Environmental Monitoring and Information Systems (EMIS)
Final Report to USAID

Theme 1 – Remote Sensing of Human Impacts
Theme 2 – Organizing Data and Regional GIS Data Access
Theme 3 – Networking Among Regional Data Users for Capacity Building
Theme 4 – Sustainable Tree Crop Management, Monitoring, and Certification

Theme 5 – Soil Carbon Sequestration

SEMSOC final report

d. Ghana report

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GHANA

Introduction

Human activities such as the burning of fossil fuels, deforestation, grassland conversion, and other land-use changes have contributed to large increases in the amount of carbon dioxide (CO_2) and other greenhouse gases in the atmosphere. It is believe that this rapid increase in atmospheric CO_2 has resulted in some human-induced global warming. Most experts agree that if the warming trend continues, climate change is inevitable: a variety of strategies are therefore needed to reduce CO_2 emissions and remove carbon from the atmosphere in order to mitigate the potential effects of climate change.
One possible mechanism for climate change mitigation is carbon sequestration, which redistributes carbon from the air to soils, terrestrial biomass, geologic formations, and the oceans. In some regions of the world, carbon sequestration in soils represents the most promising option for climate change mitigation.
Carbon enters the soil as roots, litter, harvest residues, and animal manure. It is stored primarily as soil organic matter (SOM). The density (weight/volume) of carbon is highest near the soil surface, but much of these decompose rapidly, releasing CO_2 to the atmosphere. Some carbon however becomes stabilized, especially in the lower part of the soil profile.

The West Africa land use /land cover project in Ghana observed a rapid change in forest lands, savanna, bare surface, settlements and water bodies with moderate expansion of crop land from 1972 to 2000. These changes which are due to agriculture and other land-use activities have altered the balance in the soil carbon cycle, contributing to an increase in carbon release from soils to the atmosphere in the form of CO_2.
Carbon sequestration in soils is a climate-change-mitigating strategy based on the assumption that carbon from the air to the soil can be increased while the release of carbon from the soil back to the atmosphere is decreased. Certain activities change soil as a carbon source (emits carbon) into a carbon sink (absorbs carbon); this transformation has the potential to reduce atmospheric CO_2, thereby slowing global warming and mitigating climate change. At the same time, land and soil management practices that help sequester carbon in soils can lead to higher soil fertility, increased yields, and other outcomes that aid local populations economically, environmentally, and socially. It also has great potential in regard to the international trading of carbon credits, where one nation may offset its carbon emissions by supporting carbon sequestration in some other part of the world.
Based on the above the Spatially Explicit Modeling of Soil Carbon (SEMSOC) Ghana project under SAIC/USGS was formed to assess and evaluate the land cover / land use change of Ghana and quantify the current biomass and soil carbon stocks and changes over time. And then identify adaptation and mitigation opportunities derived from land use changes and appropriate land management options which will lead to enhanced carbon sequestration, food security and sustainable livelihood.

Ghana has distinct vegetational zone which cuts across the country from high rain forest in the south-western corner through forest-savanna transitional zone in the middle part of the country to sudan savanna at the north eastern corner. The tropical forest has been reduced to secondary forest while the savanna zone is being threatened to desertification.

The study therefore addresses a critical need to provide quantitative understanding of how this vegetational profile is changing. In Ghana, the major challenge facing policy makers and scientist is lack of comprehensive data on the types and rates of land use land cover changes for development planning and sustainable management.
The findings of this study would come out with land use land cover trends and the driving factors that effected the change. It would also have direct implications for the quantity and distribution of carbon storage and also serve as an input to biogeochemical modelling.

Project Area

In Ghana land use trend analysis was conducted in three (3) areas, selected to cut across the major ecological zones of Ghana (figure 1). These include Assin district (2,416km^2) representing the high forest, Ejura-Sekyedumasi (1,244km^2) of the forest/transitional and Bawku district (2,130km^2) representing the savanna zone respectively. The 3 project areas lie between latitudes $4^0$44' and $11^0$15'N and longitudes $3^0$15'W and $1^0$12'E. (figure 1).

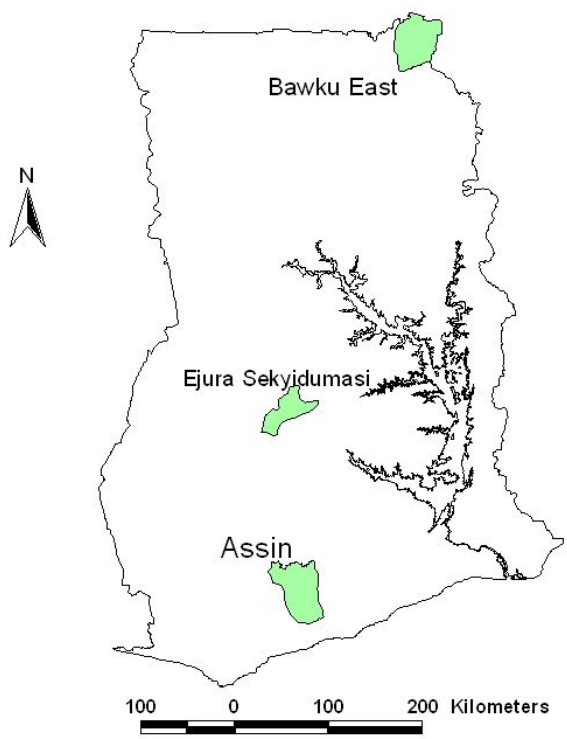


Figure1: Location of the three study areas in Ghana

1. Land Use/Land Cover Change Assessment

1.1. Objectives

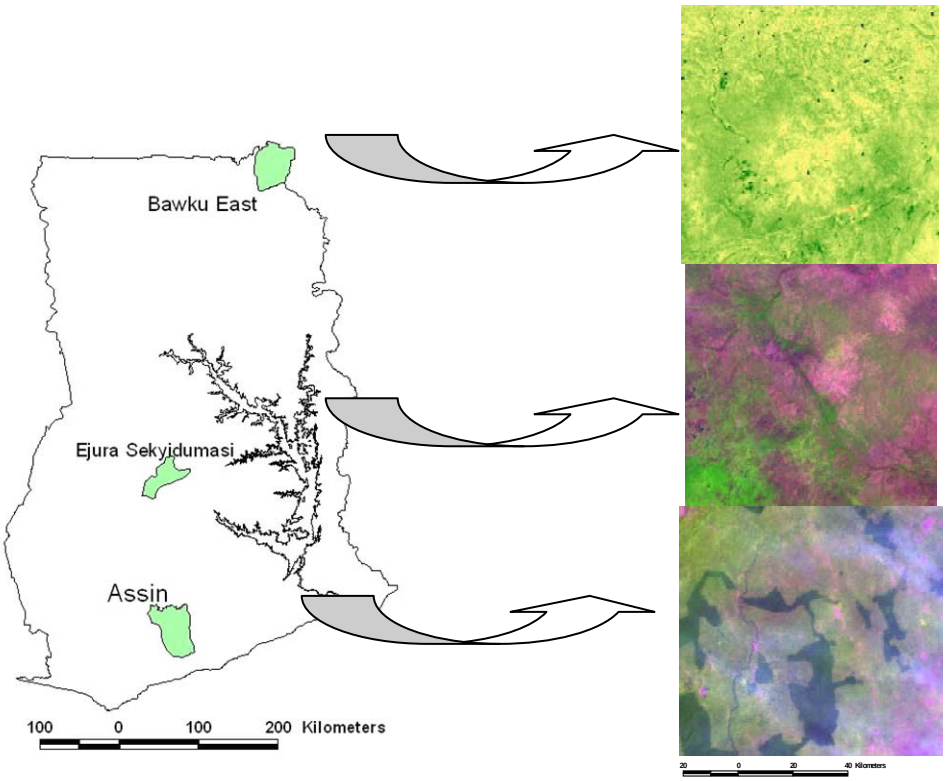
The principal purpose of the mapping project was to provide an in-depth assessment of land use change and identification of land resource improvement and degradation. The specific objectives include:

- determine changes in landuse/ land cover activities over time and highlight the state and condition of the resources;
- determine drivers of land use change
- investigate NDVI to identify areas of increase and decrease greenness and
- outline future trends and interventions.

1.2. Expected Output

The expected outputs of the land use/ land cover component of the SEMSOC project were:

- Thematic maps in print and digital showing historical changes of Assin, Ejura Sekyedumasi and Bawku districts
- Data bases showing trend analysis for each of the study area
- Description of systems and trends for each land-use activity
- Description of drivers to change and future interventions for sustainable development



1.3. Approach and Methodology

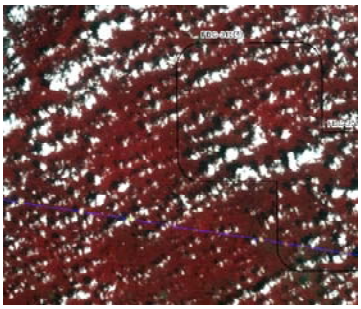
Approach

The approach for determining the land use classes were based on the Centre for Remote Sensing and Geographical Information Systems (CERGIS) base map in 1990. In addition, new land use types were derived for areas which were not distinctly mapped on the base map.

Although the project initially purposed to undertake change mapping for 1972, 1985 and 2000, limitation of Landsat images in some of the study area necessitated in mapping in the following:

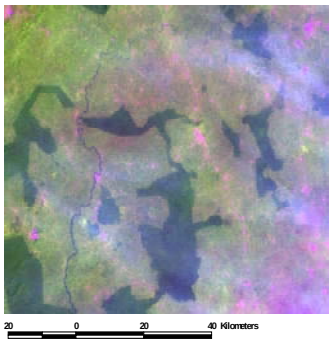
- 1985 and 2000 for Assin district due to clouded Landsat image of 1986 (fig.2)
- 1972 and 2000 for Bawku district due to the fact that 1985 Landsat images for mosaic were not in the same resolution (figure 4) and
- 1972, 1985/6 and 2000/01 for Ejura-Sekyedumasi district (figure 3)

No NDVI was calculated because all the images for 1972 were in jpeg format.

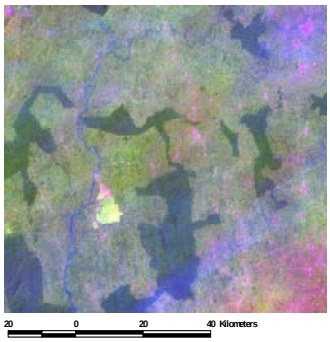


1986

Figure 2: Clouded Landsat image of 1986 of Assin Study area

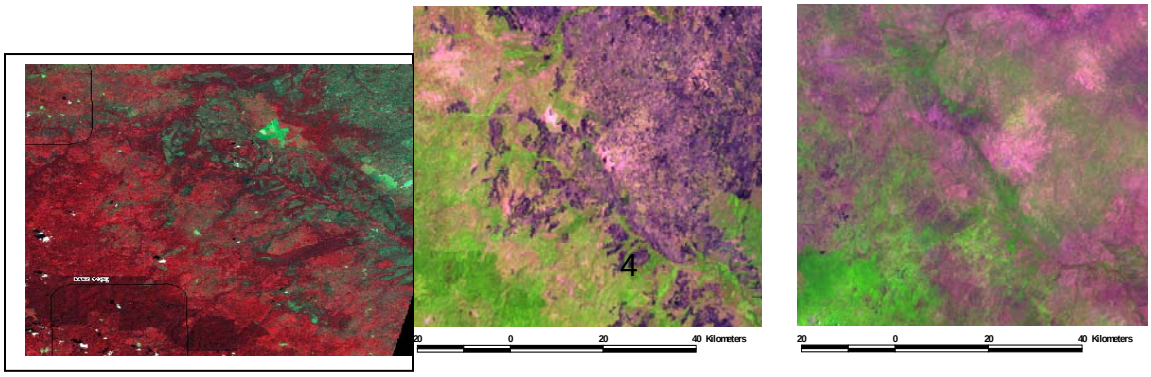


1985



2000

Figure 3:1985 and 2000 Landsat images used for the Assin study area

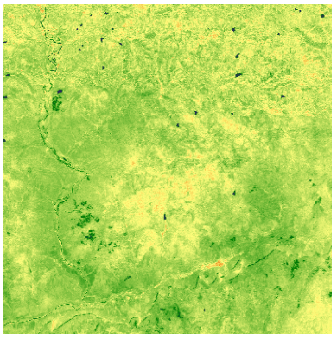


19
72
1972

1972 **1986** **2000**

Figure 4: 1972, 1986 and 2000 Landsat images used for the Ejura study area

1972



2000

Figure 5: 1972 and 2000 Landsat images used for the Bawku study area

During the fieldwork, the project team consulted a lot of communities within the study area to gain indigenous knowledge relating to the community's usage of the land and conservation practice employed to ensure sustainable management.

Methodology

The mapping exercise was done using Landsat images of 1972, 1986 and 2000. All the images which were received, had been georeferenced by USGS EROS Data Centre. Apart from the MSS (1972) images which were in false colours, the TM (1986) and the ETM (2000) were in natural colours making mapping and interpretation more friendlier.

The following classification systems were used for each study area based on the land use/ land cover of the satellite images as follows:

Assin district

- Closed forest (>60%)
- Moderately closed trees (>15 trees/ha) canopy with herb and bush cover
- Moderately dense herb /bush with scattered trees (<15 trees/ha)
- Planted cover
- Settlement

Ejura-Sekyedumasi district

- Closed cultivated savanna woodland (>20 trees/ha)
- Closed savanna woodland (>25 trees/ha)
- Moderately dense herb/bush with scattered trees (<15 trees/ha)
- Open cultivated savanna woodland (11-20 trees/ha)
- Open forest (<60%)
- Planted area
- Riverine savanna vegetation
- Settlement
- Widely open cultivated savanna woodland (6-10 trees/ha)

Bawku district

- Grass/herb with/without scattered trees (0-5 trees/ha)
- Open cultivated savanna woodland (11-20 trees/ha)
- Open forest (<60 %)
- Open savanna woodland (<25 trees/ha)
- Riverine savanna vegetation
- Settlement
- Widely open cultivated savanna woodland (6-10 trees/ha)

In each of the study area, six main processes were carried out during the land use/land cover interpretation and change detection stage. The activities were:

Satellite data preparation

- Mosaicking - where more than one Landsat satellite data is required to cover study area as in Bawku district.
- Image enhancement using adobe photo

Preliminary land use land cover interpretation

Team members created land use land cover maps for 1972, 1986 and 2000 from respective images using their image interpretation skills and other ancillary data such as 1:50,000 topographic maps and Ghana at a glance.

Field verification

The image interpreters identified and visited specific sites on the images with GPS technology to navigate to the site to cross-check their interpretation.

Final image interpretation – where the finding of the fieldwork were incorporated into the preliminary interpretation to produce refined land use/ land cover maps for the study areas

Change detection and analysis – where the data sets of final land use/ land cover maps for 1986, 1972 and 2000 are analysed and statistics of land use land cover change produced for 1972, 1986 and 2000. Annual rate of change were also determined for each of the classification systems

Producing shape files for biogeochemical modelling – where various important GIS databases of the study areas were produced in shape files. These GIS layers of the land use classes were compiled for the running of the GEMS model.

Software Used
The software used were Idrissi Andes
ArcGis 9.0
Arcvier 3.2a
Adobe Photoshop

1.4. Analysis and Results

Land use/land cover mapping were analysed for each of the study areas below:

a) Assin district –the high rain forest study area
As shown in figures 5 and 6 land use land cover classes were mapped in the study area.

