LAND USE LAND COVER CHANGES AND IMPLICATIONS FOR FOOD PRODUCTION: A CASE STUDY OF KEUMBU REGION KISII COUNTY, KENYA

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Abstract
Keumbu Region in Kisii County is experiencing a high rate of land use / cover changes which has affected food production significantly. The agricultural land fragmentations, high population increase and urbanization has led to decrease of agricultural land, food production and impacted on agricultural production and biodiversity an effect which has left the rural livelihoods food insecure. Study explored land use /cover changes, food production trends and main drivers behind deteriorating agricultural land, relationship between population, land use changes and implications on food production and security. The land use / cover changes classification of landsat TM image and change analysis done in Erdas Imagine with soil fertility and DEM data, population density and poverty prone areas processed and analyzed and correlated to food production using ArcGIS 10.1, SPSS and Microsoft office computer programmes. Results showed 58% forestland and 91% grassland reduced and 11% of cropland and 0.6% of settlements increased between 1990 and 2010 respectively. The population increased by average of 20.5% between 1989 and 2009, population density of 830 persons per square kilometers, Nyaura location having an extremely high density of 3135 persons per square kilometers, with 65% of Kegati location in absolute poverty. The soil fertility depletion trend negatively impacted on food production which decreased by 29% and cash crop yields increased by 12.5% respectively. In conclusion Keumbu is food insecure region with agricultural land already degraded and densely populated. In recommendation, the government and other stakeholders should make small scale farmers adapt to good farming practices and land tenure systems.

Key words: Land use, land cover, population density, poverty, land degradation, food security

1.0 Introduction

Land use is the process of arranging the activities and inputs people undertake in a certain land cover type to produce, change or maintain it (FAO/UNEP). Land resources are used for a variety of purposes which include agriculture land use, reforestation, settlement, near-surface water and eco-tourism, in a sustainable manner.

Food production is the cultivation of food crops with special regard to maximization of the total yield gained per acre in one planting season. The problems of food supply and farming are among the most bewildering, diffuse and frustrating of mankind contemporary dilemmas (Gregory & Paul 1976). Food security refers to the availability of food and one's access to it while food problem is the apparent inability of the world's people to feed them adequately and consistently. The ever increasing human population threatens the future food production in Keumbu region. Construction of houses and other non-food uses of agricultural lands have reduced food supply as the area under food crops reduced. The world grain stocks was noted to have dwindled to dangerously low levels, highlighting the fragility of food supplies in a world where the population is expected to rise (FAO, World Food Summit in Rome Italy 2009).

Chronic under nutrition persists mainly in countries with low incomes in Africa Kenya and in particular Keumbu region included, most of which depend heavily on agriculture. Eliminating hunger will require a lot of effort to accelerate agricultural and rural development in these very countries. There have been good land use land cover strategies put in place to increase the output of land resources. But there is failure in the relationship between good land use land cover practices, good economic benefits and good nutrition of the population.

The Kenyan economy is dominated by agriculture regardless of the fact that only 15 to 17 percent of its total land area has sufficient fertility and rainfall to be farmed and only 7 to 8 percent can be classified as first-class land. Most of the land is either arid or Semi-arid. These areas are highly productive with animal husbandry

especially when the correct numbers of animals are stocked in a specified area to enable sustainable use of the land as a resource. The 7 to 8 percent which are classified as first class land submits to the economic challenge with their first choice being cash crops rather than food crops (FAO, 2009).Agricultural sector directly contributes 24% of the Gross Domestic Product (GDP) and 27% of GDP indirectly through linkages with manufacturing, distribution and other service related sectors. Approximately 45% of Government revenue is derived from agriculture and the sector contributes over 75% of industrial raw materials and more than 50% of the export earnings (KARI, 2013).

Climate change is one issue of major concern to food production Vis a Vis land use land cover. Global warming threatens the amount of crop yield and productivity of the land which dictates adoption of other uses of the said land to become more economically viable in Kenya. The rate of population growth, land fragmentations for settlements, culture and norms of land tenure affects land use land cover changes and food production in Keumbu region significantly. Cash crop growing for better incomes and failure to adapt sustainable agriculture e.g. minimum tillage, crop rotation and subsistence farming affects food production. Environmental degradation due to cutting down of a few trees for firewood and timber in the region, interferes with water catchment areas and wetlands.

The objectives of the study was to analyze land use land cover changes and implications for food production in Keumbu Region Kisii County, Kenya using GIS and Remote Sensing, food production trends and main drivers behind deteriorating agricultural land, relationship between population, land use changes and implications on food production and security.

