

Land Use Changes And Their Impact on Agricultural Biodiversity in Arumeru, Tanzania.

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Abstract

This study was carried out to analyse and describe agricultural and biodiversity changes in representative villages of Arumeru district in Arusha Region, Tanzania. The sample villages involved in this study are Ngiresi and Olgilai in the sub-humid zone, Moshono in middle altitude zone and Kiserian in the semi-arid zone.

Formal and informal interviews of key informants were used to gather data. In addition secondary data was collected from village and government offices. This study also immensely exploited data from historical trends as it was explained by individuals from different age groups of the “Waarusha” tribe since early 1900s. The data was used to discuss and expound land use dynamics and their effects on agricultural and biodiversity sustainability in the district.

It was observed that each time the growth per unit area in numbers of animal and human population in the district has contributed to decreased size of the average farm size for both cropping and grazing. Also there has been a change in biodiversity, some of the cropping systems have become extinct whereas others have emerged. The negative aspect of the changes has been the reduction of species diversity due to degradation and over exploitation. The changes have also been positive through the introduction and intensification of cropping of some crop species. Options have been open for people to manipulate the cropping systems in order to efficiently use the scarce resources. Farmers have opted not only to intensify agricultural practices but also to deliberately restore some of the lost species diversity. Reduction in the number of animals per household, adoption of new techniques of land management, changes in the type of crops cultivated and intensive use of the available resources are some of the indicators describing farmers' efforts to cope with the changes. The introduction of non-traditional cash crops e.g. flowers and the growth of various horticultural crops such as cabbage and round potatoes in recent decades are some of the living examples. Sustainability of the farming system and biodiversity has been enhanced through peoples' efforts that include planting

trees, use of fertilisers mostly on high valued crops such as round potatoes and other horticultural crops and conserving soils erosion.

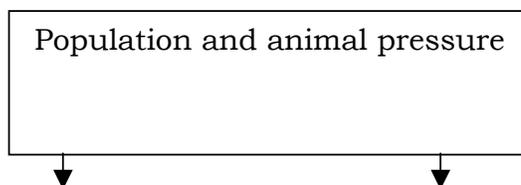
Introduction

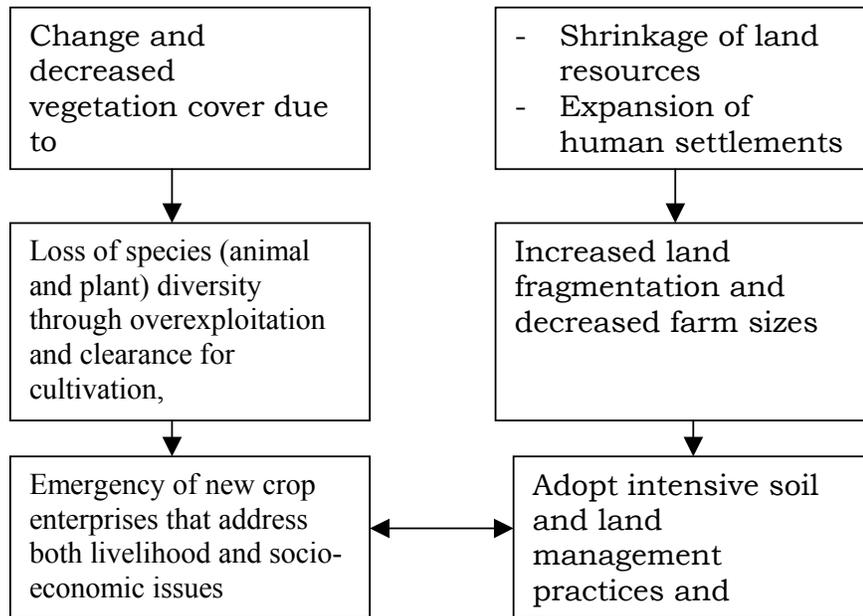
Few researchers in Tanzania have devoted time and resources on studies on land use changes, their role in the evolution of the present farming systems and causes of biodiversity changes. Land use changes are influenced by multiple and complex factors. In Arumeru district in Tanzania the forces driving land use changes act in response to some rates of change. Fresco (1993) observed that the most obvious forces governing the changes are population growth and concomitant demand for land use products, which seem to differ considerably across and within farming systems.

There have been continued changes in land use in many parts of Tanzania. Many of these changes have been discerned by the use of remote sensing techniques at appropriate scale and quality.

