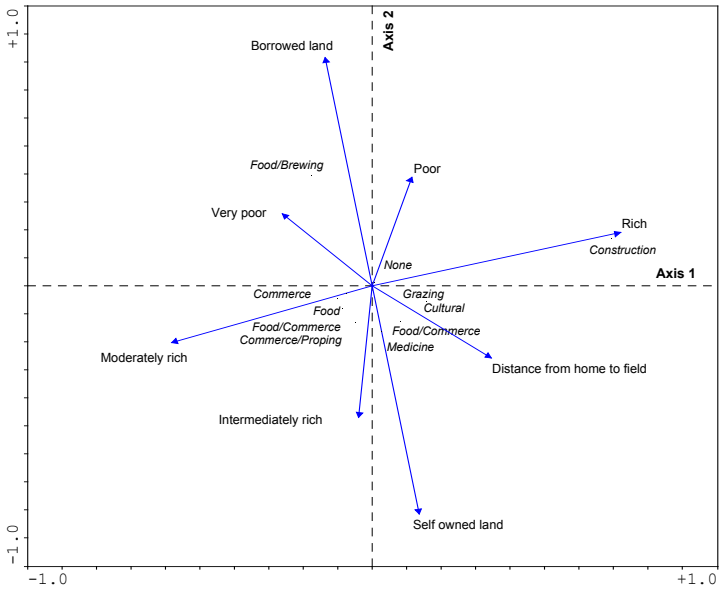

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Figure 1: *CCA Ordination of species utility and socio-economic factors. The arrows indicate the socio-economic factors while the species utilities are indicated in italics.*

Resource endowment seem to influence utilisation of the biodiversity, and thus indirectly influence capacity to conserve it on form. The poor and very poor formers generally cultivate borrowed land and thus are probably not able to conserve much biodiversity in their gardens. What they have is only crops utilised for food and brewing. The moderately rich and intermediary categories who are also the majority in Bushwere community cultivate land that they own and are also the ones that have a lot of utility for biodiversity on their farms as shown in Figure 1. On the other hand the very rich farmers who in most cases own a lot of land are able to have wood lots and thus conserve some species for construction purpose above others. They however do not have as many utilities of different species as the intermediary class of people. Rich people in Bushwere are mostly traders, with no time invested in conservational management.

Models of sustainable Approaches for Agrobiodiversity conservation developed in Bushwere

Examples of sustainable approaches for integration of biodiversity conservation into agriculture developed by PLEC farmers and scientists in Bushwere demonstration site, Mwizi sub-county, Mabarara district are given below. Demonstrations to other farmers and Policy makers have been centred on these.

1. Integrating stall-fed livestock into crop production systems, as Demonstrated by expert farmer : James Kaakare. His integrated Plot is illustrated in Figure 2