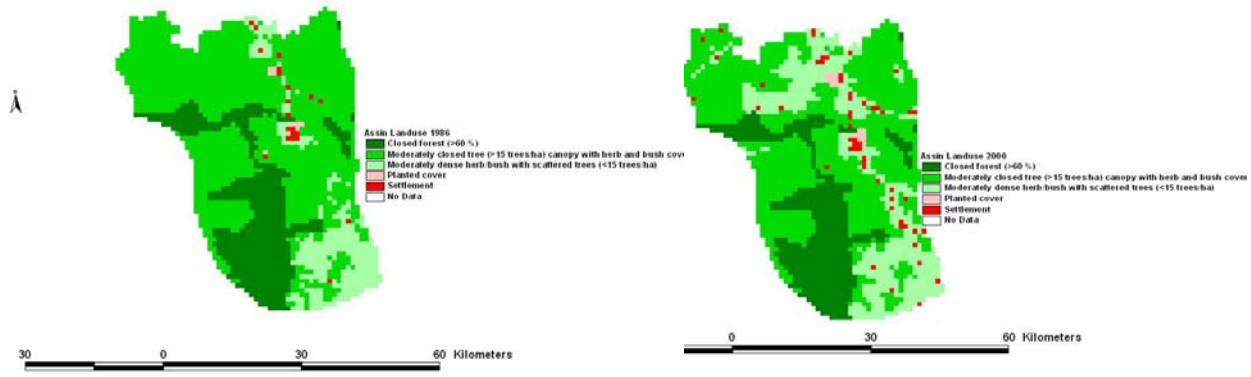


Figure 6: *Land use and land cover maps of 1986 and 2000*

They were:
- Closed forest (>60%)
- Moderately closed trees (>15 trees/ha) canopy with herb and bush cover
- Moderately dense herb /bush with scattered trees (<15 trees/ha)

- Planted cover
- Settlement

The table and figures shows analysis of the total area covered by each of the 5 land use/land cover types in 1986 and 2000 as mapped from the Landsat satellite images. They also illustrate the changes that were calculated by subtracting the sums of the areas of each cover class in 2000 from their corresponding areas in 1985. The annual rate of change was also computed for the 15 year period of the satellite images.

Table 1: *Total areas of land use/ land cover per class, change and rate of changes in areas from 1986 to 2000.*

Land use / Land cover Class	**1986 Area (Km^2)**	**2000 Area (Km^2)**	**1986 to 2000 Area Change (Km^2)**	**Rate of Change (km^2/yr)**
Closed forest (>60 %)	524	504	-20	-1.33
Moderately closed tree (>15 trees/ha)	1557	1277	-280	-18.67
Moderately dense herb/bush with scattered trees	306	564	258	17.20
Planted cover	8	16	8	0.53
Settlement	21	55	34	2.27

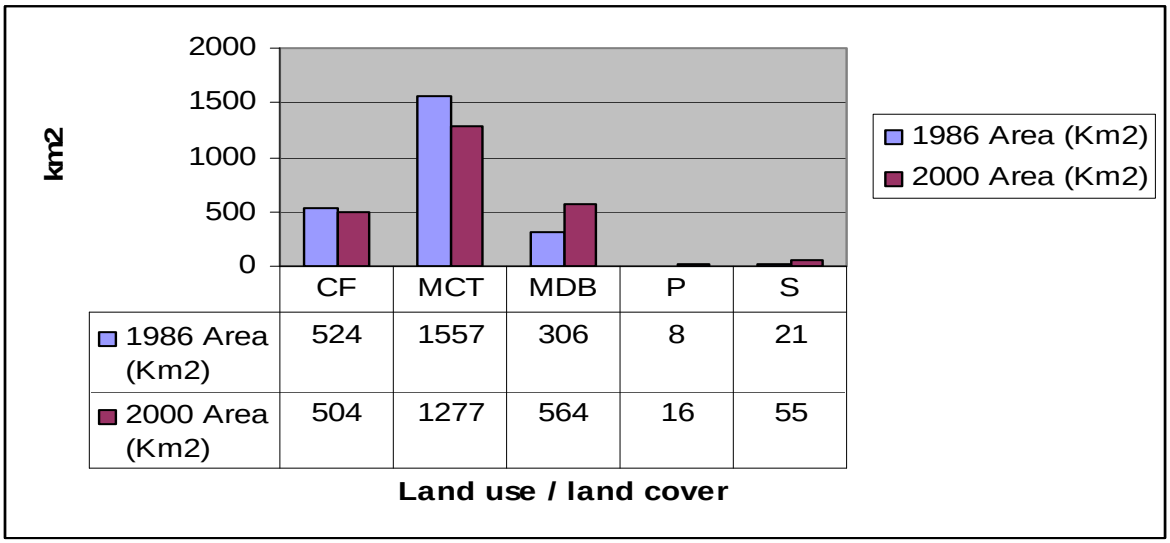


Figure 7: *A graph showing changes (km^2) of cover types between 1985 and 2000*

From the results indicated in the table 1 and figure 7, the changes in land cover types that occurred in the Assin district between 1985 and 2000 were moderately stable. Area under closed forest slightly reduced from 524km^2 to 504km^2 (20km^2) due to strict regulations on the protected areas. However, area under moderately closed trees showed significant decrease by 280 km^2 between 1985 and 2000 given way moderately dense bush due to increase in human population and scarcity of land for agriculture.

The two (2) land cover types show phenomenal increment in area. They are settlement and planted area that increased by 34km^2 and 8km^2 respectively.

Change in land cover types

Table 2 shows the change areas in km^2 by land cover types that occurred in Assin district between 1985 and 2000. The major changes occurred in the Assin District as follows:

Other notable changes were closed forest to moderately closed trees (23 km^2), moderately closed tree to settlement and moderately dense herb to settlement as 11km^2 and 19 km^{2}respectively. This explains that increase in human population due to expansion of settlement of 42 km^2 has consequently led to decline of vegetation cover in the district.

Table 2: Land use / land cover changes by class for 1986 and 2000

LAND USE/LAND COVER CAHNGE (1985-2000)	**AREA IN KM^2**
Closed forest to moderately closed trees	23
Moderately closed trees to planted cover	8
Moderately closed trees Moderately dense bush	380
Moderately closed trees to close forest	3
Moderately close trees to settlement	11
Moderately dense herb to settlement	19
Moderately dense herb to settlement	7

Drivers of land use change in the Assin district

- Spontaneous rise of farmer population
- High demand of land for cash crop plantations (oil palm, teak, oranges and cocoa)
- Slash and burn farming methods and
- Illegal exploitation of natural resources

Future trends and interventions

The enormous demand for more land for cash crop plantations coupled with increase in human population and slash and burn farming had resulted in mass decline in tree cover outside the government protected areas. This occasionally had led to encroachment of the permanently protected forests, which currently remains the only priority areas for wildlife and nature conservation. The situation poses a great threat to continuous reservation of the remaining forest for posterity.

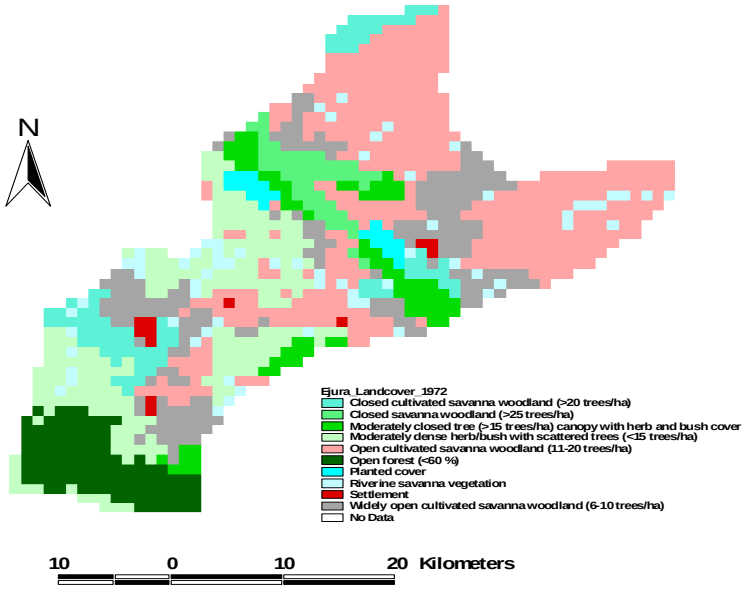
With increasing environmental awareness and the desire to protect tropical forests with local participation, it is expected that buffer zones could be created around the forest reserves to keep human activities away from the protected forest reserves.

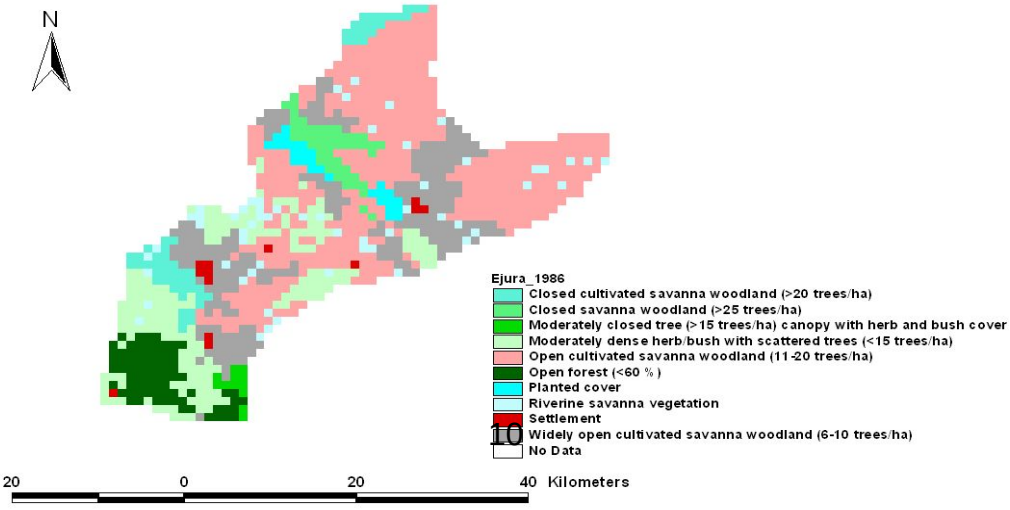
Alternative livelihood support projects and cottage industries, which could possibly help ensure sustainable use of agricultural lands, alleviate poverty and reduce pressure on the remaining forestlands, must be encouraged as a means of protecting the remaining resources.

b) Ejura-Sekyedumasi district – forest/savanna transitional zone.

As shown in figures 8 land use land cover classes were mapped in the study area. They were:

- Closed cultivated savanna woodland (>20 trees/ha)(CCSW)
- Closed savanna woodland (>25 trees/ha)(CSW)
- Moderately dense herb/bush with scattered trees (<15 trees/ha)(MDB)
- Open cultivated savanna woodland (11-20 trees/ha)(OCSW)
- Open forest (<60%) (OF)
- Planted area (P)
- Riverine savanna vegetation (R)
- Settlement (S)
- Widely open cultivated savanna woodland (6-10 trees/ha) (WOCS)





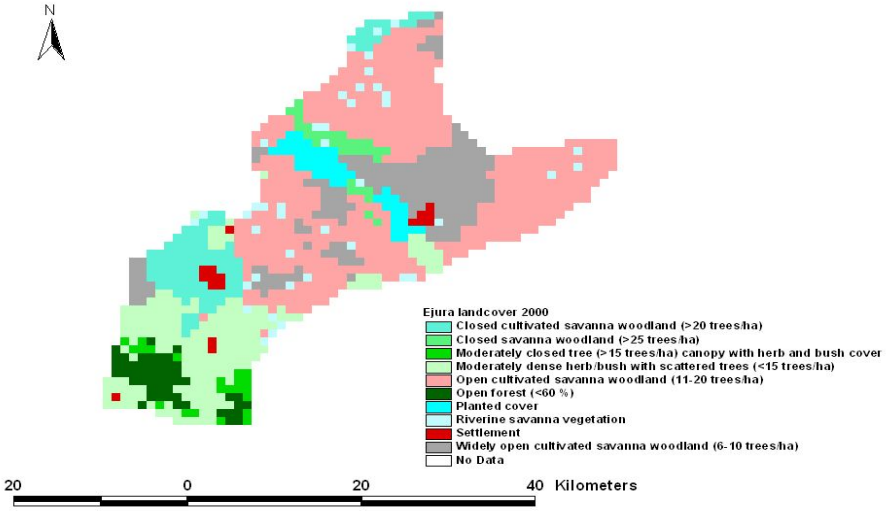


Figure 8: *Land use and land cover maps of 1972, 1985 and 2000*

The table 3 and figures 8 show land use/land cover types in 1972, 1986 and 2000 as mapped from the Landsat satellite images. Land use land cover changes were calculated by each of the land cover classes in 2000 from 1985 and 1985 from their corresponding areas in 1972. The annual rate of change was calculated over the 28- year period of the satellite images.

Table 3: *Total areas of land use/ land cover per class, change and rate of changes in areas from 1986 to 2000.*

Land use / Land cover Class	**1972 Area (Km^2)**	**1986 Area (Km^2)**	**2000 Area (Km^2)**	**1972 to 1986 Area Change (Km2)**	**1986 to 2000 Area Change (Km2)**	**Total Change**	**Rate of Change (km^2/yr**
Closed cultivated	50	57	100	7	43	50	1.79

savanna							
Closed savanna woodland	71	48	31	-23	-17	-40	-1.43
Moderately closed tree (>15 trees/ha)	21	12	22	-9	10	1	0.04
Moderately dense herb/bush with scattered trees	186	189	198	3	9	12	0.43
Open cultivated savanna	463	521	541	58	20	78	2.79
Open forest (<60 %)	106	76	51	-30	-25	-55	-1.96
Planted cover	27	28	49	1	21	22	0.79
Riverine savanna vegetation	82	58	42	-24	-16	-40	-1.43
Settlement	12	13	17	1	4	5	0.18
Widely open cultivated savanna	226	242	193	16	-49	-33	-1.18

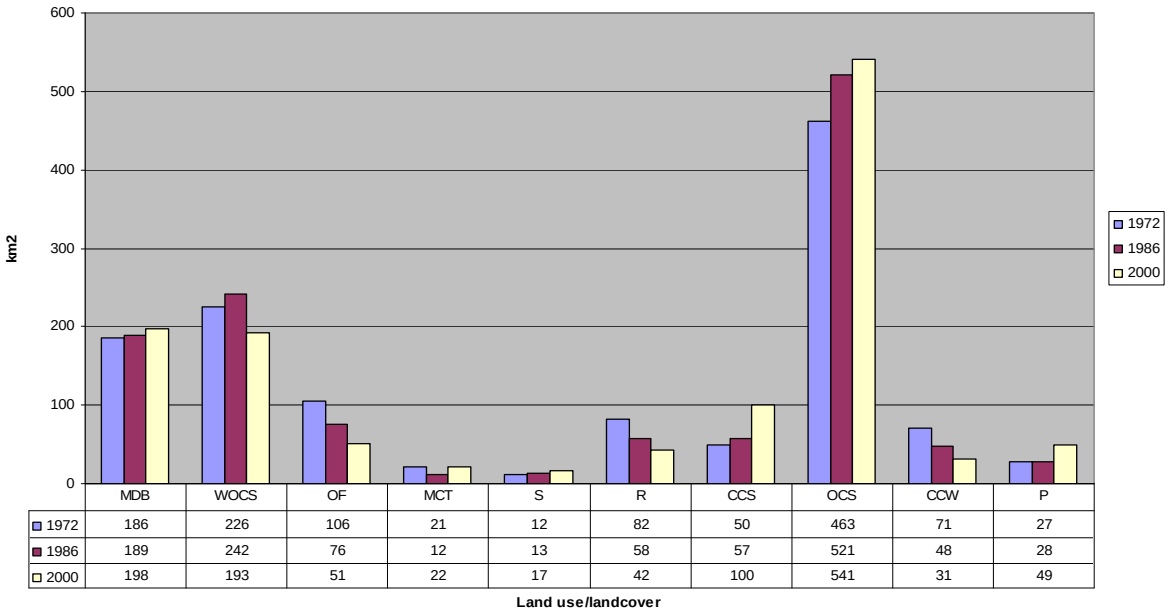


Figure 9: *A graph showing areas and changes (km^2) of cover types between 1985 and 2000*

From the results indicated in the table 3 and figure 8, woody vegetation in a form of open forest, riverine vegetation and closed woody savanna reduced from 105 km^2 to 51 km^2, 82 km^2 to 42 km^2 and 71 km^2 to 31 km^2 between1972 and 2000 respectively indicating destruction of more than half of the vegetation cover.
From figure 4, more than half of that Ejura land area is covered by open cultivated savanna in 2000. It therefore indicates that closed cultivated savanna and open cultivated savanna generally increased from 50 km^2 to 100 km^2 and 463 km^2 to 541 km^2 from 1972 to 2000. However, plantations increased only by 22 km^2.