2.0 Methodology

Keumbu region lies on Latitude: 0° 41' 0 N and Longitude: 34° 46' 0 E in the western region of Kenya (newly created Kisii County), covers total land area of 132.3 square kilometers and an elevation of 1700m above sea level. It lies on a highland equatorial climate with rich volcanic soils and experiences two rainfall seasons; Short (September - November) and Long (February - June), of over 1,500mm per annum with temperatures ranging from 16°C to 27°C.

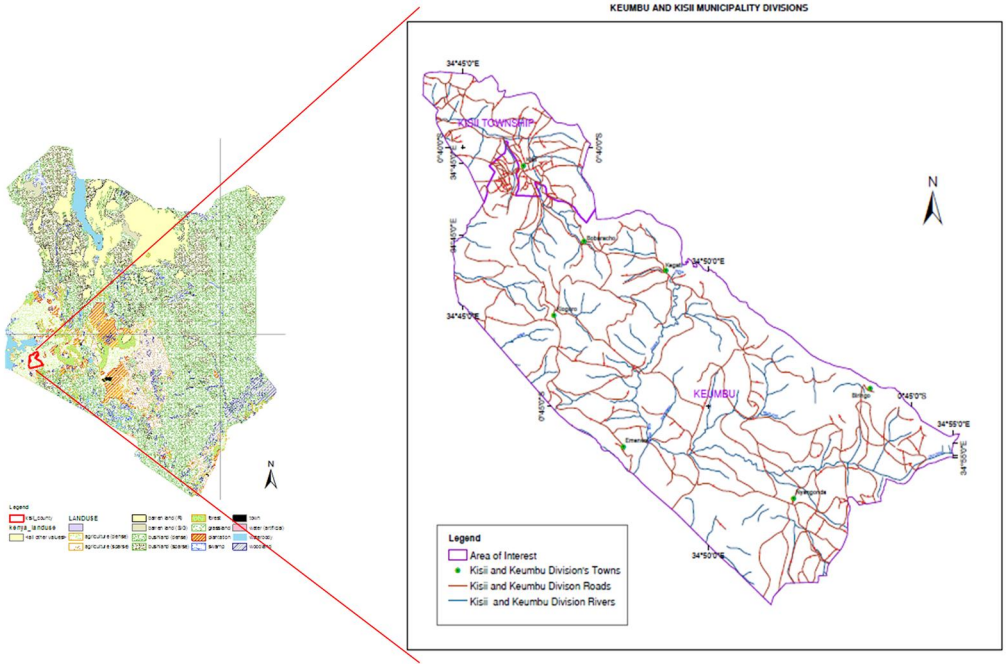


Figure 1: Map showing Keumbu Region in Kisii County

The data sources used were topographic map sheets 130/1, 2, 3 and 4 at a scale of 1:50,000, Land sat Tmimage of path 170 and of row 60 of 1990, 2000 and 2010, Demographic data for years 1989, 1999 and 2009 and Poverty Index data from the Kenya National Bureau of Statistics,Crop production data from the District Agriculture Officer, Soil and Terrain data from the International Livestock Research Institute (ILRI).