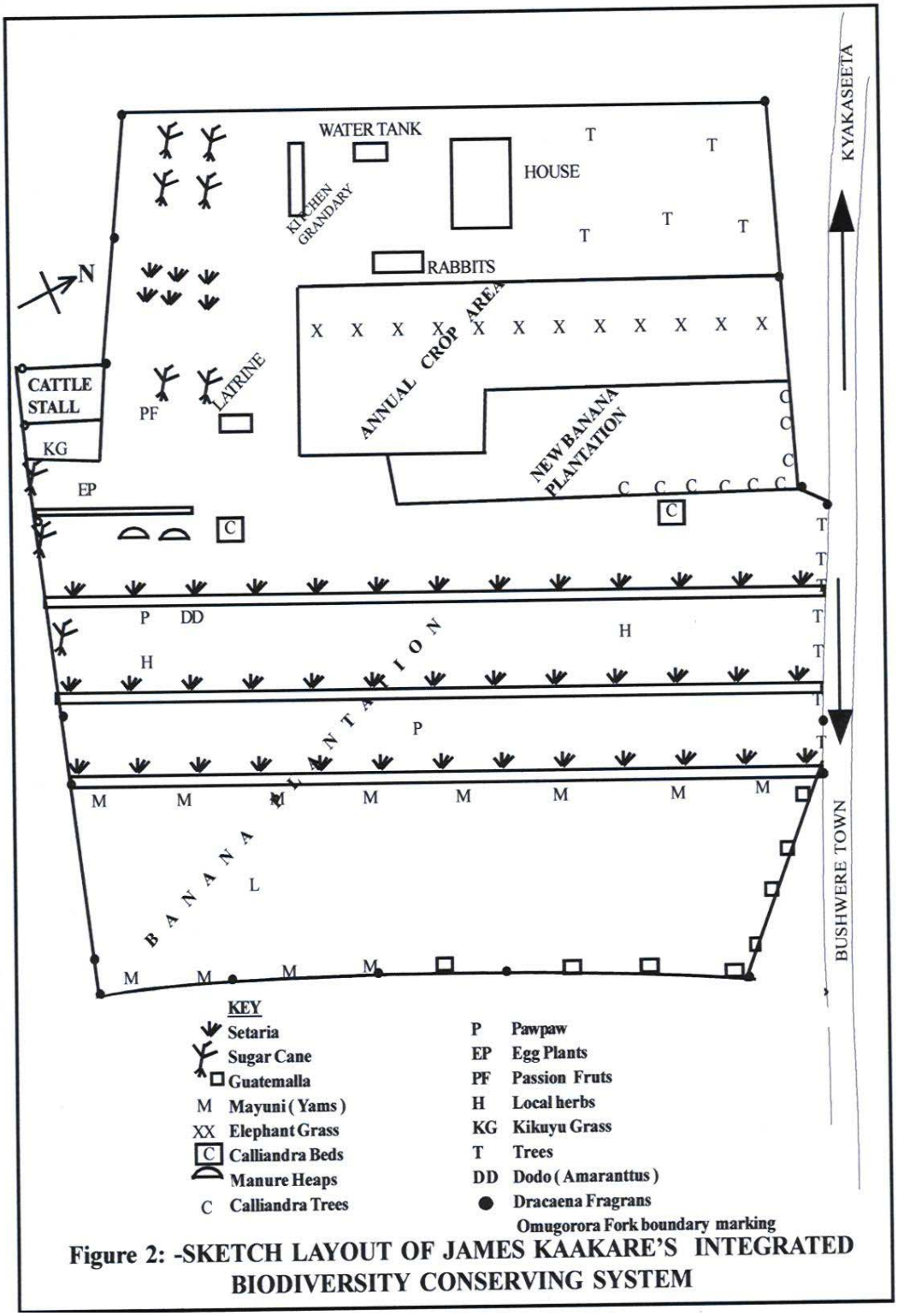

Figure 2: -SKETCH LAYOUT OF JAMES KAAKARE'S INTEGRATED BIODIVERSITY CONSERVING SYSTEM

2. Integrating Apiculture into agriculture as demonstrated by Fred Tuhimbisibwe. His farm has a rich plant diversity as shown in Table 5 below.

Table 5 Plant Diversity in Fred to Tuhimbisibwe's Farm

Functional grouping	**Number of Species**
1. Medicinal	8
2. Food crop species (banana varieties grains and vegetables)	16
3. Fruit trees	4
4. Fodder (legumes and grasses)	4
5. Coffee	1
6. Windbreaks(trees & 2 banana var.)	4
7. Beehive and banana props	3
8. Boundary markers	2
9. Plant species in apiary: At edges Within Neighboring fallow	 4 over 10 over 50

NOTE : Fred's always has the following to say on his biodiversity conservation:

- **"All flowers of these species provide nectar and pollen for bees**
- Several of these are multipurpose
- Sap of some species is used by bees to repair the combs and hives, some are fed to my goats and cow, some give firewood, at the same time they fix nitrogen in soil
- My Management of biodiversity in this integrated system significantly improved through collaboration with PLEC scientists
- I now have improved benefits and yields for:
  - Food security
  - Income
  - Better environment in my farm "