In some cases land use changes have occurred in various environments in response to various situations. Adverse climatic conditions, changes in population, land pressure and changes in socio-economics are among factors that favour or discourage certain changes. Figure 1 below hypothesize some of the major causes and effects of animal and human population on the agro-ecosystems in Arumeru.

Figure 1. Hypothetical summary of land use and biodiversity changes in Arumeru District. Cause and effects.





On the slopes of mount Meru the changes in land cover seem to be most important thing in the assessment of aspects of sustainability. Land cover influences biodiversity, soil erosion or nutrient balances. The aspects of biodiversity are critical to the overall aim of promoting a more ecological approach in agricultural systems and the integrated management of land resources with a view to enhancing agro-ecosystem sustainability (Brookfield and Padoch, 1994.). Farmers are rational in the sustainable use of resources. In Arumeru district they rotated their land utilisation types across the landscape units in order to successfully utilise the land resources and maximise crop yields. Similar cases are reported elsewhere by Padoch and de Jong (1992) in which farmers have concentrated also on conservation. Biodiversity

conservation has a fundamental role on the food and the livelihoods, of farming communities and the future of the people all over the world (Brookfield, 1994). To the small scale farmers changes in agrodiversity have been an important component for ascertaining their livelihoods. This is because of its importance as the main life support system.

The objectives of the study were:

- To evaluate the impact of population pressure on land use and land cover.
- To evaluate population pressure impact on peoples' lives.

Most of the data in this study was collected at farm level and no modeling was attempted. The fundamental task was to answer how the small-scale farmers on the slopes of mount Meru have survived despite the pressure on the shrinking land resources. This study has the objective of looking into the effects of land use changes and its influence on both agriculture and biodiversity on the windward slopes of mount Meru Arusha Tanzania. It taps to a large extent on the rich experience of the indigenous people of different age groups and farmer categories in collecting necessary and useful information on biodiversity and land use changes over time. At the end it assess the sustainability of the system.

Materials and Methods

The study area

The approximate geographical location of the study villages is about 36 42'50"E; 3 19'36" and 36 45'00"E; 3 19'36"S. The study villages – Ng'iresi, Olgilai, Moshono and Kiserian represent a simple catena on the windward side of Mount Meru. The mountain is volcanic in nature. Its highest peak is 4,562 meters above sea level. Volcanic eruptions resulted in the formation of several cones of various sizes around the mountain. The slopes of the cones are steep and dissected forming both broad, U-shaped and V-shaped valleys. The four study villages are located on the slopes of a volcanic cone called Kivesi, characterised by steep slopes, in some places slopes are as steep as 30-40-50%, broad valleys and a gently undulating plain extending to Kiserian village. The lithology of the

area is late cretaceous to recent volcanic materials composed of basalts, trachytes and pyroclastics (Morss, 1980). The soils are invariably rich in some nutrients but fertilisation for better crop is indispensable.

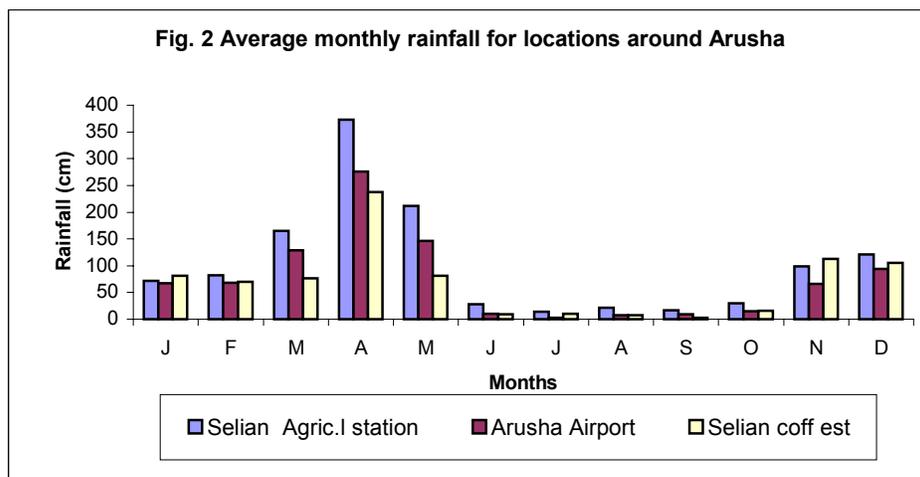
The projected population size of Arumeru District for the year 2001 is about 320,000. The population grows at a rate of about 3%. This rate is considered one of the highest in the country and it is well above the national growth rate of about 2.8%. Due to high population increase the number of persons per unit area has steadily been rising. At the moment the population density for the district is about 110 persons/Km². (Bureau of Statistics, 1988).