Table 4: Land use land cover changes by class for 1972 and 2000

LAND USE/LAND COVER CAHNGE (1972-2000)	**AREA IN KM^2**
Open forest to moderately dense herb	19
Open forest to moderately close trees	16
Closed savanna woodland to planted cover	4
Closed cultivated savanna to widely cultivated sav.	4
Moderately close trees to planted area	15
Moderately close trees to moderately dense herb	16
Moderately close trees to open cultivated savanna woodland	30
Moderately close trees to widely open cultivated savanna	7
Open cultivated savanna woodland moderately dense herb	23
Open cultivated savanna woodland close cultivated savanna	17
Open cultivated savanna woodland widely open savanna	68
Open cultivated savanna woodland riverine savanna	10
Planted cover to open cultivated sav, woodland	5
Riverine savanna vegetation to planted cover	11
Riverine savanna vegetation to moderately dense herb	3
Riverine savanna vegetation to close cultivate savanna	6
Riverine savanna vegetation open cultivated sav.woodland	29
Riverine savanna vegetation widely open cultivated sav.woodland	5
Widely open cultivated savanna woodland moderately dense herb/bush	34
Widely open cultivated sav. woodland close cultivated sav. Woodland	32
Widely open cultivated savanna woodland to open cultivated savanna	49
Widely open cultivated savanna woodland to riverine savanna	3
Widely open cultivated savanna woodland to settlement	1
Moderately dense herb to close cultivared savanna	5
Moderately dense herb to open cultivated savanna woodland	83
Moderately dense herb to widely open cultivated sav woodland	27
Moderately dense herb to settlement	2

Table 4 therefore confirms that, 83 km^2 were converted from moderately dense herb/bush to open cultivated savanna woodland, while 68 km^2 of the open cultivated savanna woodland was converted into widely open cultivated woodland. It is also wealth to note that 29 km^2 of the riverine vegetation was cultivated into open savanna woodland.

Drivers to land use change

- Wildfires
- Mechanization and extensive land cultivation
- Charcoal production
- Traditional slash and burn farming methods
- Widespread burning of rangeland by herdsmen
- Decline in soil fertility
- Illegal exploitation resources
- Increased population density

Future trends and interventions

The Ejura Sekyedumasi which lies within the forest/ savanna zone had lost its forest cover given way to savanna woodland. This is viewed against the background that wood harvesting for use in domestic and commercial levels are not well integrated into farming practice, particularly mechanical farming. This also reveals that woodlots established purposely for meeting fuel wood demands are not appreciably developed in the district. This is crucial to sustaining the woody resources while addressing fuel wood needs.

Mechanized agriculture, which first altered the high forest cover, needs to incorporate agro-forestry practices to avert further decline of the current increase in desertification. Charcoal production, extensive cultivation, inappropriate farming methods and the use of fire as a major domestic energy source will continue to deplete the vegetation and reduce the soil fertility, if appropriate measures are not taken to regulate the situation.

Education on the use of fire in farming systems and application of agro-forestry techniques hold the future of meeting food security in the district. This could help enhance regeneration and protect the current vegetation cover from perpetual loss and control of desertification.

Managing natural resources for the future is the responsibility of the by local community among national, regional and global environmental agencies. In an attempt to tackle land degradation, greater environmental education and awareness need be created in all levels of society to enable people consider and appreciate the value of natural resources and to restore them to safeguard the environment and manage them as a productive resources. This will help provide conditions for soil restoration and protection from erosion, wildlife habitat, grazing for pastoralists, wood fuels, fruits and medicinal products from the already degraded land of the district.

c) Bawku district – Savanna Study area

As shown in figures 10, land use land cover classes were mapped in the study area for 1972 and 2000. The satellite image for 1985 was not mapped because they were not in the same resolution for mosaicking.

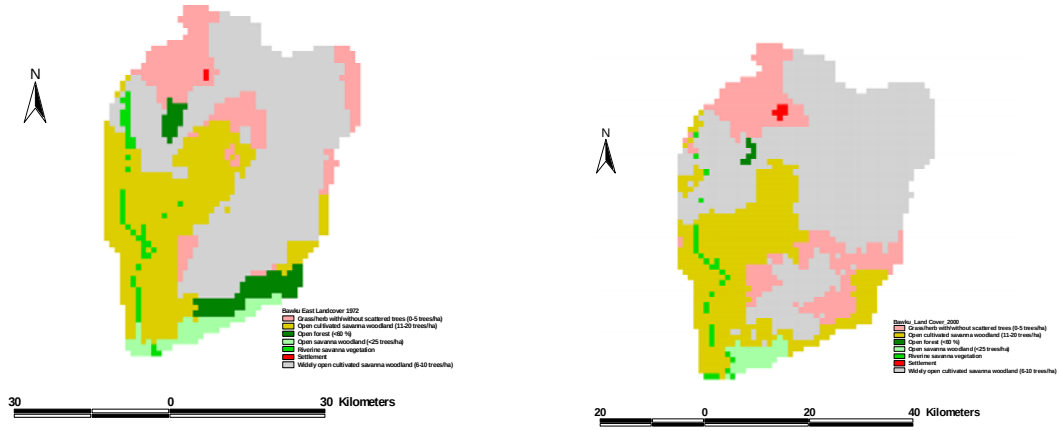


Figure 10: *Land use and land cover maps of197 and 2000*

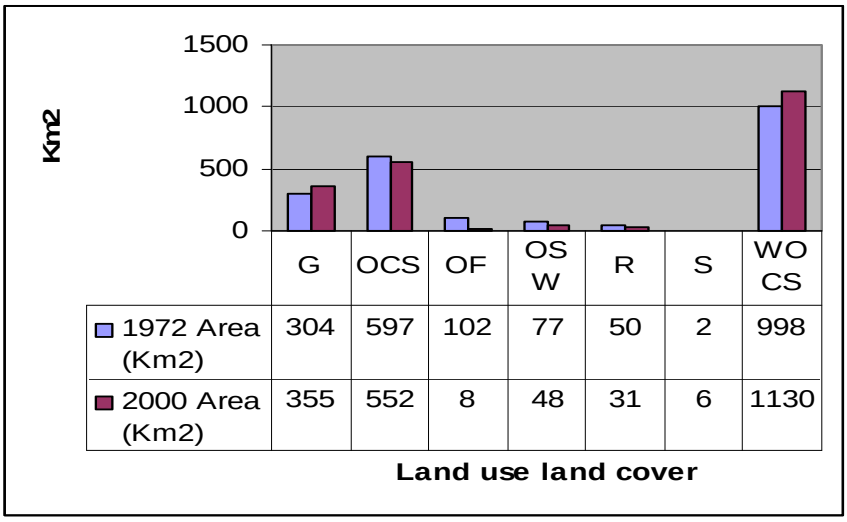
The land use classes used for the mapping were:

- Grass/herb with/without scattered trees (0-5 trees/ha) (G)
- Open cultivated savanna woodland (11-20 trees/ha) (OCS)
- Open forest (<60 %) (F)
- Open savanna woodland (<25 trees/ha) (OSW)
- Riverine savanna vegetation (R)
- Settlement (S)
- Widely open cultivated savanna woodland (6-10 trees/ha)(WOCS)

Table 5: *Total areas of land use/ land cover per class, change and rate of changes in areas from 1986 to 2000.*

Land use / Land cover Class	**1972 Area (Km^2)**	**2000 Area (Km^2)**	**1972 to 2000 Area Change (Km^2)**	**Rate of Change (Km^2/yr)**
Grass/herb with/without scattered trees (0-5 trees/ha)	304	355	51	2.83
Open cultivated savanna woodland (11-20 trees/ha)	597	552	-45	-2.50
Open forest (<60 %)	102	8	-94	-5.22
Open savanna woodland (<25 trees/ha)	77	48	-29	-1.61
Riverine savanna vegetation	50	31	-19	-1.06
Settlement	2	6	4	0.22
Widely open cultivated savanna woodland (6-10 trees/ha)	998	1130	132	7.33

The table 5 and figure 11 show each of the 7 land use/land cover types in 1972 and 2000 as mapped from the Landsat satellite images. Land use changes were calculated by subtracting the sums of the areas of each cover class in 2000 from their corresponding areas in 1972. The annual rate of change was also computed from the sums of the areas of each cover class over the 28-year period of the satellite images.



	G	OCS	OF	OSW	R	S	WOCS
1972 Area (Km2)	304	597	102	77	50	2	998
2000 Area (Km2)	355	552	8	48	31	6	1130

Figure 11: *A graph showing areas and changes (km^2) of cover types between 1985 and 2000*

From the results indicated table 5 and figure 11, more than 50 percent of the land area of Bawku was covered by widely open cultivated savanna by 2000, an increase of 12% from 1972. Another striking feature in that area under open forest and riverine vegetation reduced significantly by 106 km^2 and 19 km^2. While human settlement increased by 60% (2 km^2 to 6 km^2)

Drivers to land use change

- High human population
- Slash and burn agriculture
- Wildfires
- High livestock populations and
- Small scale surface mining
- in-migration of Fulani herdsmen from neighbouring Burkina Faso and Mali

Future trends and interventions

High human population coupled with scarcity of land in the Bawku district accounts for decline in land use land cover. Continual abuse of land resources in terms of high livestock populations in free range, small scale mining coupled with land scarcity are disincentive to tree planting and other natural resources management activities that would enhance food security and sustainable development.

Special initiatives on woodlot establishment, particularly incorporation of multipurpose fruit trees as sources of food, energy, soil enhancement and protecting the environment for posterity focused on community groups could hold a better option in future. To ensure and sustain land cover improvement on the land cover in the district, small scale dams must also to encourage for all year round farming to enhance human livelihood and poverty alleviation.

1.5. Conclusions and Recommendations

The results of the time series land use land cover analysis portray a moderate change in protected tropical forest in Assin district by 8 percent (524 km^2 to 504 km^2) from 1985 to 2000 while, protected woodlands in Ejura-Sekyedumasi and Bawku districts degraded significantly by 51 percent (106 km^2 to 51 km^2) and 92 percent (102 km^2 and 8 km^2) from 1972 to 2000 respectively due to their location in different ecological zones (moist, drier and more drier). Again, annual bushfire which is uncommon in Assin district, was very rampant in protected areas of Ejura-sekyedumasi and Bawku districts.

Another great threat to ecosystem in all the study areas was farming. Slash and burn method of cultivation succeeded in conversion previously woodland into open cultivated and widely open cultivated woodland. All the study areas therefore had 50 percent or more of their land cover as agricultural with scattered trees or no tree cover. More than 60 percent of riverine woodlands were converted to agriculture.

In all the three study areas increased in human settlement was significant (about 70%). Human induce activities therefore had direct impact on land use land cover change which has generally over the last 28years. There is a strong relationship between human activities and land use land cover change for all the three ecological zones studied.

The following recommendations are therefore proposed:

- The need to mainstream environmental issues and considered priority in formulation of government policies;
- Provide logistic support to natural resources and environmental management organizations to develop management models which aim at reversing the degradation trends;
- Provide support to develop educational materials to sensitize the general populace on the state of our natural resources and the need to protect them;
- Need for urgent shift in the pattern of settlement and farming along river banks in order to maintain water quality and control erosion and siltation;
- Promote community based sensitization on agroforestry strategies focused on meeting the economic, social and the environmental needs of the people.
- Manage natural resources responsibly for the future by making all levels of society consider and appreciate the value of the environment and to restore, safeguard and manage them as a productive resource;
- Provide conditions for soil restoration and protection from erosion, wildlife habitat, grazing for pastoralists, wood fuel, fruits and medicinal products from the already degraded land;
- Establish an effective institutional framework that could see to a nationwide bushfire control through awareness creation, promoting incentives schemes to community participation and execute fines as a deterrent to offenders
- Promote sustainable livelihood projects like reforestation, snail rearing, and honey making together with extensive education and awareness programmes on sustainable use of natural resources need be prioritized in future programmes.

2. Socio-Economic Assessment of Drivers of Land Use Change, Management Practices, Vulnerability, and Adaptation

EXECUTIVE SUMMARY

This report gives a full description of the study areas showing land cover and land use changes, soil associations, socio economic activities and land management strategies which will lead to an enhanced local economic, environmental and social benefits from soil carbon stocks.

- The landscape and farming system dynamics which includes land use activities, seasonal calendar, natural resource exploitation, land use/ land cover change was assessed at the community level: using the focus group discussion and guided by semi structured questionnaires. Some levels of land adaptation or pathway to change were identified within some communities.
- The social, economic and policy drivers of land use and land use change were identified and evaluated. Social networks within the community were also assessed using the Venn diagram method in a participatory mode involving household heads of the community selected.
- Farmers' perception of poverty, risk and vulnerability were assessed.

Livelihood strategies identified in the study area are as follows: Majority are farmers which include livestock (sheep, goat and cattle) rearing, piggery and poultry farming, charcoal producers, a few trade in smoked fish and cooked food, dye extractors, herbalist, teachers, artisans, hairdressers, pito brewers and casual labour for others' farm.

Livelihood Assets

- Using the livelihood framework each household has the following capital assets; human, social, financial, natural and physical.
- The levels of the physical and natural capital assets within the 5 communities differ and members do not have equal access. While natives have free access to land for cultivation, migrant farmers have to sign agreements which involve payment of monies for release of land depending on the crop one intends to crop in the Ejura Sekyedumase district. On the contrary land for farming is free for persons in the Bawku East district, with migrant farmers paying for lease of land to crop with a few bowls of grains or cereal cropped on the land. Access to physical structures within the community is free to all but they are all not well endowed because they fall under the rural poverty level within Ghana.
- Social capital also varied, with a community like *Anyinasu* being well networked socially, and because of lack of trust among community members *Babaso* have less social groups or networking. Differences exist between the types of social group formation in the 2 districts studied.
- The level of institutional networking was the same with the District Assembly, the Forestry Department and Ministry of Food and Agriculture giving them the same support. The presence of different non governmental organizations makes some communities better than the other. A higher proportion of development agencies and non governmental agencies support Bawku East district.

- Financial capital levels in the communities vary. The presence of a rural bank at *Anyinasu* and *Pusiga* and none in *Babaso, Nyamebekyere* and *Basyonde Sabzunde*; makes those communities have a culture to save. They also have access to local susu collectors and group access to loans from banks in the district capitals.
- Human capital varies depending on ability to hire labor; most of them depend on family labor. In all cases they have the capacity to work and adapt technologies that improve their livelihood as observed during the study. Their level of education is low when compare to the whole district; with the highest education being Technical education in *Ejura Sekyedumase* and University graduate in *Pusiga*; majority have basic education.
- The study revealed that female headed households exist within the study area and households headed by single parent(female) and widows are more vulnerable than the male headed households. Within the female headed households, the divorced and the abandoned wife with no support from husband are the most vulnerable.
- Stressors identified include poor rains, poor soils, alternate employment or non farm jobs for female members of the household, lack of money for food and expansion of farms and children education.

The socio-cognitive mental modeling of their perception and adaptive capacity of risk and stressors was done. Female headed households had less stress (40%) whilst male headed households have greater stress (60%); with some stressors being peculiar to a particular gender in *Ejura – Sekyedumase* district. Stressors were classified according to their livelihood context and vulnerability accessed using risk index.
The study identified the following as high risk stressors with risk index above 0.3: Extended family upkeep, Children upkeep, Limited / poor access to farm inputs, Farm size small and lack of jobs, low cash and repayment of loans. The causes and processes of development of these stressors were found to negatively impact their livelihood and the environment. The most frequently mentioned stressors in the 2 study districts affected their financial and human assets.