3. Adding value to sustainable use of biodiversity for farm structures and handicrafts e.g improved local granaries and modern maize cribs for better post harvest handling and storage demonstrated by Mrs. Nevas Tugume, James Warugaba and John Nyamwegyendaho
   - Improved local and modern bee hives demonstrated by D. Rubaramira
   - Beautiful bathroom sheds and fuel saving stoves demonstrated by Mrs. Joventa Kurigamba
4. Home gardens with different vegetables, fruits, herbs and shrubs for ornamentals and other uses demonstrated by Mrs. Joventa Kurigamba and Mr. Charles Byaruhanga.
5. Integrating agronomic soil & water conservation as demonstrated by Frank Muhwezi

1. Formation of common interest groups e.g.

(a) Bushwere Zero Grazing and Crop Integration Association (BUZECIA) with 24 members

(b) Bushwere Nursery and Home Garden Farmers, Association (BUNUHOGAFA) with 29 members

(c) Bushwere Development Group (BUDEG) with/O. Member.

(d) Mwizi PLEC Experimenting Farmers Association (MPEFA) with 12 members

7. Income generation from plant nurseries as demonstrated by BUDEG and BUNAHOGAFA, forestry demonstrated by Mr.D. Rubaramira and herbal medicines demonstrated by late Mzee Luka.

Lessons Learnt

1. Close collaboration of agro-biodiversity conservation advocates like PLEC increase the farmer's knowledge base on ecological and economic (long term and global) benefits of biodiversity conservation. It also stimulates their alertness and yearning for innovativeness on integrating compatible enterprises

2. The intermediary- to moderate classes of resource endowment have greater potential for integrating agro-biodiversity conservation into production through

security of resource tenure and ability to manage and utilize the biodiversity resources.

The rich invest in more biodiversity that does not require regular management like trees (afforestation).

3. Conservation and sustainable use of agro-biodiversity depends on direct benefits and thus cost-benefit analysis should be included in technology development packages in order for good approaches to be screened for feasibility to promote adoption

4. Ethnic diversity and intermarriages promote agro-diversity in general and agro-biodiversity in particular.

5. Integrating biodiversity conservation in agriculture encourages participation of all household members(gender balance) and trains all including children sustainable resource management

References:

1. *Nkwiine C., J .K Tumuhairwe and J.Y.K Zake (1999). Farmer selection of bio-physical diversity for agricultural land uses in dissected highland plateaus of Mbarara, Uganda. In proceedings of 17th conference of Soil Science Society of East Africa. p. 340. ISBN 9966- 879 – 27-7.*
2. *Statistics Department . (1992). The 1991 Population and Housing Census Summaries. The Republic of Uganda*
3. *UNEP (1990) Land use estimates*

Table 5: Average number of species by field types assessed.

Field type	Average number of species	Field type	Average number of species.
Banana/Maize/Beans (Ht)	16.8	Banana/Maize/Beans (Valley)	32.0
Banana/Maize/Beans (Bs)	20.8	Beans/Maize (Bs)	32.8
Beans/Maize (Ht)	22.0	Maize/Beans/Cassava(Bs)	33.8
Irish potatoes/Maize (Ht)	25.0	Cassava/Beans/Maize/Irish potato(Bs)	34.0
Banana/Beans/Maize/Coffee(Bs)	25.5	Irish potato/Beans/Maize (Ht)	34.3
Banana(Valley)	27.3	Irish potatoes/Maize (Ht)	34.5
Peas(Bs)	27.3	*Cymbopogon/Loudentia*	36.3
Irish potato(Ht)	27.5	*Combretum/Hyperrhenia/Cymbopogon*	50.5
Loundentia/Hyperrhenia (Ht)	28.8	*Pteridium/Combretum/Savanna*	51.0
Sorghum maize(Bs)	29.0		
Maize/Millet (Bs)	29.3		
Peas(Ht)	30.3		