Most of the PLEC project research activities for the past four years have been conducted in these villages.

Climate

Long-term rainfall data show that, there are two major rainfall season, the short rain season normally falls in November to December and the long rains begin as early as the month of March and terminate at the end of May or June.

The second growing period is not reliable. The decreasing and high rainfall variability between seasons is partly responsible for the changes in agro-diversity. Given this condition there are occurrences of crop failures. In some cases the variability in rainfall has been claimed to be caused by the tendency of many farmers to clear forests along the slopes of the mountain for cultivation.



Study Methods

Information was collected from farmers using the following major methods

Use of Questionnaires

Farmers interviews

For each village, farmers of different wealth categories i.e. rich, average and poor in resources endowment were interviewed. Sample size was 30 farmers from each village. Various questions were asked on farm productivity and land use changes including the adjustment strategies and the range of options available to indigenous farmers and immigrants to adjust to changes. Farmers' responses were important in gathering data on field types and land use changes in time and space.

Transect walks and historical records

Key informants accompanied researchers during visits to selected routes. These were transects deemed most representative for each village and are those from which changes on land use could be depicted in detail by most members of the age groups Table 1. Information was recorded from farmers of same age groups from the older age groups to the youngest. In most cases the older farmers information was more reliable than the younger farmer groups.

In each age group a selection was made of 10-15 knowledgeable farmers from each village. The main assumption was individuals in the same age group have common knowledge of understanding the various social and other issues, which have taken place during their lifetime. It was with this consideration that the farmers from the age groups were interviewed to provide information on land use changes in time and space for the given area. The information gathered from these farmers was used to supplement information collected from the selected households. The different age groups are presented in Table 1 below.

Table 1. Age groups according to the Waarusha tribe in Arumeru District

Age groups	Approximate year of birth	Approximate present age
Illnyangusi	1930	70

Ilseuri	1950	50
Ilmakaa	1970	30
Illlandisi	1990	10
Ilameijok	2000	01

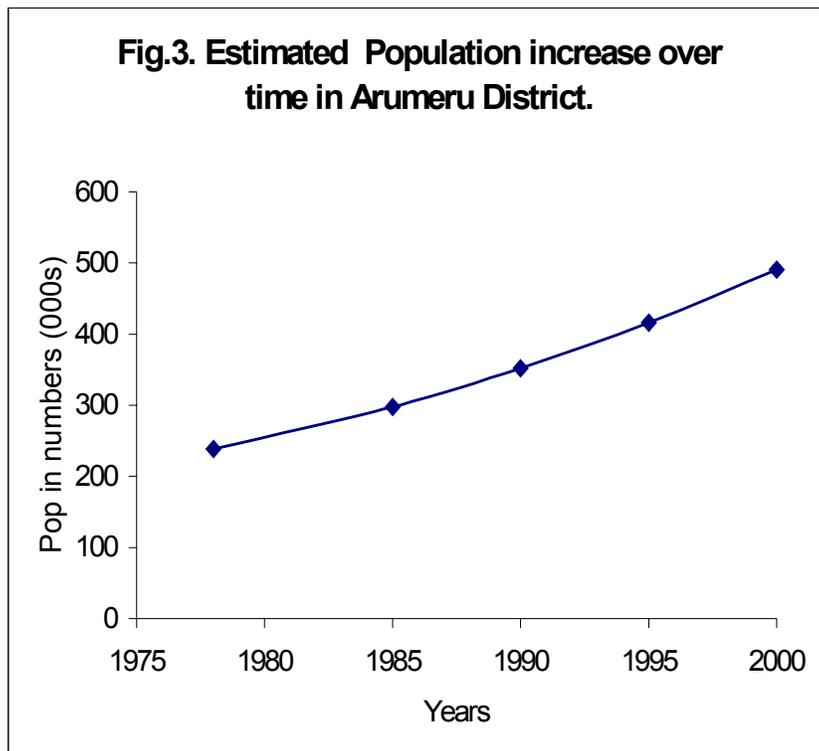
The main study period considered starts from late 1900s. this information was correlated with various available records. There was a good correlation of information with the events as narrated by respondents. In many cases the information gathered from farmers was very useful, sufficient and relevant for assessing any land use and biodiversity changes.