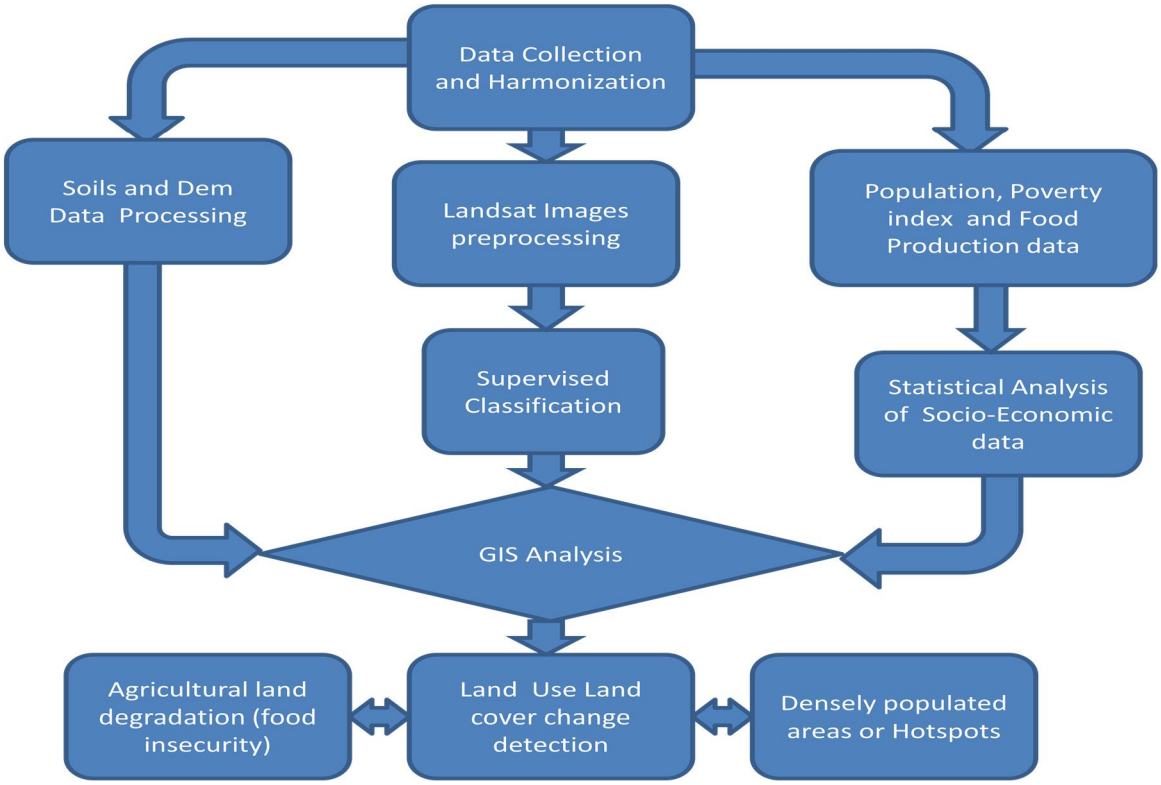


Figure 2: Conceptual framework

The vector and raster data sources were harmonized to the same coordinate system of WGS84 spheroid zone 36S, soil map and DEM developed to determine soil fertility, landsat TM images processing involvedlayer stacking, sub-setting, visual image interpretation, image enhancement. creating training sites, supervised classification, post-classification for change detection and analysis in Erdas Imagine, population, poverty index and food production data were tabulated, maps developed to determine densely populated and poverty stricken areas and correlation analysis done using ArcGIS 10.1, SPSS and Microsoft office computer programmes

3.0 Results

The region is endowed with deep, well-drained, relatively fertile soilswith good rainfall. Most of the farms had soil conservation structures. The main cash crop grown was tea while the foodcrops included maize, beans and sweet potatoes. The soils were of good fertility and drainage but overused. The poor farmers in the region encountered numerous problems, which contributed tolow crop and livestock productivity. These included: continuous cropping on less fertile land, nonuse of therecommended manures, fragile easily erodible soils, poor crop and animal husbandry. Poor soil managementpractices, use of unimproved low yielding crop varieties and livestock breeds had culminated to low livingstandard. In order toincrease the per capita land productivityartificial fertilizers were used as soil fertility had already depleted.