Appendix 1. Dominant Land Use Stages and their landscape positions in PLEC demonstration sites of Uganda

Land Use Stages		Landscape			
		Hilltop	**Backslope**	**Ravine**	**Valley**
1.	**Perennial crops**				
	Banana Agroforestry	*	*	*	*
	Ba/Co/Ca/Mz/Bn/Tb	*	*	-	-
	Ba/SWCt/Grass strips	*	*	*	*
	Ba/Co	*	*	*	*
	Ba Homegarden	*	*	*	*
	Ba/Mz/Ca/Bn	*	*	*	*
	Ba/MHg/trenches/G strips	*	*	*	-
	Ba/SWCt	*	*	*	-
	Ba/Mz	*	*	*	*
	Ba	*	*	*	*
	Ba (Old)/Mz/Bn	*	*	*	-
	Ba (Young)/Mz/Millet	*	*	*	*
	Sugarcane	P	P	*	*
	Eucalyptus woodlot	P	P	-	-
	Ba/Bn	*	*	*	-
	Co	*	-	*	
	Co/Ba (with trenches)	*	*	*	*
	Co/Ba/Bn/Mz	*	*	*	*
	Co/Mz/Bn	*	*	*	*
	Co/Mz/So	*	*	*	*
		*	*	*	*
	Total	**20**	**19**	**18**	**20**
2.	**Annual crops**				
	Mi/Com. Agro.	-	*	-	-
	Mi/Mz/Ca	*	*	-	*

	Mi/Mz/So	*	*	-	*
	Mi/Ca	*	*	-	*
	Mi/Mz	*	*	-	-
	Bn/Ca	*	*	-	-
	Bn/I.Po	*	*	-	-
	Bn/Mz/Ba (Young)	*	*	*	-
	I.Po/Ca	*	*	-	-
	I.Po/Mz	*	*	-	-
	Peas	*	*	-	-
	So/Mi/Co (Young)	*	*	-	*
	So/Mz	-	*	-	-
	So/Mi	*	*	-	*
	Bn/Mz	*	*	*	*
	Bn/Mz/Ca	*	*	*	*
	Cabbages	-	-	-	*
	Ca/Mz	*	*	-	*
	Groundnuts	*	*	-	-
	Groundnuts/Bn	*	*	-	-
	Groundnuts/Ca	*	*	-	-
	Groundnut/Mz	*	*	-	-
	I.Po	*	*	-	-
	I.Po/Bn	*	*	-	-
	I.Po/Bn/Mz	*	*	-	-
	I.Po/Bn/Ca	*	*	-	-
	I.Po/Mz	*	*	-	-
	Sweet potato	*	*	-	-
	Sweet potato/Ca	*	*	-	-
	Fallow (Old)	*	*	*	-
	Fallow (Young)	*	*	*	*
	Field edges	*	*	*	*
	Grazed farm fallows	*	*	-	-
	Ungrazed farm fallows	-	-	*	-
	Total	**30**	**32**	**7**	**11**
3.	Home gardens				

	Pineapples	*	P	-	-
	Mixed Orchards	*	*	-	-
	Vegetables	*	*	-	*
	Agroforests	*	*	-	-
	Compounds	*	*	-	*
	Edges	*	*	*	*
	Total	**6**	**6**	**1**	**3**
4.	Natural grassland				
	Combretum wooded grassland	-	*	-	-
	Cymbopogon + Combretum + Pteridium	*	*	-	-
	Hyperrhenia + Loudensia	*	*	-	-
	Loudensia + Cymbopogon grassland	*	*	-	-
	Fenced grazing land	*	-	-	-
	Papyrus	-	-	-	*
	Total	**4**	**6**	**1**	**3**
5.	Natural Bushland/woodland				
	Natural forest (woodland)	*	P	*	
	Natural bushland (patches)	*	*	*	*
	Pteridium woodland	-	*	-	-
	Total	**2**	**3**	**2**	**1**
6.	Gazzetted forest				
	Natural forest (woodland)	-	-	*	*
	Plante forest (Cyprus, Pine, Eucalyptus)	*	*	*	*
	Natural reserve (wood grassland)	*	*	-	-
	Tuagya system (Annual crops + young rees)	*	*	-	-
	Total	**3**	**3**	**2**	**2**