Results And Discussions

1. Causes of land use and biodiversity changes

a) Population

There are many factors that can be postulated to be as major causes of land use and biodiversity changes but the continual increase of human and animal populations is among the major factors in Arumeru. Increase in population pressure led to the decrease in the area needed for, building, grazing animals and more importantly for cultivation of both food and cash crops. In the same way due to increased populations more of the rich biodiversity was exploited for human and animal use. People required trees for building their homes and needed pasture for feeding their animals. The negative interaction of population and the environmental components has upset the ecological balance in Arumeru district.



The district is experiencing population pressure, which is mainly dependent on agriculture as the main activity. This population constitutes about 26% of the total population in the region (Bureau Statistics, 1988). The population density is also second to Arusha municipal. The population growth (Fig.3) in the district is largely attributable to natural increase. According to interviewees contribution to the district population by migration is not substantial because more and more people are considering moving out to find more land than continuing living in the district.

The gradual increase ought to have an impact on resources available in the area. At this rate and trend of population increase, resources such as soil, water and vegetation have gradually shrunk. In such conditions land degradation ought to take place. The trend presented in Fig. 3 above is for a short period but can firmly support the fact that the area has been facing continuous population increase.

The calculations for the growth of population above have taken into account the growth rates as provided by data from population statistics of Tanzania. The

projections made for the year 2000 and beyond also predict an increasing trend of population rather than a decreasing one.

b) Periodic changes of weather

Most farmers (60%) assert that decreasing rainfall trend and in some cases acute droughts frequently have upset the ecosystem leading to some of the environmental components to change. The present rainfall data show a high degree of variability within years. This is the main problem coupled with very poor distribution throughout the year. Otherwise the total amount has been almost similar. This has sometimes forced farmers to abandon some of the older crops thereby negatively affecting on-farm biodiversity.

c) Shrinkage of land resources

Farmers have opted to shift to new areas in response to continued land fragmentation, (60%) have purchased new land elsewhere and most of them have almost abandoned the tradition of distributing their land to children as inheritance. To-date in many families, there is very little land left any further for distribution to the coming generations.

2. Effects of population pressure and weather changes in the area

The continuous growth in population has affected farmers and their environment. Some of the factors have a direct influence in the lives of the people. For example the deterioration of the agro-ecosystems has a direct effect in the livelihoods of the poor because of food on a sustained basis has been affected. From this study farmers agree that the some of the major effects of population include:

a) Increased land fragmentation

About 90% of farmer responses showed that land fragmentation is a result of continuous increases in population that has continually decreased the effective area required for agriculture. Most families at the moment have insufficient land for their children. Some farmers have moved to new open areas others have opted to intensify production on the small fields they have and supplement them with support plots away from the homestead.

Table 2 indicates different farm sizes for the different farmer categories in study villages. Large farm sizes are found in semi arid Kiserian. Poor farmers in both sites are the most constrained by land. The data on farm size confirm the land pressure constraint especially in the sub-humid uplands and for the poor.

Table 2 Average farm sizes (acres) per household in survey villages.

<i>Village name</i>	<i>Household category</i>		
	Rich	Medium	Poor
Olgilai/Ng'iresi (SHZ)	2.27	1.78	0.90
Moshono	3.50	3.32	1.50
Kiserian (SAZ)	7.55	5.25	3.8

b) Introduction of quick income generating crops

A good number (60%) of farmers ascertain that, nowadays, crops such as round potatoes, onions, flowers have been cultivated in response to market demands. There is a local demand for round potatoes onions and cabbage within the Arusha Municipality. Such crops earn cash within a short time. Due to concentration of efforts to the cultivation of such crops many farmers have limited time to look after coffee. Foreign markets abroad require flowers. In order to maintain quality and supervision companies have selected few farmers who participate in the production of the crop. Many other farmers would prefer to participate in future. With time there has been an increasing and decreasing demand of some animal and plant products. Sometimes, these changes have lead to over-exploitation or abandonment of some plants and animals. The case of reduction of “ngwala” (Lablab sp) cultivation by farmers in the study area is referred to. The demand for lablab in the area has substantially declined. The reason is not only the market but seems to be that, the farmers themselves are no longer using it as one of the dependable sources of food. Market surveys during PLEC project indicated that ngwala is highly demanded with good price in Kenya. The crop has now been reinboded.

c) Change in land use and cropping systems

Table 4 provides information on the decrease or increase of certain crop enterprises over the years. Changes have occurred in areal extent and composition of traditional field types and agrodiversity as a whole.