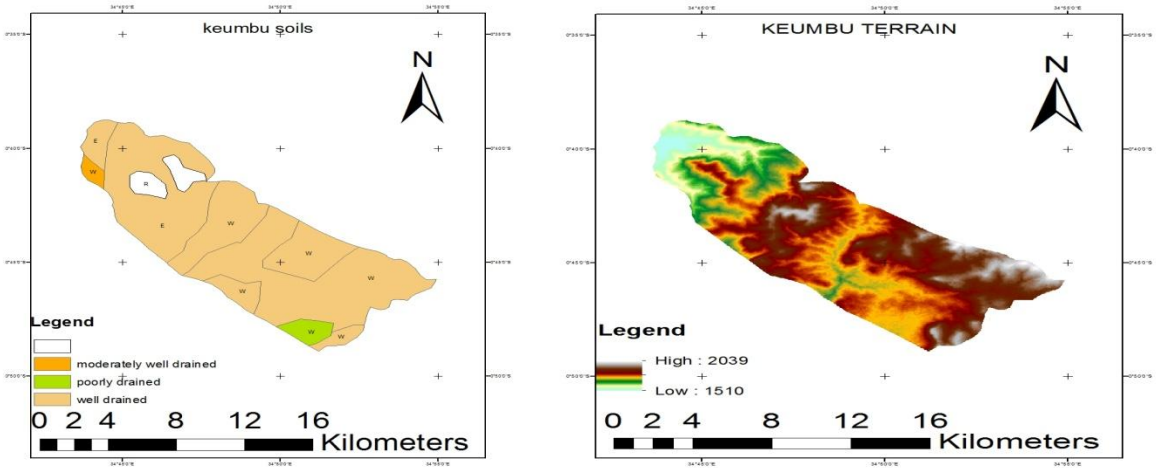


Figure 3: Soil and Terrain maps of Keumbu region

3.1 Population Growth Trends and Land Use

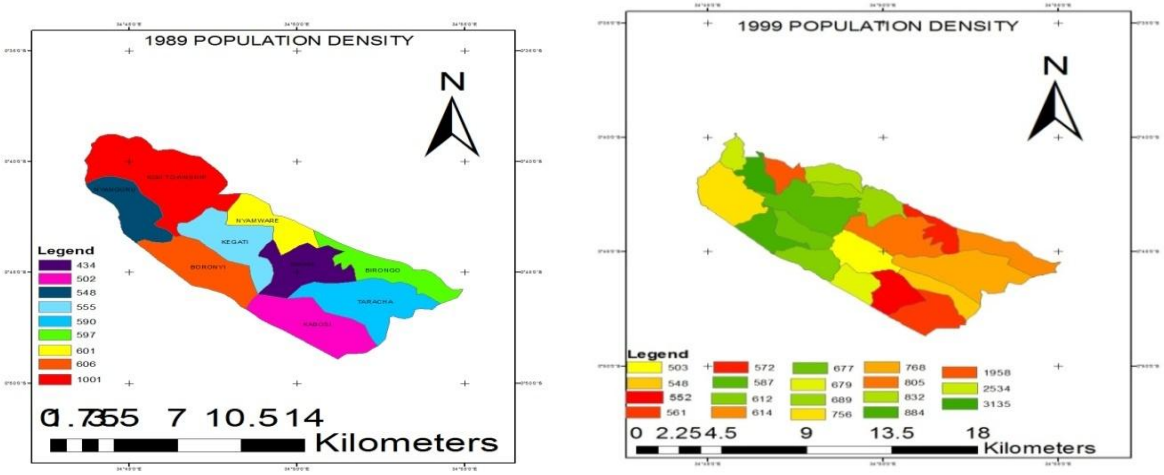


Figure 4: Map showing densely populated as per 1989 and 1999 census

Kisii township location was densely populated with population density of 1001 persons per square kilometers slightly followed by Boronyi location.During the 1999 population census Keumbu division which comprises Kisii municipality that time had 109837 people comprising of 52797 males and 57040 females residing in an area of 132.3 square kilometers.

The average population density of the division in 1999 was 830 persons per square kilometers, with Nyaura location having an extremely high density of 3135 persons per square kilometers. Rural densities go up to 950 persons. The average number of persons per household in the division was 4.9, meaning that the average landholding size per family was approximately 0.6 ha only, deducting the town people o.7 ha. In 2006 these low figures were already reduced to 0.45 ha respectively 0.6 ha. This means very intensive agriculture to make a living out of this small piece of land, a very difficult situation.

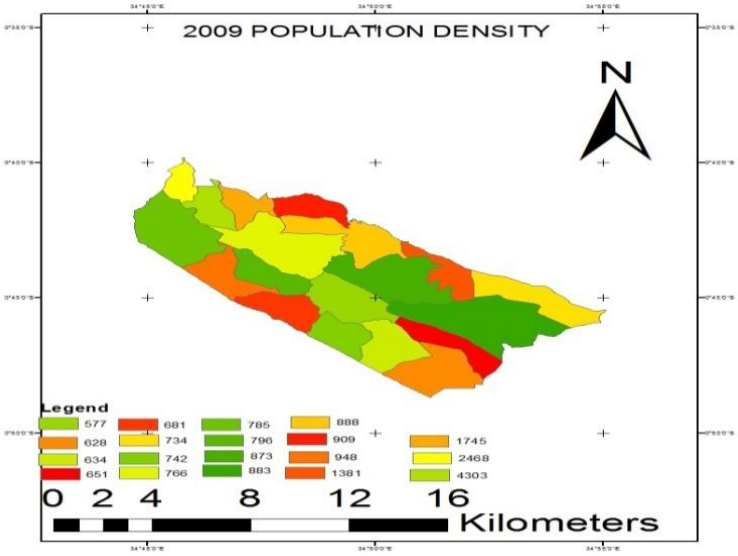
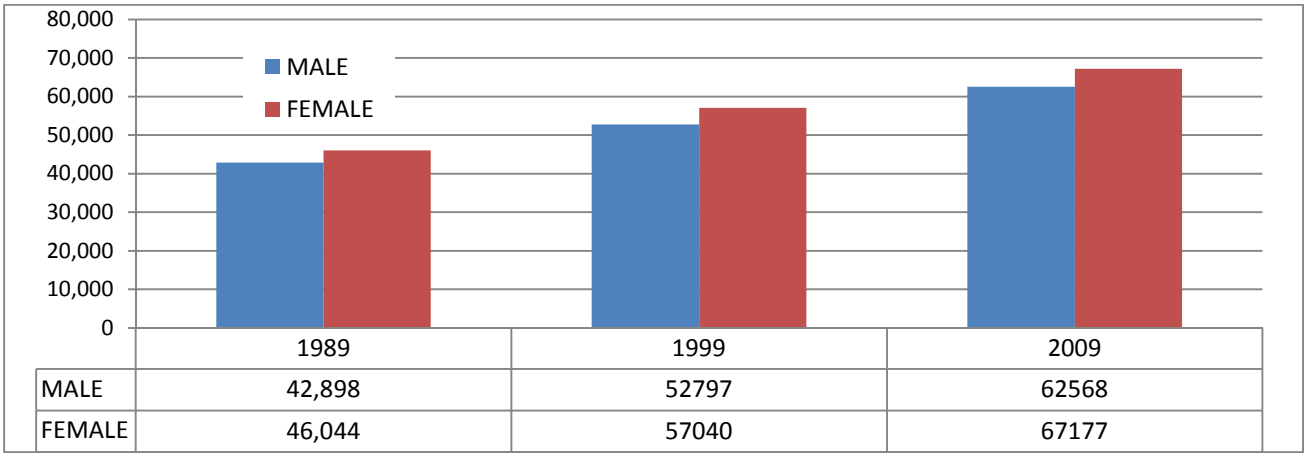