NB: * = Present

P = In patches

- = Not available

h = Very rare

Table 2

Field type	Average	Field type	Average

	number of species		**number of species**
Banana/Maize/Beans (Ht)	16.8	Banana/Maize/Beans (Valley)	32.0
Banana/Maize/Beans (Bs)	20.8	Beans/Maize (Bs)	32.8
Beans/Maize (Ht)	22.0	Maize/Beans/Cassava (Bs)	33.8
Irish potatoes/Maize (Ht)	25.0	Cassava/Beans/Maize/Irish potato (Bs)	34.0
Banana/Beans/Maize/Coffee (Bs)	25.5	Irish potato/Beans/Maize (Ht)	34.3
Banana (Valley)	27.3	Irish potatoes/Maize (Ht)	34.5
Peas (Bs)	27.3	Cymbopogon/Loudentia	36.3
Irish potato (Ht)	27.5	Combretum/Hyperrhenia/Cymbopogon	50.5
Loundential/Hyperrhenia (Ht)	28.8	Pteridium/Combretum/Savanna	51.0
Sorghum maize (Bs)	29.0		
Maize/Millet (Bs)	29.3		
Peas (Ht)	30.3		

The role of livestock in soil no fertility, biodiversity, land use, cultural and welfare change in Nduuri Embu, Kenya.

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Abstract:

Population pressure is one of the major constraints in Nduuri, Embu, Kenya. More than 60% of the farmers own less than 1 ha land. Coffee monocropping is the major land use system. Both coffee and dairy industries went down affecting the land use and peoples'

livelihood as dairy cows were acquired through sales of coffee. Livestock reduction was associated with reduced production of manure which improved farm agrobiodiversity through nutrient recycling. Surface cover was also degraded due to soil fertility decline. Little livestock remaining was further sold instead of coffee to meet domestic needs. The vegetation was dominated by Digitaria scalarum and Rhynchelytrum repens which are indicators of low soil fertility.

Introduction

Nduuri is situated in the South East slopes of Mt. Kenya in the Agricultural ecological zone (AEZ) UM 2, the main coffee growing zone. The population pressure, has led to subdivision of land to such an extent that over 50% of the household live in less than 1 ha. of land. Only 13.5 % of the household has 2 ha or more of land. About 69% of household cultivate in their own land while 29% cultivate undivided family land and about 2% on rented land. The most common land use type has been coffee mono crop with a few Grevillea trees to provide shade. Coffee has been the main cash crop while the food crops includes a wide range of crops which are in most cases intercropped. However, the major food crops includes: maize, beans, bananas and the tuber crops (Cassava, Irish potatoes and sweet potato). Livestock keeping is practiced by majority of the farmers in Nduuri as it is prestigious to own some and also serve as source of food and income.

In the recent past, farmers in Kenya have been going through a hard time with the dairy and coffee industry which has affected the way of living and the land use. There was need therefore to clearly identify these changes as it affect biophysical and socioeconomic environment, the role of livestock in the dynamic land use system and the way forward. A study was undertaken in July 2001 to elucidate this role in a changing economy.

Methodology

A team of 6 scientists including a vet, agronomists and animal productionists were involved in a survey in which 51 representative household were selected randomly in the 9 villages of Nduuri sub-location. A senior member of each household was interviewed alone or together with his or her spouse using a semi structured questionnaire. A farm visit was made to verify the biodiversity and also see the state and condition of soil,

crops, animals, people and house structures. These were listed, scored and recorded. The information was entered into computer and analyzed using SPSS.

Findings

Role of various farm components in the household.