The study also identified the following as drivers of land use and land use change:

Social Drivers of Land Use Change

- Gender disparity in crops grown were observed during the study, women accessibility to land size is very small and they lack funds to buy inputs like fertilizer hence their inability to crop maize which is a main cash crop in the area. Women farmers therefore crop groundnuts, cassava, pepper, yam, plantain, cocoyam and a little of maize with no fertilizer. The male farmers mostly crop maize on a large scale, cowpea, lowland rice, yam, cocoyam, tomatoes, okra, cassava and plantain among others. In *Bawku East* women have less decision powers and therefore crop only the traditional crops which are millet, sorghum, leafy vegetables, groundnuts and cowpea.
- Linking farmers to credit source through the formation of social groups like the commodity groups encourages an increase production of a particularly crop. This type of social networking was observed in most of the communities visited. While some were highly organized and networked others have tried and could not get any benefit so they have abandoned such groups.

- Marketing group like the maize group in *Anyinasu* assist members in the form of credit to purchase maize produce in the village. Cattle dealers association in *Basyonde* is also a typical example of such groups. This assures the farmers of ready market for their commodity.

Demographic Drivers of Land Use Change

- Increased population has reduces land availability per person, resulting in the shortening of fallow periods.
- Persons of different ethnic group especially from Northern Ghana migrate and they tend to crop millet, rice and sorghum which are their staples and also produce charcoal as alternate livelihood in *Ejura - Sekyedumase*.
- Household size which is an index of availability of access to labour would determine the number of farms and type of farms that a household can crop or cultivate. The study revealed that male headed households have a higher access to human capital than female headed households especially divorced, widow or single mothers.

Policy Drivers of Land Use Change

- Alternate livelihood (domestication of grass cutters) for group hunters who hunt with fire and normally set the forest on fire will prevent the starting of wild fire which destroys the forest.
- Sustainable forest management practices, the Taungye system being promoted by the forestry department determines what one can use the land allocated to them to crop.
- Packages are available for persons who want to crop economic trees like teak exist and are being promoted by the Forestry department in both districts.
- Root and Tuber Improvement Program under the Ministry of Food and Agriculture promoting the use of improved cassava varieties and Sasakawa Global 2000 promoted the cropping of improved maize which replaced late millet in the *Bawku* district.
- The land tenure system that exist in communities who cropped on *Ejura* stool land; agreements are prepared and payments made depending on the type of crop you intend to undertake. Tree crops and long term projects demand higher payments for land, whilst land for cropping food stuff is virtually free. Community members with access to family land have the least problem with land acquisition and would therefore invest in any land use that may yield profit.

Economic Drivers of Land Use Change

- Marketability /marketing policy for tobacco production in the district was not favorable so farmers stopped growing tobacco in Ejura. Cotton farmers in Bawku also stopped growing the crop because of the marketing policy. Most farmers who cropped tobacco or cotton were normally with no food and therefore go hungry.
- Income or prices of commodities / fast source of income will encourage the production of maize which is a male dominated crop. They claim it is capital expensive but it gives fast income.
- Capital supports from NGOs such as Self Help Foundation, Sasakawa Global 2000 in the form of cash or inputs encourage the cultivation of certain crops like maize within the community.

Cultural Drivers of Land Use Change
Indigenous technical knowledge and cultural background determines what is cropped. Crops like the millet, rice and sorghum are traditional staples of the migrant farmers from the north, hence they cultivate it. Charcoal production is also a traditional past time of the S*isalas (north accent)* but some A*kans (south accent)* now produce charcoal especially in communities which fall within the lowest poverty pocket like *Nyamebekyere*.

Given the fact that not much study have been done in the communities in area of adaptation and costs, they can reduce the consequences of hazards by adapting to climate change. They can alter planting patterns; improve upon their physical assets such as information systems, health centres and make adjustments in the construction of houses among others. However, adaptation measures do not consist only of physical measures; they also comprise a mixture of economic and social features such as personal savings and in some cases, insurance.
There is the need for a policy to encourage people to diversity their sources of income which is part of the strategic plans of the 2 zonal areas studied in the Bawku east district. Activities such as snail farming, mushroom cultivation, fish-farming, grasscutter rearing and processing of farm produce where appropriate could be encouraged. Farmers should be taught and encouraged to prepare hay silage to feed livestock in the dry season. This policy is being pursued vigorously by the Ministry of Food and Agriculture in the Bawku East district. And the establishment of fire belts through established woodlots and forest resources. There can also be programs to support the development of practices that sustain or increase crop yields and reduce emission per crop yield.

2.1. Introduction

This section provides the objectives and expected output of the study.

Objectives
The project is to identify adaptation and mitigation opportunities derived from land use changes and appropriate land management options which will lead to enhanced carbon sequestration, food security and livelihood.
The project was divided into 5 main components with the socio economic component assessing the social, economic and policy drivers of land use and land management options; and adaptation to climate change. The socio-economic team was tasked with the following terms of reference;

- Choose two study areas within the study sites provided
- Undertake intensive socio economic studies in the chosen areas with several ethnicities using highly participatory methods.
- Describe soil, climate, vegetation, demography, socio-economic and land use activities in the areas
- Assess existing variation in terms of soil types, village size, ethnic groups, agriculture / seasonal calendar, exploitation of natural resources and land cover / land use change.
- Assess Landscape and farming system dynamics, decline in rainfall and drought and changes in land use and management as a consequence of transformation.
- Explain major drivers and specific adaptations or pathways to change in selected communities.

- Assess farmers' management practices at household and field levels with emphasis on successful sequestration of carbon and activities that enhanced small holder livelihood and attractive to potential carbon traders.
- Assess the socio-economic implications of environmental changes and carbon sequestration.

Expected output
It is expected that the final document would contain a full description of the study area showing land cover and land use changes, soil associations, socio economic activities and land management strategies which will lead to an enhanced local economic, environmental and social benefits from soil carbon stocks.

2.2. Methodology and Activities

This section describes the research approach that the team followed in the study. The tools used in gathering information from the field and from various stakeholders are also discussed in this section.

To achieve the objectives set out in the terms of reference, the following **activities** were planned:

- Identify study district and select communities for detailed study.
- Source for soil, land use and vegetation map of the districts.
- Assemble secondary data available on land use change, which will include population growth, Gross Domestic Product(income levels), Land productivity, Land suitability and Water availability
- Assemble available information and data on demographic and economic change.
- Assemble information on agricultural intensification and environmental change.
- Assemble data at the district level on community basis on the following;
- Population, number of farm households, area of cultivated land and production by crops and livestock.
- Assess District document which spells out development policy for the future.
- Design a participatory assessment framework to capture social, economic and policy drivers and implication to land use/land cover changes and carbon sequestration of the study site.
- Implement this framework at household or field levels using any of the following methods where appropriate; focus group discussion, semi- structured interviews and interview key informants. This will help in the identification and analysis of the stakeholders involved and the various drivers and strategies adopted by farmers to mitigate land use / land cover change. Farmers' perception and generic vulnerability will be assessed. Risk indices of the various households would be developed.

Review of the literature and desk study
The team undertook considerable amount of literature search and desk studies. The consulting team met to discuss and harmonise literature that individual members of the team have obtained. Key sources of literature are from the Crops and Soil Research Institutes in Kumasi, the District Assemblies directorate and the Forestry and Agriculture Departments at the district levels.

Reconnaissance visits to the study area

Initial visits were undertaken to the Kakum forest reserve in the Assin district and Awura forest reserve in the Ejura- Sekyedumase district to gain a quick but fair assessment of the two districts. This was the maiden visit of the consulting team to the field. A second trip to *Ejura-Sekyedumase* was done to rapidly appraise the area. Specific objectives for the rapid rural appraisal were to:

- Undertake preliminary discussions with some stakeholders
- Assess their level of understanding of carbon stock and its implication to their livelihood from some key informants.
- Assemble literature and statistics available on the district.
- Identify communities for the detailed household studies.

To achieve the first 2 objectives, informal interviews were conducted with some key personnel of the 2 districts; Ejura-Sekyedumase and Bawku East. The following check lists of **questions** or issues were discussed:

- What human activities within the district disturb the soils in its natural state?
- Which of these activities has the potential to degrade the soils or increase carbon stock?
- Which of the activities has a greater impact on carbon sequestration?
- How can these activities lead to carbon sequestration and then increase the livelihood of the community?

The key personnel interviewed were the District Directors of Town and Country Planning Unit and Ministry of Food and Agriculture, the District Forestry Officer, the District Development Planning Officer, Soil Scientist working on soil organic carbon and past National Best Farmer who is also a private forest developer.

2.3. EJURA – SEKYEDUMASE DISTRICT

Location

This district is located between longitudes 1° 15' – 1 4^{0}'W and latitudes 7^{0}12' – 7^{0}35' N, which is the zone between the south of the dry savanna and north of the forest zones. The district is one of the largest districts within the Ashanti Region, sharing boundaries with *Atebubu* and parts of *Nkoranza* to the North; *Afigya Sekyere and part of Sekyere west* to the south; part of the *Nkoranza* and *Offinso* to the West; and *Sekyere East* to the East. The district occupies an area of about 1,782.2 square kilometers with 130 settlements out of which 128 are rural settlements. The 2 urban settlements are Ejura and Sekyedumase.

Climate

This district is located within the transitional zone of the Semi – deciduous Forest and the Guinea Savanna zones, thereby experiencing both climatic conditions. Two rainfall patterns, the bi-modal in the southern part and unimodal in the northern part occur in the district. Annual rainfall varies from 1,200 – 1,500 mm. The major rainfall starts from April to July and the minor season starts from September to October. Separating the 2 rainy periods is a cool dry period in August. The dry season is from November to April. Temperatures are uniformly high with mean annual maximum value being 32°C experienced in November and a minimum of about 20°C

experienced in January. Relative humidity values are high during the rainy season with mean monthly ranges between 80 - 88% in the morning and decrease to 70 – 75% by midday. Relative humidity values during the dry season decrease from 75% in the morning to 45% by midday.

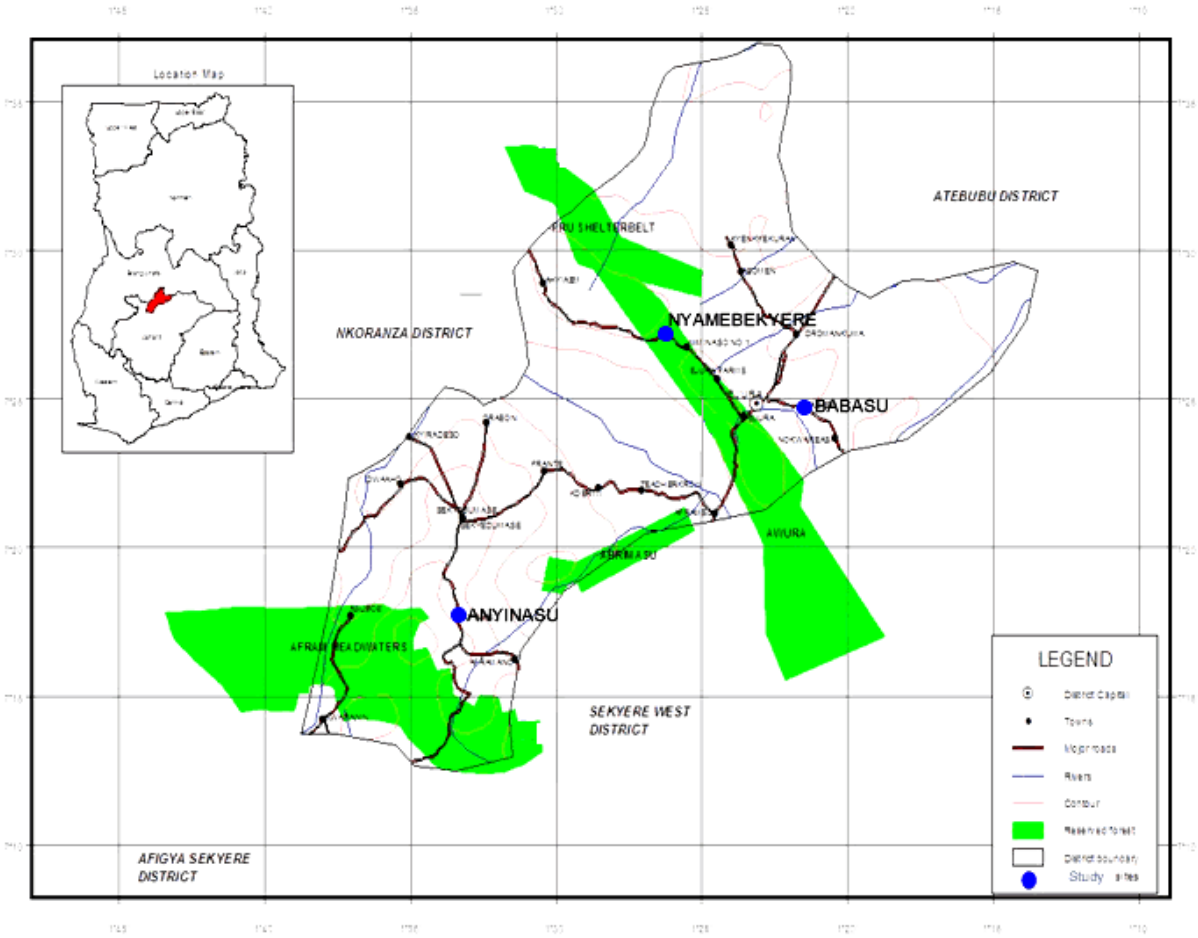
Vegetation

There are 2 distinct types of vegetation; the semi – deciduous forest which covers the south western part and the Guinea Savanna which covers the Northern and eastern parts of the districts. The predominant vegetation is mainly derived from the Savanna with substantial patches of Forest and Savanna vegetation. The increase in bush fires and shifting cultivation have resulted in the growth of savanna vegetation and a forest cover degraded to a partially closed low canopy at a height of 18 – 24 meters.

The common tall grasses found in the savanna vegetation in the district include, *Andropoge, Beckeropsis, Chasmodium, Rottebellia* and *Schizachyyrium*. These are interspersed with short fire - resistant tree species, examples are *Butryospermum, Daniells, Lophira* and *Vitex.* The trees tend to have thick corky barks, twisted and guarled as a result of frequent burning. Within the semi – deciduous forest the common economic tress are wawa (*Tripolchiton scleroxylon*), odum (*Milicia excelsa*) and sapele (*Guthagrophragma*).

Wildlife population within the district has recently been reduced because of human activities which includes frequent bush fires, hunting and excessive noise from vehicles which ply through the forest.

MAP 1. EJURA SEKYIDUMASI DISTRICT SHOWING STUDY SITES



Geology and soils

The general relief of the district is low lying to very gently undulating making it suitable for mechanized farming. The district has numerous streams and rivers, some of which gets dry during the long dry seasons. Most of the soils are derived from the upper Voltaian sandstones and shales, Granites and Alluvium. The major agricultural soils are the *Luvisols, lixisols, Acrisols, Nitisols* and *Gleysols*. Most of the soils are multipurpose and are therefore suitable for the cultivation of a variety of food and cash crops.

Soils in the forest zones of the district are classified under the following associations; The Kumasi-Asuansi-Nta-Ofin, Bediesi-Sutawa, Yaya-Pimpimso and Damango-Tanoso compound (Lixisols, Arenosols, Plinthosols, Leptosols and Fluvisols under the FAO/WRB classification). The soils are recommended for tree and food crops, with the lowlands for rice, sugarcane and vegetables production. The Leptosols and Plinthosols which are generally shallow to moderately deep are suitable for forestry and quarrying. They are therefore highly susceptible to erosion. Soils in the northern part of the districts are mainly classified under the following associations; Yaya-pimpimso, Damango-Tanoso, Ejura-Denteso, Kintampo-Techiman, Nyankpala Kpelesawgu-Volta, Denteso-Sene and Dukusen-Bramso (Classified under the FAO/WRB legends as Leptosols, Lixisols, Fluvisols, Plinthosols and Gleysols).