Table 4. Farmers' perception of trends in land use for various crops (percentages) in the study areas (1930 – 2000).

Zone	Crop	Age groups					
		Ilnyangu si (1930)	Ilseur i (1950)	Ilmak aa (1970)	Illandi si (1990)	Ilameijo k (2000)	Avera ge
Sub- humid Olgilai/ Ng'iresi	Maize	30	30	25	20	27	26.4
	Beans	25	25	15	15	11	18.2
	Finger millet	20	15	5	2	-	8.4
	Labalab	10	8	5	1	-	4.8
	Cowpeas	5	5	2	1	-	2.6
	Sweet potato	2	2	2	2	2	2
	Coffee	1	5	25	22	15	13.6
	Banana	5	6	10	18	20	8.2
	Taro	1	2	2	4	5	2.8
	Round potato	1	2	8	12	20	8.6
	Cabbage	-	-	1	3	5	2.2
Total		100	100	100	100	100	

Semi Arid Kiserian	Maize	31	29	20	22	20	24
	Beans	15	17	20	23	18	18.6
	Finger millet	11	11	10	6	8	9.2
	Lablab	14	8	5	3	3	6.6
	Cowpeas	9	6	8	5	6	6.8
	Sweet potato	5	1	5	2	9	4.4
	Cassava	4	4	6	8	2	4.8
	Pigeon pea	11	11	10	11	13	11.4
	Chickpeas	-	8	9	10	5	6.4
	Sorghum	-	5	2	3	4	2.8
	Flowers	-	-	5	7	12	4.8
Total		100	100	100	100	100	

Source: Field data, June 2001.

In both sites maize production has dominated throughout the study period followed by Beans. Beans production slightly declined with time in Olgilai/Ngiresi probably due to increase in round potatoes production as a cash crops. Coffee production also went down in production and most of the coffee is now in stubs intercropped with cabbages, potatoes etc.

From Table 4 it is clearly observed that farmers have set priorities for some crops. For instance maize and beans in both zones have occupied a significant part than other crops. food security seems higher in the farmers agenda. The cultivation of such crops assures the households that food requirements will be satisfied. In the SHZ, coffee as a cash crop has occupied a significant (13%) part of the lands. This is because in the past coffee was the main cash crop and although its importance as a cash crop has continued to decline, most of the farms still have coffee intercropped with other annuals. Round potatoes and finger millets on the average occupy 8.6 and 8.4% respectively. These are not the main food crops but are used as cash crops.

In the semiarid zone the cash crop is pigeon peas. Flowers typically for cash but are normally not grown under the farmers' control but rather under the clients demands. Maize (24%) and beans (18.2%) are the major food crops grown by farmers. It can be

concluded that allocation of land to a crop or crop combination under conditions of land pressure depends on its ability to improve household food and income requirements.

1. Coping strategies at farm level in response to effects of land and Biodiversity changes

Farmers have devised several means to cope with effects of land use changes. For those who cannot settle elsewhere in the region, their available land would be the only land remaining for production. Most farmers have maximized the use of their plots with considerations of the varying seasons, market demand and crops' ability to address farmers' needs for cash and food. Coping strategies have been devised and implemented and they include:-

a) Intensification of land use in the different seasons

Farmers carry out intensive agriculture on available land by rationally utilizing the land to suit their socio-economic needs in response to seasonal changes and market demands. Such a system has allowed the farmers to exploit the scarce resource to meet their economic needs.

Observations from the proportion (55%) of the farmers interviewed have shown that land can variously be utilized in years and reasons. It is also observed that the production system in the area is a diverse one, involving the use of a range of available soil and land types. On the other hand it is also a complex one since it has the ability to integrate effectively the use of micro ecological niches within the farmers area according the prevalent intra and inter seasonal conditions.

The land in all years is comprised of both permanent and short seasons crops. The short seasons crops are observed to be rotated with plots reasons and year. Short-term crops mostly rotated in different seasons and plots are such as maize, beans, irish potatoes and most vegetable.

Tree crops such grevillea, pinus, calliandra and other fodder trees are permanently grown in the same plots each year and seasons.