Role of Coffee:

The main source of the households income is derived from agriculture. Out of farm employment contribute little to Nduuri households. 68% of the household interviewed relied on agriculture only for their livelihood. Of those with extra farm income, 12% had a steady income and constituted mainly school teachers and retired pensioned civil servants. The bulk of income used to come from coffee as the main cash crop. Good permanent and semi permanent houses were constructed from coffee proceeds. Education and hospital fees were also met easily by coffee as a farmer would collect a cheque in advance to pay the school and hospital fee and this was recovered from his sales. Coffee directly provided food security during the drought as farmers cooperative bought food in bulk and this was distributed to its needy members and payment recovered from their coffee sales. Most of domestic needs were met by the income generated from coffee.

Coffee also provided funds for investment in other non agricultural and agricultural enterprises. This is because although coffee was paid after sometime i.e. 3 or 4 times in a year, the amount was large and enabled the farmer to invest without a loan. Most dairy cattle were acquired through coffee revenue. Poultry keeping has a very high initial capital investment and this too in many households were possible through coffee sales. The number of coffee trees also indicate the potential to pay any borrowed money and therefore used as a guarantee to effect payment of loans in local market. Coffee also serviced other farm enterprises, Such as livestock for feeds and veterinary services, and the food crops for fertilizers, seeds, pesticides and labour.

Coffee was therefore given a lion share of all the production resources such as land, manure, fertilizers, pesticide and labour over the other farm enterprises. In most farms, Coffee received more than two thirds of farm yard manure generated in the farm and the arable land.

Role of food crops:

Food crops grown by many households provide the food security and ease of survival while waiting for the coffee sales to be paid. It helps in providing cheap balanced diet for the family through out the year so long as there is adequate rain. This also reduces dependence on coffee as source of every households need. This sector also provides a large quantity of herbage in form of crop by-product or residues for ruminant feeding. This sector receives little of the available production resources. In many farms a large proportion of land is under coffee and therefore little portion is spared for food crop. It also receives less than one third of manure generated in the farm. In many farms food crops got manure only if some remained after fertilizing coffee. The Major food crops include: Maize, Bananas, Beans, cassava , sweet potatoes, yams, and vegetables. They are usually intercropped among themselves but farmers have started to intercropping them with coffee. Quality score for the various socio-economic conditions and farm enterprises are presented in table 1. During the survey, maize which is the major food crop was scored as a representative of the food crops and coffee for cash crops. Among the farms under study only 22% had good to excellent maize crop. The others were either fair or poor crop. In 33% of the farms visited maize was poor or miserable. The other crops except bananas and arrow root (Nduma) had similar score as maize.

Table1 Quality score for various farm socio-economic conditions and enterprises

Description	Maize	Coffee	Household Welfare	Livestock	Condition of people
Very good	7.8	3.9	3.9	5.9	3.9
Good	13.7	51.0	17.6	31.4	23.5
Fair	46.1	27.5	60.8	41.2	52.9
Poor	25.5	17.6	17.6	3.9	15.7
Very poor	7.8	nil	Nil	5.9	4.0

Role of Livestock

Livestock was second to coffee in order of importance. 90% of the farmers in Nduuri had at least one type of livestock. The most popular being chicken found in 71% of the households and dairy cattle which was owned by about 69% of the households Table 2. The most popular dairy cattle breed is the cross breed between exotic breeds or between the Zebus and the exotic cattle. Aryshire is the most popular of the purebred dairy

cattle (Table 3). The number of cattle in the farm is dictated by the household land size, the larger the farm the more the feed available and the more the animals are kept. Table 4 presents the number of dairy cattle and percentage of the farm who had such number. Majority of the farms had one or two cattle. Within the herd structure only 49% of the households had one mature cow and the rest 20% had either a heifer, a bull calf, or a draft animal. About 70% of the household had 3 or less hens , 1 or 2 cock and a total of about 7 chicks. Here the chick mortality is high due to predation and disease under the free range management.