Figure 5: Map showing 2009 population density of Keumbu region

Kisii township location was densely populated with population density of 4303 persons per square kilometers this is because it was partly urban.



	1989	1999	2009
MALE	42,898	52797	62568
FEMALE	46,044	57040	67177

Figure 6: Graph showing population trends of Keumbu region

High population pressure was the main indirect cause of agricultural land degradation followed by poverty. In 1989, Keumbu's population was only 88,942 people, but by 2009 - 20 years later- the population had rose to 129,745 (KNBS). An increased human population resulted in the shrinking of the farm sizes. Without expansion areas, the intensity of land use was increased leading to depletion of nutrients. A large population meant higher demand for fuel wood and land for cultivation and settlement, and these impacted on forestland and grassland leading to the degradation of these resources.

3.2 Poverty Index

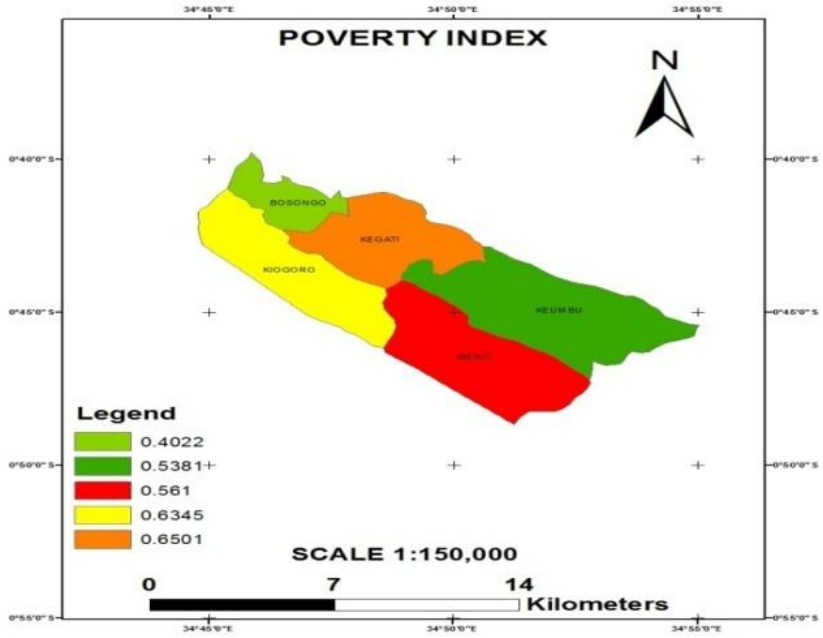


Figure 7: Map of poverty index of Keumbu region

The poverty index Survey conducted in 2005, found that 65% of the population in the Kegati location were living below the poverty line (Republic of Kenya 2005b). In fact the poverty levels in Keumbu region are very high. Resource-poor farmers cannot afford the use of agricultural inputs to replenish the nutrients lost from the farm. Equally, the households lack sufficient labor to invest in soil and forest conservation. Pressures leading to land degradation were stronger in cases of social inequality. Studies have shown that poor small scale landowners tended to cultivate marginal areas such as those with low soil fertility, steep slopes and wetland areas (Kelley 1983). Over time, these fragile areas became overexploited as their occupants did not afford to invest in sustainable management practices.