There are several reasons why farmers behave the way they behave in Arumeru district with regard to the use of their lands:

- i) Declining fields has forced farmers to undertake crop rotation.
- ii) As part of means of controlling pests and diseases.
- iii) Varying the area under production may be a response to the market demands to produce a particular crop.
- iv) Land scarcity has forced most of the farmers to grow many crops in the field types, this makes sure that all space is used.

b) Adoption of improved soil and water conservation techniques

Parallel to the changes in land use due to different factor, a large proportion (70%) of the interviewed farmers have witnessed the introduction of many soil and land management technologies in the villages through various projects e.g. PLEC. Some of these technologies include the use of fertilisers, use of improved seeds, afforestation and soil conservation. All were meant to assist the farmer in conserving the resource base, at the same time realising reasonable yields.

We have witnessed also that, due to the decrease in grazing area more improved breeds of cattle and goats have been introduced and all are zero grazed in the (SHZ). Grassed contour bunds were introduced and maintained in order to simultaneously curb the soil erosion problem. The grasses were planted on contours and were cut and carried home for feeding the animals. Such simple but yet effective technologies were introduced when demands for land was over ridden by large numbers of both animal and human populations. Soil management technologies play a role in land use changes. The changes especially those advocating the use of fertilisers and manures are in most cases positive leading to increased yields.

c) Introduction of improved breeds and seeds

In Arumeru district, population increase has not only resulted in the deterioration of the agro-ecosystem but also on the decline of the agro-ecosystems' capacity to support large livestock numbers. At present the majority of farmers in the high altitude zone cannot keep larger numbers of cattle and goats despite the fact that

milk, meat and manure are still one of the most needed resources for food and for fertilisation. During our study a minimum of two could be kept on the average, each household in the highland zone keeps mainly cows mostly needed for milk and manure production.

d) Exploitation of the natural forests biodiversity

Many factors contribute to the loss of bio-diversity. The destruction of natural forests in search for timber and building materials is partly responsible. Other immediate causes include the migration of farmers from overpopulated areas to fragile ecosystems, poor farming practices, and the over-exploitation of plants, animals and other resources to meet their ever-increasing demands. According to 90% of the Ilnyanguse (1930s), the forest cover on the slopes of Mt. Meru was thick. A diversity of tree and animal species were plenty. Most of these species are now extinct and few of them can be spotted on isolated places.

e) Reintroduction of the lost and endangered species

Farmers have realised that there will be no recovery of the lost vegetation species unless deliberate efforts are done to restore the lost biodiversity by planting them. Farmer groups for tree planting have been formed through PLEC initiatives. These farmers want to restore the trees that have been lost when the forests and the scattered vegetation were invaded show tree plants that are being planted by PLEC farmers in nurseries and are being distributed to farmers.

Conclusions And Recommendations

There are a number of causes and causal effects of land use and biodiversity changes that have led us to the following conclusions:-

- 1) Population pressure is the major driving force to the observed land use and biodiversity changes in Arumeru District. Other factors include changes in the pattern of the market and the emergency of new opportunities through the advent of new field types and activities in the peri-urban interface.
- 2) The major land use and biodiversity change in Arumeru over the years has been land fragmentation to accommodate family land requirements. Family requirements are socio-economic e.g. food, cash and the need to better utilise the soil and land resources.

- 3) The livelihood of the majority of people in the study area depends on agriculture. Certainly, the ever-increasing population will continue to rely heavily on agriculture in the many year to come. Shortage of land for production especially in the densely populated upland parts of the study areas makes agriculture intensification imperative to cope with the increasing population pressure and declining productivity.

In view of the above conclusion the following are the recommendations

1. There is a need to follow up at short interval of years, the major changes taking place in the area in order to generate information to assist in efforts geared towards curbing land degradation and loss of productivity and biodiversity.
2. A greater research effort is required to assess and evaluate land-use and biodiversity change and to relate it to population growth in Arumeru district.
3. There is a need to look into the household food security and environmental sustainability.
4. Gross margin analysis of the various field types adopted at present and their relative contribution to farmers' socio-economic conditions compared to past ones. This can assist in advising farmers on crops to be cultivated given the available resources i.e. land, capital and labour.

Lessons Learnt:

- *Additional comprehensive understanding of land use and biodiversity changes can be made possible by tapping farmers' knowledge.*
- *In order to reduce the adverse effects on land and biodiversity degradation, the focal point should be the farmers and their farms.*
- *Farmers are rational in the use of resources.*
- *Farmers are more knowledgeable of the environment in which they live and are rational in the decisions they make and ways by which they use their resources.*

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