Table 2 distribution of livestock species

species	% of the farmers with
Cattle	69.0
Sheep	15.7
goats	36.4
Chicken	71.0
Rabbits	20.0
ducks	2.0

Table 3: Distribution of the dairy breeds

Breed	popularity (%)
Crossbreed/upgrade	21.6
Aryshire	15.7
Friesian	11.8
Jersey	11.8
Guernsey	7.8

Table 4. Number of cattle per farmer

Number of cattle	Percentage of the farmers with cattle
Nil	29.4
1	29.2
2	17.9
3	2
4	7.8
5	2
10. or over	1

Livestock, though very important have been allocated very little land for fodder or pasture production. In about 45% of the farms there was no land spared for livestock. In such farms, animal are maintained on food crop by-products like maize stover, banana pseudo stem and leaves, bean straw, sweet potato vines, weeds, multipurpose fodder trees etc. Table 5 presents the percentage of households and the land they have spared for livestock. Most fodder crops, the main one being Napier grass, are grown on terraces and in small portions not exceeding one fifth of the farm. The small ruminants are usually tethered on the roadsides, home stead or stall fed. All the cattle are zero grazed except draft cattle which are semi-zero grazed. In most cases chicken are free range except during the flowering of low laying food crops or when they are likely to destroy vegetable like kales and spinach. In this method the birds fends for themselves most of the time and are only supplemented with some grains in the morning or some where during the day.

Table 5. Land allocated for livestock fodder production

land spared in acres	% of the farms	Cumulative %
Nil	45.1	45.1
0.07- 0.17	9.9	55
0.2-0.25	15.7	70.7
0.5-0.75	13.8	84.5
on terraces and boundries only	15.5	100

Chicken are mainly kept for Meat, eggs and sales. Their manure output is low because they spread it in the farm as they forage around. However, the little manure that is

collected in the pen where they are housed at night is used in banana or coffee crops. The eggs provide regular income from chicken which is used to meet the minor domestic needs. Mature birds are sold to meet slightly larger domestic need. Such as purchasing cooking fat, sugar, pesticides and even casual labour. Chicken also contribute in the improvement of family nutrition through regular supply of easily accessible quality protein.

Sheep is not very popular in Nduuri only about 16% have kept them. While goat is kept by about 36% of the farmers. Goats are popular as they do not compete with cattle for pastures as most of them were maintained on weeds and indigenous fodder trees like *Bridelia micrantha Trema orientalis Vernonia lasiopus*, *Lantana camara* etc which grow wildly on uncultivated niches. Their meat is also cherished than sheep and quite a number of people take it as a ceremonial animal. A few dairy goats have been introduced in the area especially by those with smaller pieces of land and business minded people who have discovered that their is unsatiable demand for dairy goats and they fetch good market price. The two small ruminants (Sheep and goat) are kept for meat, sales, manure and ceremonies. They are more prolific and multiply faster than cattle, are easy to dispose and requires less initial capital out lay. They also produce more manure than other smaller stocks. The income generated from small ruminants provide for major domestic needs such as fees, clothes, purchase of fertilizer and seeds. This is currently more dependable than the coffee.

The zero-grazing system of managing dairy cattle has made dairy keeping the major farmyard manure generator in the farms. In some farms milk used to be the secondary, the primary product being manure. About 65 % of the households generate farm yard manure ranging from 0.9-20 ton per season per household. Table 6 presents the range of cattle manure produced by different households per season. This is generated by collecting crop residues which could not be eaten by cattle and any other trashes in the farm, mixed up as bedding in the zero grazing unit and be trodden to form manure. Toward the end of dry season manure is removed from the stall and heaped to decompose before applying it to crops. Rarely do farmers use inorganic fertilizers singly, but often either manure alone or in combination with inorganic fertilizers.