3.3 Land use Land Cover Changes

Results showed 58% forestland and 91% grassland reduced by 21% and 72%, and 11% of cropland and 0.6% of settlements increased by 12% and 71% between 1990 and 2010 respectively.According to the Keumbu study, 55% of forestland changed to cropland, 2% to grassland, 2% to settlements and 41% remained unchanged. The 60% of grassland changed to cropland, 28% to forestland, 3% to settlements and 9% remained unchanged. The 9% of cropland changed to forestland, 1% to grassland, 1% to settlements and 89% remained unchanged. The 1% of settlements changed to cropland and 99% remained unchanged.

Table 1: Land use change between 1990 and 2010

	Percentages					
	Forestland	**Grassland**	**Cropland**	**Settlements**	**Row Total**	**Class Total**
Forestland	41.157	27.895	9.127	0.143	99.942	100
Grassland	1.728	8.809	1.349	0	100	100
Cropland	55.028	60.04	88.418	0.515	99.943	100
Settlements	2.046	3.209	1.063	99.342	100	100
Class Total	100	100	100	100	0	0
Class Changes	58.842	91.191	11.582	0.658	0	0
Image Difference	-21.908	-72.685	12.618	71.228	0	0

The main driver to deteriorating Agricultural land was established as being the increasing settlements use that has come as a result of increased land sub-divisions and population pressures. The trend for Keumbu's population has been increasing at a rate of 20.5% in average since the census of 1989 and 2009. Increase in population led to conversion of more agricultural land into settlement use. This led a 0.658% increase in settlement land.