Soil erosion is very prevalent with erosion being moderate on 3 – 5% slope and slight on 0-2% slope. Inappropriate farming practices have lead to the depletion of the soils and reduction in soil fertility.

Natural resources

The district is endowed with numerous natural resources, some of which has been exploited and others remain unexploited. These include gold, diamond, clay, stones, gravels and sand. Clay deposits are mainly use for constructing mud, land crete and brick houses. Gravel, stone and sand mining is being used by the construction industry. But the Gold and Diamond deposits in the hills of *Anyinasu* has not been exploited.

There are 3 forest reserves in the district. These are the *Pru* Shelter at *Ebuom* which is the largest and occupies an area of 92.7 km^2; the *Awura* forest reserve which is about 82.2 km^2 and the *Abirimasu* at *Teacherkrom* and covers an area of 26.2 km^2.

Other natural resources of economic importance are the numerous water bodies that exist within the district and wildlife which includes grasscutters, rats, antelopes and deer.

Forestry/land use and land cover

The total land area reserved in *Ejura-Sekyedumase* district as forest reserve is 201.11 km2 which is about 11.3% of the total land area. Most of the original forest cover has been destroyed by agriculture production (tobacco, kenaf, yam, maize and cassava); fuel wood collection, charcoal production and bush burning.

Demography and ethnicity

This district forms about 2% of the Ashanti Region with a population of 81,115 (2002) out of which 52% are males and 48% females. Forty eight percent of the populace live in *Ejura* and *Sekyedumase* (Urban Centers) whilst 51% live in the rural areas of the district.

About 60% are engaged in Agriculture production and the rest are engaged in trading or commerce, manufacturing, institutions and teaching professions. The average household size is 5.9 persons which is higher than the national rural household size of 5.3 persons. Out migration is not prominent in the district but there are few who migrate to other settlements within the district for employment reasons.

The ethnicity of the district is heterogeneous with about 15 ethnic groups (Table 3.1). Out of these 11 are of the Northern ethnic groups (42.6%) and the remaining 4 are Akans (52.6%), Ewes (1%), Nigerians (2%) and Togolese (1.8%). Most of the Northerners are migrant farmers who farm food crops like yam, maize, sorghum and millet.

With respect to Religion, Christians dominate being 59.9% of the surveyed population, Moslems are 36.9% and traditional or other religious group are 3.2% of the total population.

Table 3.1: Ethnic composition of Ejura –Sekyedumase district in 2000

Ethnic group	Number of persons/respondent	Percentage
Asante	743	48.4
Brong	24	1.6
Fante	40	2.6

Ewe	16	1.0
Hausa	31	2.0
Dagomba	204	13.3
Dagarti	74	5.0
Kokomba	75	4.9
Frafra	86	5.6
Chokosi	6	0.4
Kotonkoli	27	1.8
Gonja	32	2.1
Grumah	33	2.1
Mamprusi	74	4.8
Busanga	67	4.4
TOTAL	**1,535**	**100**

Source: Development plan for *Ejura-Sekyedumase*, 2000

Environmental situation

Most farmers who use traditional and intermediate technology all practice slash and burn in land preparation. With about 75.5% of farmers in the district using this method renders the land bare and exposes it to erosion.

Annual bush fires started by group hunters and their mode of preparing their lands for cultivation threatens the vegetation cover. Further about 71.2 % of the populace use fuel wood and charcoal for cooking their food. This depletes the forest and calls for an urgent afforestation program.

Economy

The employment structure with reference to a survey in 2000 classified the economy as rural, with 59.8% of the population earning their income from agriculture and 32.2% from trade and commerce and 8% from industry. These industries employ an average of about 5 persons and these are mostly related to the resource base of the district. These are carpentry, soap making, palm oil extraction and blacksmithing.

The annual average household income of the district is estimated to be 1,930,000 cedis for an average household size of 4.8 persons. The main sources of income are from trade and commerce (32.8%), agriculture (12.8%), salaries (10.7%), pension emolument (24.1%), rent of property (10.9%), industry (6.4%) and remittance (2.3%). The main expenditure item for the district is food, taking about 21.2% of the total expenditure made within a household.

The district statistics show 75.6% of the total active labour force to be employed but then majority still live in the poverty line. This is because of the large force of agriculture employment and the relatively low production and producer prices; thus contributing to low income levels. In 2000, a district level survey identified 62% of the population (311 households) to be below the poverty line *ie*. those with income less than two-third of the average income per annum and 21% (105 households) are within the hard core poverty zone *ie*. those below one-third of the average income per annum. Poverty was found to be more pronounced in the rural villages and hamlets than in the 2 urban settlements (*Ejura* and *Sekyedumase*).

The poverty status of this district has been zoned into 4 pockets depending on their major economic activities, key poverty problems and issues and potentials of the areas involved.
The first pockets who are poor occupy the northern part of the district, north west and north east inclusive. They have poor roads and therefore can not send their farm produce to the market, unable to access health facilities and credit to expand farms, although they have rich arable land, timber, sand and gravels for mining. Their major activities are peasant farming, charcoal production and shea butter extraction.
The second pockets or groups cover the southern most part of the district, the south west and south east inclusive. They also are poor because they lack credit to expand farms; roads are bad, water-borne diseases are prevalent and have low school enrollment and high school drop out. Their major economic activities are farming of food and tree crops, livestock production, stone quarrying, alcohol distillation and gari processing.
The third group or pocket is fairly endowed and it stretches from *Aframso* to *Anyinasu* through *Sekyedumase* that is, the mid-east portion of the district. They experience a lot of chieftaincy dispute, high cost of farm inputs, low producer price for farm produce, poor storage facilities for farm produce and lack of credit to expand farms. They are mainly tree and food crop farmers and also general traders. They have a vibrant weekly market, fertile land for food and cash crop production, sand, stone and gravel deposits, timber and gold deposits.
The fourth group or pocket is relatively well endowed and it stretches from *Aframso* to *Kasei* through *Ejura* occupying the mid – west part of the district. The populaces within this pocket are mostly farmers, traders, small scale processors / manufacturers and public and civil servants. They are well endowed to produce cereals, root and tuber crops, legumes and poultry and livestock production. Bush burning, high cost of farm inputs and tractor services, poor storage facilities, poor land tenure system, low produce price and high crime rate are some of the issues identified.
Based on these divisions, the different soil associations and land use, Awura forest reserve and areas where production has declined for the past decade the following communities were selected for detailed surveys; *Nyamebekyere* (North West) is within the first poverty pocket, *Babaso* (middle) is within the 2nd poverty pocket and *Anyinasu* (south) is within the 3rd poverty pocket in a decreasing level of poverty. These sites reflect varying degrees of degraded lands, poverty levels and soil associations in the *Ejura-Sekyedumase district.*

2.3.1. Results from the household surveys

This section focuses on the population characteristics of communities identified and examines issues such as population growth, ethnicity, religion and occupational characteristics including off farm activities and livelihood assessment.

a) *NYAMEBEKYERE*

Nyamebekyere is within the North Western portion of the district on the main *Ejura – Nkoranza* road (longitude 1°25'W and latitude 7° 26'N). This community is located within the Damango-Tanoso soil association formed over Voltaian sandstone which is the savanna version of the Bediesi-Sutawa association. Soil series within these associations are the Ferric Lixisols and Dystric Gleysols. The major upland soils in these areas are suitable for yams, cassava, maize,

millet, sorghum, cowpea, groundnuts, tobacco, kenaf and cashew. The rocky lands are good for forest plantations and the valley bottom soils for rice and vegetables. The sandy textures of the soils make it more prone to erosion and droughty during dry spells. It has poor roads and farmers are unable to access health facilities and credit to enlarge their farms.

Demographic characteristics

The community is about 35km from the district capital *Ejura*. It is mostly a settler community and falls under the category of a village and poverty pocket 1 which is the poorest within *Ejura.* It has about 620 people and a household number of about 50. The 2000 population and housing census reported the presence of 325 males and 295 females in this community. It is a heterogeneous community, with the *Akans* forming the majority of the ethnic group. Others include, *Frafra, Grushie, Sisala, Konkomba, Dagomba, Dagarti, Grumah, Kusase, Busanga, Mossi and Kajanga.*

Occupational characteristics

The major activities in *Nyamebekyere* are peasant farming and charcoal production which employs about 75% of their able-bodied men and women. Migrant settlers labour has played a major role in farming/agriculture in *Nyamebekyere*. They operate as farm owners or as hired labourers. The farmers rely solely on rain fed agriculture, and those who happen to have their farms along riverbanks, manually cart water from the rivers to irrigate their farms. They till their land, using cutlasses and hoes, tractors, shifting cultivation and slash and burn method. These have resulted in low yields, low income and general poverty among them.

Gender disparity in crops grown were observed during the study, women accessibility to land size is very small and they lack funds to buy inputs like fertilizer hence their inability to crop maize which is a main cash crop in the area. Women farmers therefore crop groundnuts, cassava, pepper, yam, plantain, cocoyam and a little of maize with no fertilizer. The male farmers mostly crop maize on a large scale, cowpea, lowland rice, yam, cocoyam, tomatoes, okra, cassava and plantain among others.

They have 3 distinct farming periods; April-May when they grow maize and cassava; the second minor season planting is from the middle of July –August when they crop cowpea and cassava and finally the third farming season is from December-January when they clear lands for major season planting, they do dry season farming along the river banks and plant yam. Human occupation and activity have had a major effect on the natural environment of this community especially yam and tobacco cultivation and their mode of fishing in the rivers.

Other farming activities include livestock (sheep, goat and cattle) rearing, piggery and poultry farming. Some are charcoal producers and a few trade in smoked fish and cooked food. A dye extractor, teacher and a hairdresser live in the community.

Land use dynamics

Cocoa production was the main economic activity of the farmers in *Nyamebekyere*. In the early part of 1960, poor weather conditions and bushfires destroyed this livelihood. This led to the decline of the cocoa production in that community

They shifted their energies to tobacco cultivation. This cash crop production was human and capital intensive it made them hungry and poorer because of the poor pricing and marketing policy offered by the then Ghana Tobacco Company.

After many decades of experimentation, they have adapted as suitable, farming food crops, vegetables and rearing livestocks. They have also adopted a system of shifting cultivation whereby the land is cleared and the debris burnt to destroy weeds, pest and diseases. This practice however, has the disadvantage of adversely affecting soil fertility and causing a decline in crop yields. To avert this situation, farmers now, leave the field fallow to restore the nutrients that are lost while a new ground is cultivated. But with increases in demand for food as well as land for development and the need for commercial agriculture as a result of population growth, the system of shifting cultivation could no longer be maintained. Neither could the hoe and cutlass used to produce enough food to meet increasing demands.

Subsequently, they have introduced farm mechanization and the use of chemical fertilizers, which seem attractive to the solution of these problems. However, the degradation that these new technologies have caused to the environment and to the food crops is beginning to unfold. The use of heavy machinery and chemical fertilizers with un-sustained water supply certainly caused further damage to the community's fragile soils. These problems have not been addressed.

Though food is grown and sometimes in abundance, it was mentioned in the discussion that foodstuffs sometimes get rotten on the farms, because there is the problem of distribution, marketing, pricing, processing and preservation.

Cattle rearing are done in an open wooden kraal and these cattle are allowed to graze on the open range during the day and returned to the kraal at night. This mode of rearing result in the destruction of the vegetation which is a major environmental problem in the village. Sheep and goats are produced together without housing. They are left to fend for themselves in the free-range system or tethered and fed by the cut and carry system. They use the semi-intensive system where the animals are confined and herded for grazing. Poultry is also done on the free-range system, whilst piggery is done through the extensive system. The pigs are allowed to roam about and fend for themselves.

Land degradation

Human occupation and activity have had a major effect on the natural environment. Subsistence agriculture has been practised for decades resulting in the conversion of savannah forest to thicket and scrub and the modification of 'natural' grasslands. Dense rain forest, which still remains in near-pristine state, has been cleared from its natural range. Other key areas of environmental concern include: Soil degradation, loss of biodiversity and forest cover, and climate change.

Factors which cause land degradation as identified by members of the community include the following:

- The continuous use of tractor to plough land for cultivation.
- Overgrazing by cattle.
- Bush burning for farming or hunting purposes.
- Sedentary farming, where farmers' crop the same piece of land for a long time without using sustainable soil conservation methods.
- Yam cropping where most of the trees are removed for staking and reduction of shade within the farm.
- Increased population has also reduces land availability to a person, resulting in the shortening of fallow periods.

- Tree cutting / felling for lumber, as firewood and for charcoal production has exposed the land to erosion by both wind and water.

Farmers within the community have been able to prevent some of the causes of degradation by adopting technologies that minimize land degradation. Some of these are the no till or zero tillage method demonstrated to them by the agricultural extension agents. No tractor service is required in land preparation. Cattle plough to replace tractor plough and the correct mode of ploughing using tractor has been demonstrated and they are being encouraged to use them. The taungye system which allows the sustainable use of the forest land is being practised in the community. They are made to crop their food crops like yam, plantain and cocoyam along side forest trees like teak.

Drivers of land use change

Factors identified as driver of land use are the ready market and pricing of the commodity. The availability of capital in the form of loans or grant for the production of the commodity will encourage most people to change land use. A favourable land tenure system would also encourage the change. This is because of the tenancy agreement one has to sign with the land owners to gain access to use of land for a particular purpose.

Livelihood assessment

This section discusses the livelihoods assessment using the sustainable framework approach. It was done at community level involving the opinion leaders and some family heads. Five main factors that contribute to their livelihood were assessed, these includes their physical, human, social, natural and financial capital.

Natural Capital

The community lies in the transitional climate zone, and experiences high temperatures throughout the year. The hottest months are March and April while the coolest months are July-August. Relative humidity is high averaging 75-80% in the rainy season mean annual rainfall varies between 1,200-1500mm.

The vegetation of the village is typical of a transition between a Forest and Guinea savannah zone. Most arable lands within the community have degraded as a result of slash and burn method of farming, charcoal burning, bushfires and other human activities. Land within the community is under the stool land of *Ejura*. Farm lands are therefore obtained through the *Odikro* who is a caretaker of these stool lands. They are acquired under an agreement with the *Ejura* chief. Land tributes or rent are paid at a rate of 100,000 cedis per acre per year if the intended purpose is for tree or cash crop production. Land for food crop production does not require the signing of agreements or payment of land rents.

Nyamebekyere is endowed with 2 rivers; the *Tsofie, and Memena*. They have a strong religious attachment to the rivers and some myths about the river. Changes in the quantum and flow of the streams and diminishing fish stocks was attributed to the drying up of the streams as a result of their fishing method and the road construction. A school of thoughts attributed the shallowness of the streams to cultural practices in relation to day of observance that has been ignored. Another group which has a strong attachment to religion, mentioned that the stream does not like dogs, black items like charred cooking utensils and women in their menstrual period are not allowed near the river. They argued that the influence of Pentecostal churches has

made the inhabitants disregard customary rites and observation. It was noted that the above-mentioned taboos were frequently being abused resulting in the state of the streams. However, they concede that if purification rites i.e. slaughtering a sheep to pacify the river god/goddess are done, and the community desist from such negative practices, the stream will flow again and will have fishes. They have a history of such acts before and it was restored after the necessary rites were performed.

Some flora and fauna have become extinct (Appendix 1) the only wildlife to be seen are grass cutters and occasional antelope. Trees and Forest Products such as *Odum, Wawa, Papa, Kyenkyen, Ewiamso, Samena, Afram, Aprakuma, Brakakaku, and Mahogany* have all near extinct. A few scattered mahogany trees could however be seen. Wild fruits and fibres are no longer common sights in the forest. The community derives the following from the forests: Food (fruits etc.,), Wood fuel, Charcoal, Herbs for medicinal purposes, Local Dyes from the bark and roots of trees.