Table 6. Cattle manure generated per season

Cart loads/season	Ton/season	% of people

		producing manure
3-6	0.9-1.5	21.6
10-16	2.5-4	23.6
18-40	4.5-10	11.9
48-80	12-20	7.9

Milk and bull calves are sold to generate income for the family. Milk payments were and still are more regular and reliable than coffee sales. This can be depended on to pay the school fees, or supplement the coffee income. Dairy income is used also to service other productive farm enterprises through purchase of such variables inputs like seed, pesticide, feed, labour, etc. When coffee income is not available then sale of cows has been taking place to pay the school fees or meet hospital bill. Ownership of dairy cattle and indeed other livestock contribute to household food security directly as food, indirectly through the revenue which can be used for food and through manure which improve the soil fertility and productivity of the land. Livestock also enhances the welfare and the status of the household.

Effect of livestock change in the change of people, land, and biodiversity.

The livestock role in biodiversity is effected through the nutrient cycle. Since most nutrient flows from food crops to livestock in form of crop residues and weeds and back to the crop as manure, removing livestock results in break of this flow. In Nduuri since the deterioration of coffee industry, many animals have been sold to pay for urgent domestic needs which were previously easily met by coffee. The collapse of dipping services since 1992 and the drought of year 2000 resulted in loss of many dairy cattle through tick borne diseases and lack of feeds. The 30% of the household who did not have cattle reported in table 4., are among those who lost their animals during this bad period. Therefore the cycle has been broken and severe adverse changes are being manifested.

Biodiversity is changing due to the fact that some indigenous plant flourish well in fertile soil. Since manure is no longer available, these plant species are also disappearing and are being replaced by others that stands low fertility. Some of the wild valuable species that are disappearing include: *Amaranthus sp* Terere, *Solanum nigrum* managu and *Pennisetum clandestenum* Kikuyu grass which were common in

land rich with organic matter or fertilized with manure. These are being replaced by *Rhynchelytrum repens* poverty grass, *Digitaria scalarum* coach grass and *Digitaria ternata*. Species manifesting severe signs of low soil fertility and decline in productivity include both food and cash crops. Some are listed below.
Some vegetables, such as Kales, spinach, cabbages, tomatoes and carrots: Maize; Irish potatoes; Bananas and Coffee.

The effect on the plant is manifested through low biomass production which is consumable as leafy vegetables and as livestock feed, reduced fruit and tuber size in banana, and potato respectively and low grain and cherry yield in maize and coffee. This has not only affected the food security but also the wealth situation, nutrition status of some families and their general welfare. There is an increase in school dropouts in Nduuri and many people can not afford good health services. Malaria is common in the area and most of it is resistant to chloroquine. Treatment of malaria nowadays is effected through expensive drugs. Therefore to reduce the cost of treatment, many families have deliberately planted one or two malaria curing herbal botanicals and are using them for treatment of selves and their neighbours.

Once the livestock mitigated nutrient cycle in a farm ecosystem breaks, to bring it back to normal requires that the livestock be reinstated to its niche in the farm food chain. Coffee payment which come in large quantity is the only way which can enable a farmer to buy a dairy cow back into the farm. This does not seem to be happening soon and the situation is deteriorating unless they change to other income generating agricultural enterprises. Already one innovative farmer, Mr. Njagi Mbarire has turned to strategic vegetable production where maize is harvested and sold when green and vegetable grown in its place. This is timed in such a way as to coincide with the lucrative market prices. Two self help irrigation projects one on-going and another one on pipeline have been formed to help in providing water for irrigating high value crops.

Conclusion

Livestock plays a major role in land use system and does effect change in soil fertility, agrobio-diversity, peoples welfare and culture in long run. Effort to revive coffee industry even if the market price improved requires that, it be accompanied with revival of dairy industry to ensure complimentality of the three farm sectors (livestock, food and cash crop) is restored. The restocking of dairy cattle should be incorporated in coffee

revival packages as a policy. If coffee does continue to deteriorate in price the farmers should be encouraged to divert to other lucrative enterprises either by uprooting coffee or intercropping without intimidation from any quarters. This calls for change in coffee growing regulations and policies which are currently unfavourable to farmers. This is the way to go for the reduction of poverty.