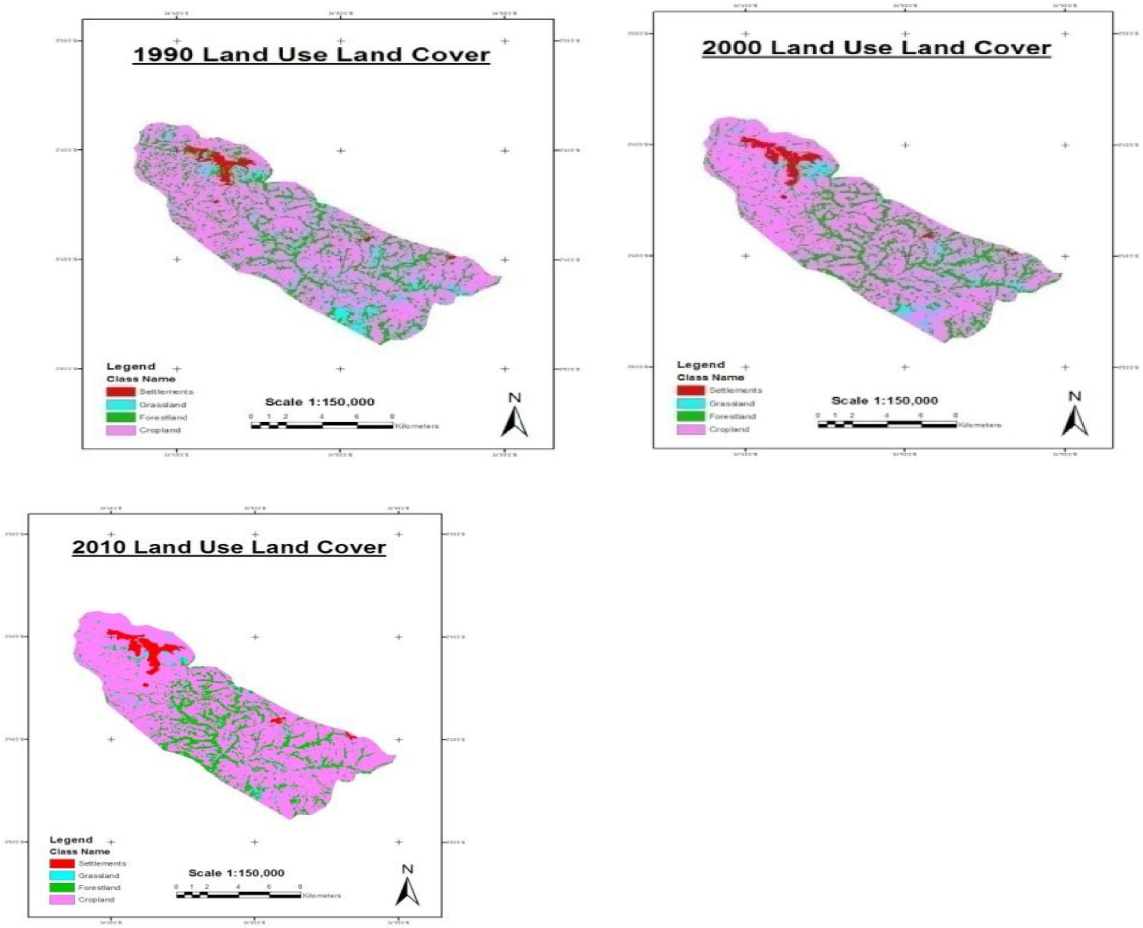


Figure 8: 1990, 2000 and 2010 land use land cover changes maps

3.4 Food and Cash crops, Total Acreage Achieved and Production

It was found out that most of agricultural land was under crops. In small scale holder areas, an average of 1.7 acres of land had been put under food and cash crops and the majority (36%) of the households had two acres of land under food crops. In the earlier 1990s most people had two to four acres of land under food crops but this reduced with time paving way for cash crops and settlements as population increased. Cash crops were grown by about 70% of the small scale holders. They had up to 2 acres of their land under cash crops, although this fell to a low of one tenth of an acre.

Maize, Bean, Sweet potatoes, Finger millet, Tea and Coffee were the commonly and most grown crops in every agricultural household in Keumbu region. This could be because these food crops do not require any further processing and so Households find them convenient to grow. Due to reduced agricultural land, households have adopted mixed cultivation on small pieces of land so as to maximize the land. Production in metric tons per hectare was computed for two year data points basing on the available statistics. From Table 2, production and land area per crop for each crop for a two year period is shown. The Figure shows that production for crops like Maize, Finger millet, Beans, Sweet potatoes, Tea and Coffee was declining by 2010.

Table 2: Crop production per acreage

Year						
	Maize	**Finger Millet**	**Beans**	**Sweet Potatoes**	**Tea**	**Coffee**
1990	2.70	0.54	0.36	12.00	0.43	6.25
1991	2.67	0.54	0.36	13.44	0.43	6.25
1992	3.60	0.81	0.12	1.78	0.43	6.24
1993	2.89	0.76	0.56	1.74	0.43	6.25
1994	3.34	0.81	0.34	1.68	0.43	6.25
1995	3.15	0.72	0.54	75.56	0.43	6.25
1996	2.70	0.72	0.54	21.86	0.43	6.25
1997	2.88	0.81	0.54	10.82	0.43	6.25
1998	2.88	0.72	0.64	20.78	0.43	6.25
1999	2.51	0.17	0.31	2.40	0.43	6.24
2000	2.70	0.54	0.36	7.20	0.43	5.79
2001	2.88	0.72	0.36	24.00	0.43	6.25
2002	2.70	0.54	0.36	17.00	0.43	6.25
2003	2.39	0.36	0.38	3.08	0.43	6.25
2004	2.91	0.56	0.19	3.64	0.43	6.25
2005	1.98	7.26	0.13	7.86	0.43	6.25
2006	2.45	0.27	0.16	8.00	0.43	6.25
2007	1.97	0.22	0.14	8.18	0.43	6.25
2008	1.26	0.52	0.14	8.00	0.43	6.25
2009	1.62	0.81	3.32	11.90	0.43	6.25
2010	0.94	0.81	0.54	17.00	0.43	6.25

In terms of production, Figure 9 shows that there was a general decline in land (ha) under cultivation of these four main food crops. The figure further shows that much as maize was mostly consumed by Keumbu households, it was the most highly grown crop. This could be due to the fact that maize can mix with beans, take shorter period

to grow and do not take too much space than tea. Households preferred to put more land under beans which matures faster.