Land degradation was prominent and visible, the community attributed it to deforestation, logging, (illegal chain-saw operators) bushfires (caused by hunters, smokers in transit and farmers), increased demand for charcoal and firewood due to population pressure and yam cultivation (which involves the complete removal of most trees for adequate shade during land preparation).

Accelerated wind and water erosion, soil compaction and loss of stability and soil fertility appeared to be contributors to the degradation of their environment due to lack of trees and grasses. If this is not checked the net result will be the removal of natural sinks for carbon dioxide. The use of pesticides as well as chemical fertilizers has also led to the pollution of their streams.

Human capital

The highest level of education that Nyamebekyere has is one SSCE graduate. He is a teacher in the next village and had his education in the Upper East Region. Some members are financially capable of hiring labour for their fields whilst others only use household labor. Most of them are strong and healthy and can therefore avail themselves as hired labor for an income in addition to cropping their own farms. Others are weak and cannot even crop their piece of land for food. Generally the older people looked frail. They have a lot of widows and children. The children did not look as if they lack nutrition, however, they did not look too healthy either. The youth were not many. Most of the inhabitants do not have any basic education. They have traditional knowledge in tilling the land and other related activities.

They also have the skills and have the capacity to work. Their capacity to adapt can be seen from their response, that before 1962 they were mostly cocoa farmers or hired labourers on the cocoa farms. However due to a fire outbreak in the early ‘60’s’ they lost almost all their cocoa farms and adapted other land use patterns such as maize, yam, rice growing etc.

Physical Capital

Nyamebekyere has only one day care centre, the nearest government school is at *BayereNkwanta* about two miles from the village. The classes are from Primary 1-JSS3. The only school in the village is a private one, and considering the levels of poverty; parents find it difficult to send their children to school. It was observed that there is a high school dropout level. This is attributed to lack of finances to send a child to school, no public schools in the community and the pupils’ love to trade in the vibrant periodic markets at *Ejura.*

There is no health or recreational facility. They have several of the local gin (Akpeteshie) drinking huts. The village can only boast of a drug store in a dilapidated land Crete building. The drug store is ill equipped. It only dispenses paracetamol (a pain killer) and ampicillin (an antibiotic). They do not have any qualified staff to operate it and when they need medical attention; they have to go to *Ejura*. However, there are Herbalists, Traditional Birth Attendants and Fetish priests who provide a first point of call traditional medical services.
Nyamebekyere as a community lags behind in developmental structures. The main road network is a seasonal feeder road, which is still under construction. Rainy season makes it practically impossible to use the road. Public transport such as mini buses and mass metro buses is non-existent. One person owns a car, but it is in Ejura. The main mode of transport is the use of a tractor or bicycles.
They do not have any communication system and information for the populace is through the beating of the "gong-gong. "
Housing condition in *Nyamebekyere* is exceptionally poor and insecure. The common materials used are land-crete blocks, mud, and thatch for roofing. Compounds are bare with no landscapes and there are no layouts drains.

There is no evidence of tree planting and grasses around the settlement. This by itself directly causes and indirectly accelerates erosion by running water and wind, and exposing the soil to severe weather conditions.

In *Nyamebekyere* the principal source of potable water is from two boreholes. The village has no electricity. It has two shops, one corn mill machine, a make-shift mosque, one (1) KVIP toilet for both male, female and children.
For tools and technological physical assets, the community can boast of a tractor, one corn sheller and assess to an extension agent and forestry officer who exposes them to new techniques in agriculture and forest management. Improved seeds for planting is supplied or bought from extension officers. In most cases they do not have money to buy fertilisers and pesticides therefore they resort to either high purchase or take the inputs on credit.

Social Capital
The village is a heterogeneous society with the *Akan*s dominating. The overall head of *Nyamebekyere* is referred to as the *Odikro* who is an *Akans*. Each ethnic group has a tribal head and is represented at the Odikro's palace. In the event of any issue arising, the representative first discusses it with the Odikro before it gets down to the ordinary members of the community. The Ejurahene is the traditional head of the district and the Asantehene is the traditional head of the Ashanti Kingdom. The king has his seat at Kumasi and rules the Region through paramount chiefs and sub-chief. The Ejurahene is a paramount chief and the custodian of all the natural resources and lands in the District. He takes the final decision on land acquisitions and therefore decision-making is hierarchical in structure.
Two Non Governmental Organizations (NGO) have worked in the community; these are the Self Help Foundation and Sasakawa Global 2000 which supported them to form eighteen food crop commodity groups. These groups formations were organized base on food crop produced by the individuals - maize, cowpea and / or groundnut groups.
And they were formed basically for capital formation. Sasakawa Global 2000 also supported these groups by providing credit in the form of inputs for crop production and technical assistance in the form of technology transfer. The presence of Root and Tuber Improvement

Program (RTIP-IFAD) in the community also provides technical support for root crop production especially in Cassava.
Tribal social groups form on the basis of their various tribes exists. Their networking is mostly as a result of making donations to assist bereaved member, a sick member or for medical purpose. An observation made was there was an atmosphere of peace and oneness. One could also appreciate the fact that there is mutual trust and support within the community.

Besides, the above social groups there are other religious groupings. These are:
Seventh Day Adventist Church (SDA), Pentecost Church, Deeper Life Ministry and Islam with its attendant religious fellowships or groups within the bigger churches. Traditional worshippers also exist, worshipping as many as 4 different gods: *Gyafana, Akologo, Akwelege and Kokoma*.
The District Assembly provided them with toilet and water. The Forestry Department gave them some portion of the forest reserve to plant teak. The forest guards sensitize them on indiscriminate bushfire especially during the dry season. They have a unit committee and area council members who liaise between the community and the District Assembly.
Social networking was assessed using the participatory method where members of the community show linkages that exist between these groups. The Diagram 4.1 shows the linkages that exist within *Nyamebekyere* as indicated by members of the community.

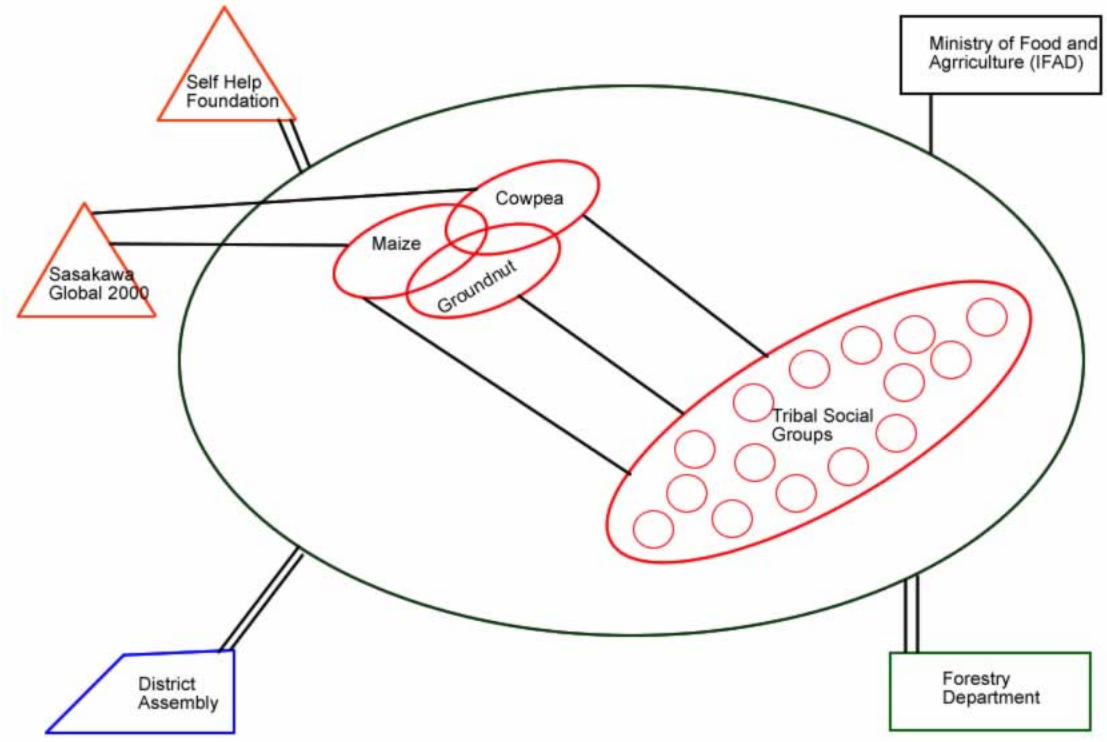


Diagram 4.1 Social networks that exist in *Nyamebekyere* showing linkages within the community and outside the community. A double line (=) indicates both physical and financial support; a single line (-) indicates either a physical or financial support or they have similar objectives.

Financial Capital

There are no banking services in *Nyamebekyere*. The only informal way of savings is the local *susu* collector which has been abandoned because they lost trust in the system. However loans are obtained by the commodity social group members through the Ministry of Food and Agriculture and some NGOs. The repayments of these loans are most of the time impossible because the loans are given at untimely periods. This has resulted in some of the farmers being imprisoned.

Another form of loan acquisition is by the provision of farm inputs like seeds and fertilizers and repayments done by the farm produce. For instance tobacco farmers are supplied with improved seeds and fertilizers for its production and at harvest the cured leaves are collected as payment of the inputs. Maize buyers also provide fertilizers during the growing season and collect bags of harvest maize as payments. This is also not beneficial to the farmers. They explained that by the time the deductions have been made from their produce, they are left with nothing.

Farm pre-financing has been another form of raising capital for the people of *Nyamebekyere*. This is done with individual traders of the produce who purchase either fertilizers or pesticides for an operation on the farm and they in return request for any quantity of the harvested produce at the end of the day. It is a form of a barter trade and this leaves the farmers at a losing end. A bag of Nitrogen fertilizer at a cost of two hundred Cedis is exchanged for a bag of maize or cowpea at harvest.

No member of the community enjoys any pension schemes; the only wage earners are the hired farm laborers and a Senior Secondary School graduate who is a teacher in the next village. The farmers and farm laborer's wages are not sustainable because the farming periods are seasonal and sometimes they never get hired due to the unavailability of land, finances and erratic weather conditions. Community member who have relatives outside send them remittances and some also receive remittance from their children outside the community.

b) *Anyinasu*

Anyinasu is the third largest community in the *Ejura Sekyedumase* District and falls within the third poverty pocket in the district. It occupies the southern part of the district and is along the main road from *Sekyedumase* to Kumasi (longitude 1°34.5'W and latitude 7° 14.5'N). The community is developed within the Bediesi (Dystric Nitisols) – Sutawa (Gleyic Arenosol) association. The upland soils within this association are suitable for most tree and arable crops. The lowland soils are suitable for rice, groundnuts, sugarcane and vegetables. The soils have low fertility status and are subject to moderate runoff and erosion. The major soils are gravel free and therefore suitable for mechanized cultivation.

Demographic characteristics

The population of *Anyinasu* at 2000 is at 4707 and this has been increasing from 2347 in 1970 to 3635 in 1984. Out of the 4707 inhabitants, 2400 are males and 2307 females. The community

has 478 houses with 667 households and average household size of 7.1 which is the third largest in the district. The average household size for the district is 5.2. The deviation from the average household sizes is due to large family sizes and responsibilities emanating from the extended family system. The major ethnic group is Akans with the minority group from the Northern parts of Ghana.

Occupational characteristics

Anyinasu is fairly endowed and the major economic activities are food and crop farming and livestock rearing. These offer employment for over 90% of the population. The food and cash crops cultivated include maize, ground nut, plantain, cassava, yams, tomatoes, okra, beans, cocoa and pepper. Gender disparities exist in the cropping system within the community. Whilst the women grow groundnuts, cassava and plantain the men cultivate mainly maize and cocoa. The rationale for the women cultivating groundnuts and cassava is that groundnuts has short maturation period which is three months, providing an early income to support the family and the other cropping activities.

The area has 2 farming seasons, the major farming season which is from March to May and the minor season which starts from July to September. The main crops grown in the major season are maize, groundnuts and cassava and in the minor season crop only maize and vegetables. The main tools used for farming are cutlass and hoes, but they practiced some form of mechanized agriculture which involves the use of the tractor. The tractor is used mainly to plough the land for cultivation of maize. Nobody owns a tractor in the community, the tractor services are hired from *Ejura*. The alternate livelihoods or source of income within the community are teachers, stone quarry to produce stone sharpeners for sale, charcoal burners, drivers and fitters. This area is fairly endowed with their key poverty issues being poor access to larger markets, poor pricing for produce, poor storage facilities and low access to credit among others.

Land use dynamics

A number of factors have account for land use change in the community. These are increase in population due to in-migration and natural growth, therefore putting pressure on land availability or reducing fallow period or change in cropping system.

Logging and harvesting of wood for timber and fuel wood for household consumption, group hunters (floaters) which has become popular in the community, animal grazing which in the past was not a common activity in the town are all factors or contributors to land use change.

The most significant factor or contributor to land use change is the National bush fire disaster which occurred in 1983. This fire destroyed almost all cocoa farms and changed the forest vegetative cover from forest to grassland. This explains why cattle rearing have become popular in the area. As result of this a number of trees, animal and birds which were common in the town are no more there (Appendix1, 2, 3).

Erratic rainfall, high sunshine, cattle grazing and shortened fallow periods were also identified as factors militating against soil productivity within the community. These conditions have resulted in soil erosions perceived as bare soils and exposed roots of trees as explained during the discussions. Farmers now travel about 4-5 miles before one can get access to a fairly fertile soil to crop. They also said that those plant and animal which use to be indicators of soil fertility like the earthworms are no longer available. The reduction in soil fertility is seen in yields and that fact one has to look for a new area to crop after three years is an indication of poor soil fertility status.

There appears to be no local name for carbon. To illustrate this point one of the respondents said because there are no trees there is no moisture in the soil, therefore carbon in the soil was considered to be a function of soil. Others also said that it is a myth so it has no name and that God does not wanted us to know, quoting Deuteronomy 29:29 to support his point. The conclusion to be drawn is that they are aware of something in the soil which helps productivity but cannot give a name to it

Livelihood assessment

This section discusses the livelihoods assessment using the sustainable framework approach. It was done at community level involving the opinion leaders and some family heads. Five main factors that contribute to their livelihood were assessed, these includes their physical, human, social, natural and financial capital.

Natural Capital

The natural resources available are land for farming and and un tapped gold reservoir, rivers and sharpening stones for cutlass. There are as many as thirteen rivers in the town. Some of these rivers dry out during the dry season and the volumes of water in some of them have reduced considerably over the years. These changes in volume of water are due to human activities, some of which are farming along the river banks especially dry season vegetable farming, the loss of vegetative cover along the river banks; Siltation, the cutting of trees along river banks and the effects of climate change over the years. However, seven out of the thirteen rivers have water through out the year. These are *Asantasan, Hwerekwasi, Afram, Subonta, Boa, Kyerede* and *Aduasa*. In the past these rivers have been the source of water for consumption and agricultural activities. Today because of the presence of boreholes in the town the community uses such rivers for farming only.

The sharpening stones are a major source of income for the people especially the youth. A variety of wildlife and economic tress exist, with some population being extinct.

Land acquisition is mainly through members of a family. Thus, every member of the community has access to land. However, the size of the land available to member of the family is a function of the amount of land available to the family and the size of the family. Land ownership is however not uniform. Whilst some families have large tracts of land others have smaller tracts. This distribution has deep seated historical antecedents and is not peculiar to *Anyinasu* alone. Land for farming could also be acquired by a tenurial arrangement; the abunu and abusa system where proceeds from the farm are shared equally after harvest (Abunu) or the farmer gets two thirds of the proceeds and the land owner gets a third (Abusa). Migrant farmers within the community could also hire the land for maize cropping and at the end of harvest pay the equivalent of I bag maize to an acre of land.

Human Capital

Anyinasu has a population of about 4000 persons, mostly Akans with a few migrant farmers. Most of the available skills within the community are farmers and it is well distributed among males and females. In the area of food crop marketing, the skills are not limited to the women alone. It was also observed that the community members have the capacity to work during major and minor season and have adaptation skills as exemplified by the cropping patterns during the major and minor season.

The shift from the cultivation of cocoa to maize production is a typical example of the adaptive capabilities of the people. Secondly people have had enough interactions with agricultural officers and have been adopting the innovative practices expose to them.

Physical Capital

The community is connected to the national grid, every household has electricity and there are number of street lights in the town. In terms of educational infrastructure, there are four primary schools, three junior secondary schools and one private basic school.

There are only two toilets facilities in the town and this is woefully inadequate for a population of over 4000 people. They have a weekly market which is not vibrant and it is organized every Tuesday. There is also a maternity home which takes care of the health needs of pregnant women and nursing mothers. It also provides first aid care for some common diseases such as malaria and diarrhea. For complicated ill health district hospitals at Ejura and Ashanti Mampong are visited for the service. Drug stores (2) where drugs are dispensed and kiosks (17 small shops) where members of the community purchase provisions are available.

Anyinasu have adequate housing for all the inhabitants except that the housing types are different. The houses have large interior compounds where all house hold activities take place. There are two main roads leading to the town. These are the Sekyedumase road and the Kofiase - Mampong roads. The 8 kilometer road from Sekyedumase to Anyinasu is not tarred and becomes very unmotorable during the dry season. The road to Mampong is 30 km and is not tarred.

Social Capital

The social capital in *Anyinasu* is seen in family relationships especially the extended family system which provides the first opportunity for utilization of social capital. The other source of social capital is seen in the various groups in the community. These groups are either community based, agriculture/commodity, occupational and religious in nature. These groups provide financial support in cash and kind for the members in times of need (Appendix 4). They all have a common objective but claim no linkages exist between the groups, although we may have some members of the community belonging to more than 2 social groups.

The agricultural or commodity groups have linkages with the District Agricultural Directorate all the other groups are locally based. Some members also belong to Marketing groups outside the community, like the Maize marketing groups which supports members in the purchase of maize during the harvest periods. The German Technical Aid (GTZ) and World Vision have links with the community through the construction of the modern market and provision of water respectively (Diagram 4.2).

Different religious sects exist in the community. They are the Christians, Muslims / Islam and Pagan or idol worshippers. The Christian sects are the Seventh Day Adventist, the Roman Catholics, Methodist, Presbyterian, Pentecost, Christ Apostolic, Deeper Life, Salvation Army, Jehovah Witness Movement and New Apostolic church of Christ. The multiplicity of religious groupings has never brought about any conflicts among the people. Religion has had a moderating influence on the socio economic life of the people. This is evinced by the number of social groups formed on the basis of religion that exist within the community. Some of these social groups are Methodist Men and Women Fellowship, Presbyterian Men and Women Fellowship, the Men's society of the Catholic Church and the Islamic Youth group.

The main objective of these groups is to assist members in time of need especially during illness, funeral, delivery of a new born baby and loans. Most groups raised their income form monthly

dues or special donations, others also do group farming and monies from such ventures used to support members in times of need.
Social networking was assessed using the participatory method where members of the community show linkages that exist between these groups. The Diagram 4.2 shows the linkages that exist within *Anyinasu* as expressed by members of the community.

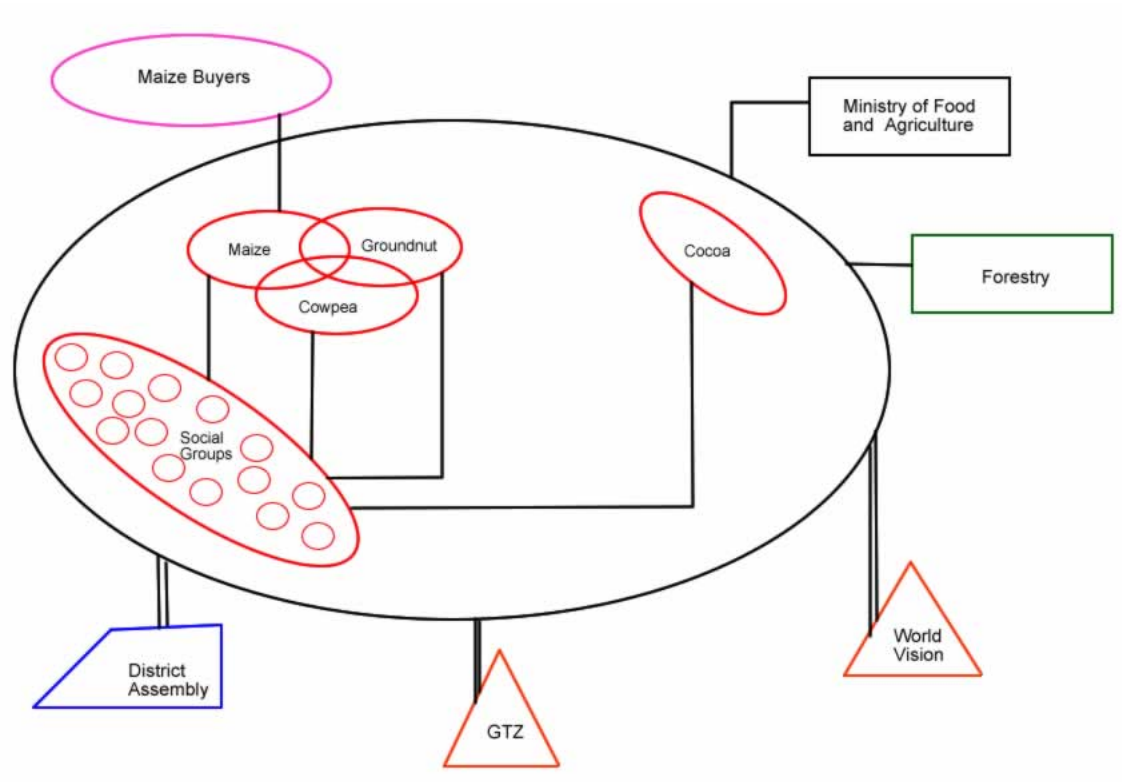


Diagram 4.2 Social networks for *Anyinasu* showing linkages between social groups within the community. A double line (=) indicates both physical and financial support; a single line (-) indicates either a physical or financial support or they have similar objectives.

Financial Capital
The financial resources in the community come from individual incomes derived from farming, off farm activities, market activities, rearing of cattle, goats and sheep. Income from cash crop such as cocoa and palm oil is on a smaller scale as there are not many people engaged in these activities. One major source of income is from transfer payments which come from relatives, and children living outside the community. Other source of financial capital is from the social groups and food crop groups (maize and groundnuts). These groups provide financial assistance to members in time of need for their farming purpose or when bereaved.
The only financial institution in the community is the Sekyedumase rural bank which operates an agency. Members of the community who have account with the bank enjoy credit facilities offered. Some members bank at the Ghana commercial bank at Ejura the district capital. Susu collectors are local persons who collect monies from their clients for keeps and then provide

loans to some members at an interest. They are a good source of savings for the people. Loans or credit are also sourced from foodstuff buyers who normally will pre-finance an activity in farming and would in return collect the farm produce as payment. Cooperative groups formed on the basis of food crop being grown have access to loans from banks.

c) Babaso

Babaso is located within the middle to north eastern part of the district on the Ejura – Afram plains (Samale Nkwanta) road and closer to Ejura the capital (longitude 1°19'W and latitude 7° 22.5'N). The settlement is within the Ejura-Denteso soil association (*Haplic Lixisols* and *Gleyic Arenosol*), it has similar characteristics and land uses as soil within *Nyamebekyere* but it is more suitable for mechanized farming. Soils in the area are more susceptible to soil erosion and therefore highly degraded when compared to the others.

Demographic characteristics
It has a population of 1336 with 65 households. Some households are made up of 3 to 4 families and some have extended family members being part of the household. Their ethnicity is diverse with the *Akans* dominating.

Occupational characteristics
This community falls within the fourth poverty pocket. They are relatively well endowed with their main economic activities being farming, trading / commerce, public and civil services and small scale manufacturing. The Poverty levels within this community also varies.
They mostly crop maize, cowpea, garden eggs, yam, pepper, okra, tomatoes and lowland rice as mono crops. Palm nuts and cashew are the main tree crops being grown in the community. Female farmers within the community grow pepper, garden eggs, okra, groundnuts, cassava, tomatoes and some times maize. Teak is being grown in collaboration with the forestry department as part of the taungye system; where farmers (both male and female) are allocated a piece of the forest and they clear and establish food crops and teak on the same piece of land. These teak plantations are maintained by the farmers until they become established and they can not crop under the tree any longer. The plantation then reverts back to the forestry department. Some farmers raise livestocks such as cattle, sheep and goat, pigs and poultry on a small scale. The community crops in the dry season cropping tomatoes, pepper, okra, garden eggs and lowland rice by rivers and streams. The agricultural calendar of the major crops cropped in *Babaso* is as follows: Maize, groundnuts and cowpea are planted in April to May during the major season and then in July to August in the minor season.
Yam is normally planted form February to April ending. Dry season cropping of tomatoes, pepper, okra and garden eggs are done by the river banks for easy access to water.
Cash crops like tobacco, cotton and bast fiber were being grown in the community some 30 years ago. These have changed because of the labour intensive nature of the crop, pricing polices were not encouraging and farmers who go into its production get hungry most of the time. Food crop production in the past 30 years was mainly yam / cassava intercropped with groundnuts after its harvest the land is cropped to upland rice. The change in land use was attributed to the mechanized way of farming which does not allow some crops like yam to be cropped, poor soil

nutrient and rainfall pattern and high population resulted in less access to land. Groundnut production in the community is also on the decline because of high incidence of diseases.

Land use dynamics

Land preparation methods have changed, farmers use to prepare land with simple implements like the hoe and cutlass and allow the lands to fallow for over 10 years before coming back to the same land. This has changed, land is prepared using heavy implements like tractor to plough and harrow before planting and this have affected the quality of farm land. This has resulted in land use change, now cropping mostly maize and cowpea which requires high inputs in its production. Yam fields are now sited at long distances away from the settlement area, mostly in the forest reserve lands which has been allocated by forestry officers for cultivation. Land within this area is under the administration of *Ejura* stool. The chief at *Babaso* acts as custodian and request from private developers to lease farm lands are through him to the *Ejura* chief. Agreements are signed between the *Ejura* chief for a specified period and one is expected to pay a hundred thousand cedis per acre per year. The type of tree crop to establish and use of land determines the period of agreement and amount to pay. Request for farm land to crop food stuffs does not require a lease and therefore a presentation of drinks is all that is required to allow one to crop a piece of land for food.

Activities that cause degradation

The following were identified as activities that cause land degradation;

- Yam production which results in the cutting of trees for more sunshine within the farm and also as stakes for supporting crop.
- Continuous cropping on the same piece of land and short fallow periods, because of lack of sufficient fertile land.
- Millet and teak production which destroys the quality of the soil and does not allow production of other food crops after 3-4 years of its establishment respectively.
- Charcoal production which causes indiscriminate tree cutting.
- Cutting of trees for mechanized cultivation which is a major practice within the community.
- Illegal chainsaw operators.
- Increased use of chemical fertilizers resulting in soils that can not support some particular crops.
- Bush fires caused by group hunters.

Drivers of land use and land use change

This was assessed using an open ended questionnaire at the group interviews with opinion leaders within the community. The most important drivers of land use and land use change were as follows:

- Marketing policy which protects the purchase of the commodity. For instance Tobacco, cotton and fiber which were cash crops being produced on large scale within the community were discontinued because of the policy agreement between the buyers and the farmers.
- Pricing policies or income obtain from the sales of the commodity. Low income obtained from the sales of tobacco, cotton or bast fiber made them discontinue its production. Low pricing of crop during bumper harvest discourages its production in the next season.

- Use of crop especially to feed family members will encourage its production. They claim those who crop tobacco go hungry because they do not have time to crop food crops and the income from this time consuming and cash intensive commodity does not pay back.
- Poverty level or the availability of small grants or credits determines what crop to cultivate. Grants or support from Ghana Tobacco Company encouraged them to go into its production. Sasakawa Global 2000 gave some support for maize production.
- Land productivity, soil type and rainfall patterns were all identified as factors that determines what to crop at a particular time.
- Modernization of farming, for example mechanized farming has changed their way of farming to mono cropping maize and cowpea as their main farming system.
- Availability of land also limits the type of crops or farming system to practice.

Livelihood assessment

This was done at community level involving the opinion leaders and some family heads. The five main factors that contribute to their livelihood were assessed, these includes their physical, human, social, natural and financial capital.

Natural capital

The community is endowed with the following natural assets which contribute to their main livelihood;

- Seven rivers and streams – Five of the rivers dries up often but 2 only dies up during prolonged dry periods. These rivers and streams use to be a major source of mud fish, shrimps, crabs and others.
- A forest reserve – where they hunt for games as a past time recreation and a source of meat protein and wild fruits and berries. Most of the wildlife is getting extinct (Appendix 1).
- Natural endowment of different tree species like *Odum, Mahogany, wawa, onyina etc.*
- Access to land for food crop production, although rich fertile lands are scarce.

Human Capital

This was assessed in terms of their health, nutrition, educational level, knowledge and skills and capacity to work or hire labor. The highest educational levels of members within the community are trained teacher certificate, technical and senior secondary school certificate holders. Most of them are skilled trained artisans and basic school certificate holders. While some have the capacity to hire labors, others do use family labor or both for field work.

Physical capital

The physical infrastructure within the *Babaso* community is better when compared with *Nyamebekyere*. Their road network or access road to the community is bad and although some drivers live within the community no member owes a vehicle. A few homes have roofing sheets, most of the homes have thatched roof. They have a Nursery, Primary, Junior secondary school and a teachers bungalow which accommodates 4 teachers. The community has 2 drinking bars and a provision store. It has a 20 seater – KVIP which serves both male and female inhabitants, 2 public stand pipes and 4 bore holes as their source of water for household chores and drinking. In terms of tools and technology for production, tractor services are available for ploughing and harrowing of their fields. These are hired from *Ejura*. Cutlass and hoes are available for non

mechanized means of land preparation. Improved seeds and fertilizers are also available for sale.
A clinic with a nurse is operated in a rented apartment to provide public health care especially ante and post natal clinics.

Social capital
Three main religious sects exist or operate within the community. Ten are Christians out of which 9 worship in the school buildings with the only church building belonging to the Roman Catholics. Some house holds worship traditional gods and the third sect are Muslims. Their social networks were assessed, apart from being members of the church or religious social groups, societal groupings based on ethnicity, or class in society does not exist. However farmer groups based on crop commodity being grown exist. These referred to as farmers association are formed to make easy access to loans and technical know how on the production of the crop. These are the maize, cowpea and yam growers association. The afforestation group also exists.

The Roman Catholics' Society for African Mission (SMA) has their presence in the community. They assisted them in the provision of the pipe borne water and a silo for storing their maize produce after harvest for a fee.
The community has a chief who answers to the Ejura stool and therefore represents the leadership of the community. He is responsible for the land distribution for farming and others within the community. In addition there is the unit committee member who lease with the district assembly which is the political and legislative body within the district.
Forestry officers or guards and community forest guards see to the protection of the forest reserves and provide technical support to the community. NGOs (World Vision International) and Extension agents under the Ministry of Agriculture also provide technical supports for sustainable land use management within the community. The social network as explained by members of the community is as shown on the diagram below.
Social networking was assessed using the participatory method where members of the community help identify linkages that exist between these groups. The Diagram 4.3 shows the linkages that exist within B*abaso* as shown by members of the community.
Member within the productive groups are linked together or belong to more than one group depending on the different types of crops grown as shown by the red lines.