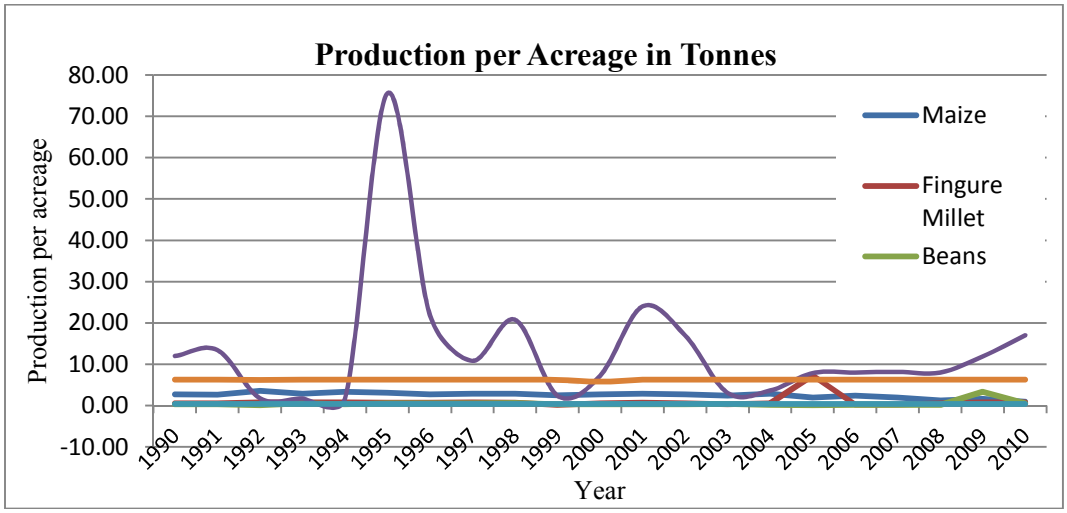


Figure 9: Production in tons per hectare

3.5 Population, Land Use Changes and Food Security

The relationship between population growth, land use changes and implications for food production and security was determined by Pearson correlation analysis. Using population, food production and land use land cover changes of three point data for correlation and data was in numerical form.

Table 3: Production, population and land use land cover changes data

	Food crops	Population	Forestland	Grassland	Cropland	Settlement
1990	13,164.60	89,942.00	3,572.01	1,133.10	10,969.20	314.37
2000	13,679.54	116,229.00	3,412.98	784.26	11,327.49	464.67
2010	10,809.58	129,745.00	2,789.46	309.51	12,353.31	538.29

Using results from Table 4 of correlation analysis, population growth had a moderate negative relationship with crop production. Increase in population demanded changes in land use where more land was converted to crop cultivation for more food production. Forestland had a strong positive correlation relationship with crop production since forest created conducive environment for agriculture as soil fertility was increased due to making the land furrow and adequate rainfall. Settlements had a moderate negative relationship with food crop production as farmland was reduced due to land subdivisions, village settlements, and shopping centers and towns.

Table 4: Correlations results

		Year	Population	Forestland	Grassland	Cropland	Settlement
Pearson Correlation	Year	1.000	.983	-.946	-.996	.963	.981
	Population	.983	1.000	-.871	-.963	.898	1.000
	Forestland	-.946	-.871	1.000	.971	-.998	-.865
	Grassland	-.996	-.963	.971	1.000	-.983	-.960
	Cropland	.963	.898	-.998	-.983	1.000	.893
	Settlement	.981	1.000	-.865	-.960	.893	1.000
Sig. (1-tailed)	Year	.	.058	.105	.028	.086	.062
	Population	.058	.	.163	.086	.145	.004
	Forestland	.105	.163	.	.077	.019	.167
	Grassland	.028	.086	.077	.	.058	.090
	Cropland	.086	.145	.019	.058	.	.149
	Settlement	.062	.004	.167	.090	.149	.
N	Year	3	3	3	3	3	3
	Population	3	3	3	3	3	3
	Forestland	3	3	3	3	3	3
	Grassland	3	3	3	3	3	3
	Cropland	3	3	3	3	3	3
	Settlement	3	3	3	3	3	3

Table 5: Descriptive Statistics for correlation analysis

	Mean	Std. Deviation	N
Year	2.0000E3	10.00000	3
Population	1.1197E5	20240.08990	3
Forestland	3.2582E3	413.61259	3
Grassland	7.4229E2	413.39598	3
Cropland	1.1550E4	718.38231	3
Settlement	4.3911E2	114.12724	3

Significance level is 0.05 or 5%.
This guide was used to interpret correlation values

- Pearson's *(r)* and Spearman *(ρ)* are correlation coefficients

Range from -1 to 1

- -1 = Perfect Negative relationship
- 0 = No relationship
- 1 = Perfect Positive relationship

- As a guide:
- ± (0.1 – 0.3) = Weak
- ± (0.4 – 0.7) = Moderate
- ± (0.7+) = Strong

Results from table 4 show that by 1990, Keumbu region was already food insecure in terms of available agriculture land degradation. From 1990 onwards as urbanization increased through increasing population, the agricultural land degradation kept on widening as a result of reducing available land as shown in figure 9. Currently the region is food insecure; to grow food crops for the current population on the already degraded agricultural land is quite impossible. Other conditions remaining constant, figure 9 also shows that available agricultural land in Keumbu region will cease out by the year 2030.

4.0 Conclusion and Recommendation

Keumbu is food insecure region with agricultural land already degraded and densely populated with high poverty levels.The government and other stakeholders should make small scale farmers adapt good farming practices and land tenure systems that will take care for the growing population and natural resource utilization. This would always check on how much natural resource is available to sustain the population. In this way, measures combating population growth and resource utilization would be determined. This will reduce the risks ahead of human life in terms of land and food availability.

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