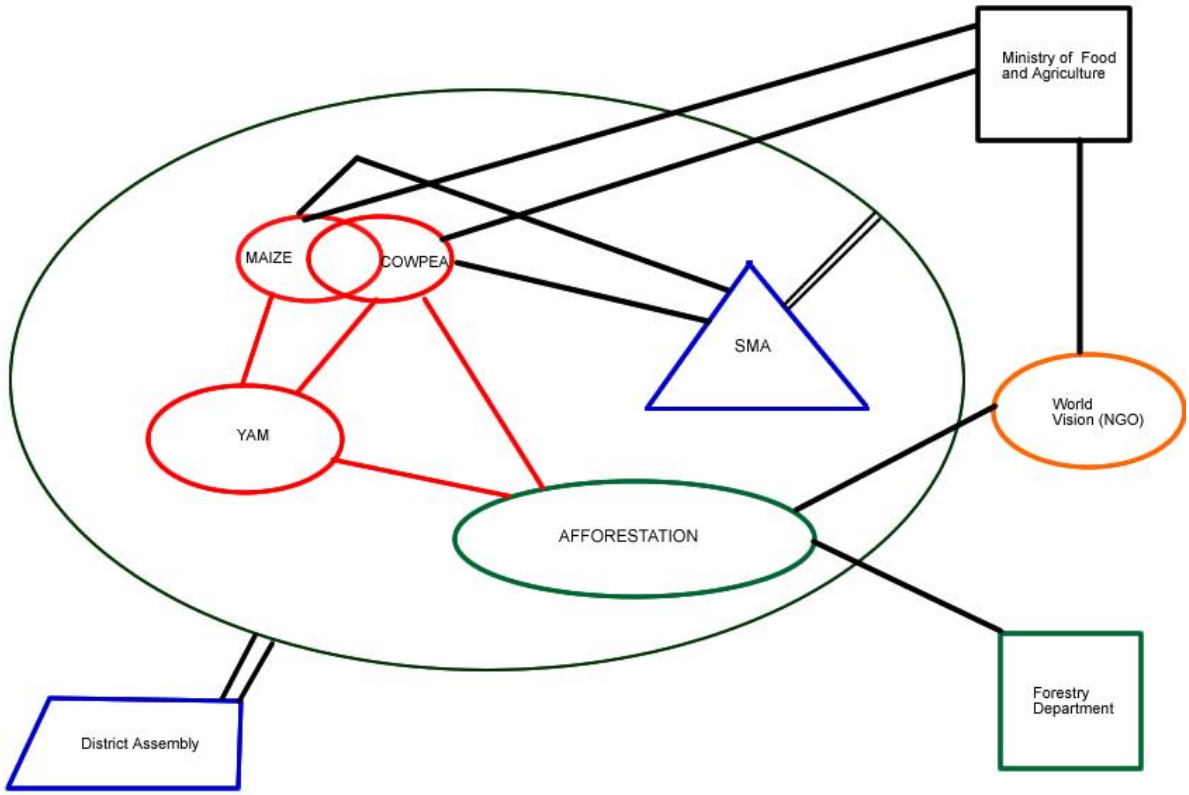


Diagram 4.3 Social networks for B*abaso* showing linkages between social groups within the community. A double line (=) indicates both physical or technical and financial support; a single line (-) indicates either a physical, material, technical or financial support or they have similar objectives.

Financial Capital

Their main source of income is from their farming activities. Other source of income is from wages for public servants who live within the community and pensions for just one person who has retired and live within the community. Remittances especially from children who live outside *Babaso* are received from time to time for those who have such privileges.

Savings which is not part of their culture because they claim they don't have enough is practiced by a few. Some save in banks (Ejura), informal banks (*Susu* collector) and the Roman Catholic Society for Missions in Africa (SMA) runs a credit union for farmers who are interested.

2.3.2. Vulnerability and Risk Assessment

This section describes the perception of poverty or wealth within the various communities studied in the *Ejura – Sekyedumase* district. It also describes the degree of vulnerability and

assesses the risk of some households within the community. This was done using the livelihood and socio- cognitive frameworks.

a) Perception of poverty -*NYAMEBEKYERE*

The community perceived a wealthy or rich households as follows:

- Owns a house, car, tractor, corn mill and sheller.
- Have several cows, sheep, pigs, goats and fowls but would not quantify.
- Have large or several farms
- Family members look healthy and children have good education.
- They can afford healthcare.
- Can hire labourers for farms.
- Own a well kept home with the basic amenities like a television set, radio, fridge and others.
- Only one person identified with this household type.

A poor household can not afford to feed his /her family well. The children lack proper education and cannot afford a proper healthcare for family members.
They have no cattle or livestocks and farm land for cropping are small or do not have any. Access to labour is absent and they live in a dilapidated home which lacks the basic amenities that make life comfortable. Widows and lazy persons within the community were classified in this group.
The medium resource households were identified as those who have the moderation of all assets listed under rich households. They have access to few lands for farming, a few livestocks and poultry but cannot afford a decent education and healthcare for family members. Most male and some female headed households fall under this group.

The following **stressors** were identified during the focus group discussion:

- Lack of finance or credit to undertake any meaningful farming activity
- Inadequacy of money to cater for family in relation to education, clothing feeding and healthcare
- Unavailability of schools in the community.
- Unavailability of any form of health post and health personnel.
- Unavailability of electricity.
- Inadequacy of portable water
- Inadequate toilet facilities
- Poor soil fertility

These stressors severally or individually affect the households and place them in the various categories.

b) Vulnerability assessment- *Nyamebekyere*

Vulnerability was assessed within the community using their livelihood assets and the pentagon method. Households were categorizes into the various resource groups and their level of vulnerability assessed in relation to the rich households. Six (6) households, 3 female headed and 3 male headed households with different levels of resources were assessed. Reasons for

female headed households varied, while some are as a result of the loss of their husbands, others have aged husbands who can not work or are divorced or husband has traveled to seek greener pastures elsewhere.

Diagrammatic presentations of their vulnerability are as shown in diagram 5.1 and 5.2, with the richest household within the community having a near perfect pentagon the richest households claim they are not rich and would need support and therefore tend to have skewed pentagons as indicated.

The most vulnerable female headed households in *Nyamebekyere* are those who have been abandoned by husband. They have the lest access to the natural assets especially land for farming, human and financial capital is low when compared with the others but have equal access to physical assets in the community but keeps to herself more often, hence not belonging to most of the social groups in the community. Widows have support from social networks and have more land to farm and therefore a better financial and social asset than the abandoned wife. Women who have support from husband but are decision makers in their home as a result of aging husband are better than any of the other 2 female heads. They are well endowed in terms of social, natural, human and financial assets.

The vulnerability assessment of the male headed households identified different levels of vulnerability as shown in diagram 5.2. The less endowed male headed household cannot afford to hire labor for his land and can therefore crop only a few acres. Although he is well connected in terms of social networking, he is not financially sound when compared with the other 2 groups. The medium resourced household has land which he gives out to people to crop and they share proceeds.

These two scenarios make the female headed households more vulnerable than the male headed households. Male headed households have a greater access to social, natural, financial and human capital than female headed households.

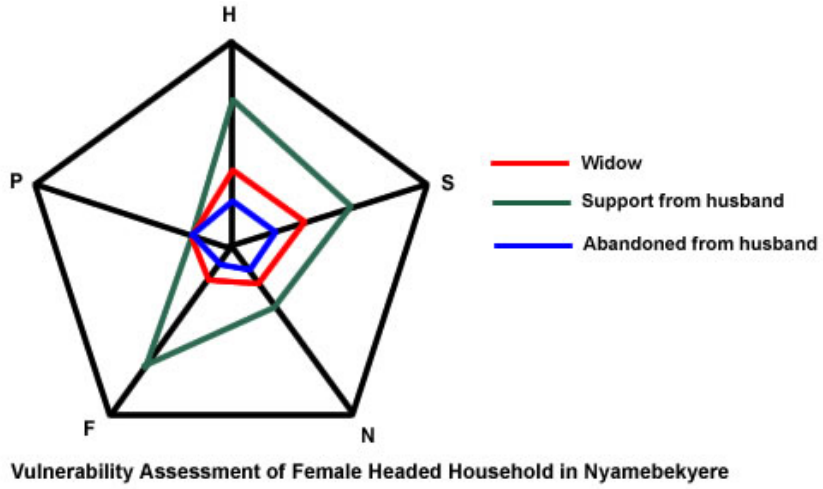


Diagram 5.1: Vulnerability as indicated by Female household heads in *Nyamebekyere*. H-Human assets; N - Natural capital: P - Physical assets: F – Financial assets: S - Social assets.

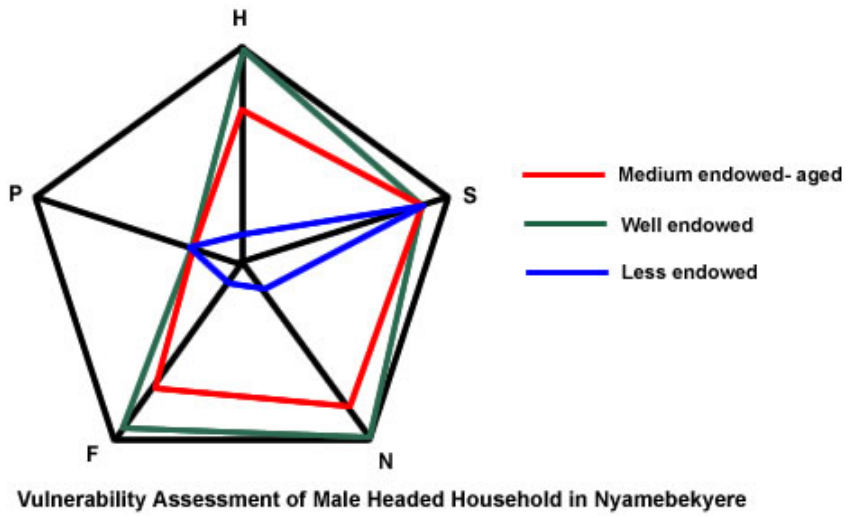


Diagram 5.2: Vulnerability as indicated by Male household heads in *Nyamebekyere*. H - Human assets:N - Natural capital: P - Physical assets: F – Financial assets: S - Social assets.

c) Perceptions of poverty - *ANYINASU*

Poverty or wealth as perceived by men and women within the community was different. Women in A*nyinasu* perceived wealth as ones ability to take care of your children or family by paying school fees, hospital bills and providing food. A rich person according to the women should own a house and a car. In addition to what the women said, the men perceived a wealthy person to have numerous farms, several cattle, sheep and goat, should be a philanthropist, have electricity in his home, and should have the basic amenities that make life comfortable like furniture, a television set, radio and fridge.

d) Vulnerability assessment - *Anyinasu*

Vulnerability was assessed within the community using their livelihood assets and the pentagon method. Households were categorizes into the various resource groups and their level of vulnerability assessed in relation to the rich households. Six (6) households, 3 female headed and 3 male headed households with different levels of resources were assessed. Reasons for female headed households varied, while some are as a result of the loss of their husbands, others have aged husbands who can not work or a divorced or has traveled to seek greener pastures. Diagrammatic presentations of their vulnerability are as shown in diagram 5.3 and 5.4, with the richest household within the community having a near perfect pentagon, the richest household claim they are not rich and would need support and therefore tend to have slightly skewed pentagons as indicated. The male headed households who are migrants are most vulnerable within the community.

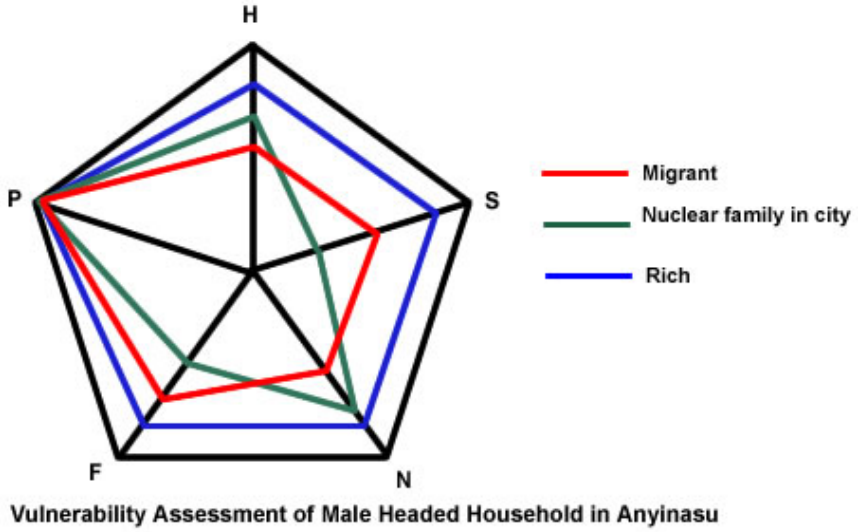


Diagram 5.3: Vulnerability as indicated by Male household heads in *Anyinasu*. H- Human assets; N - Natural capital; P - Physical assets; F – Financial assets; S - Social assets

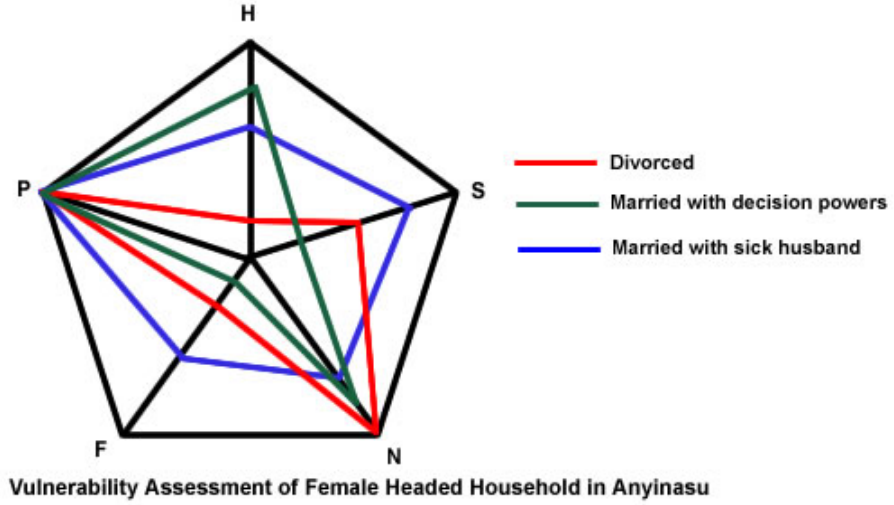


Diagram 5.4: Vulnerability as indicated by Female household heads in *Anyinasu*. H- Human assets; N - Natural capital; P - Physical assets; F – Financial assets; S - Social assets

e) Perceptions of poverty - *BABASO*

The community assessed poverty as ones inability to educate ones children and feed the household properly. The poor were also classified as lazy and does not dress properly or physical appearance is bad, has no land to farm and does not owe a home. He is also not able to pay hospital bills. Physical household assets like television, furniture and bicycle were not what make one rich within the communities. A rich household however has the following characteristics and assets;

- Children have good education.
- Household members are well feed.
- Owes a fine house
- Have cattle, sheep and goats.
- Have large and numerous farms.
- Can afford medical bills.
- Owes a car or tractor.
- Owes a corn mill, corn sheller

f) Vulnerability assessment - *Babaso*

Vulnerability of 6 households, 3 female headed and 3 male headed households with different levels of resources were assessed using the livelihood asset framework for each community. Reasons for female headed households varied, while some are as a result of the loss of their husbands, others have aged husbands who can not work or divorced or a husband who has traveled to seek greener pastures elsewhere.
Diagrammatic presentations of their vulnerability are as shown in diagram 5.5 and 5.6, with the richest household within the community having a near perfect pentagon, the richest household claim they are not rich and would need support and therefore tend to have skewed pentagons as indicated. Male headed households in *Babaso* are better of than those in *Nyamebekyere*. The less endowed male headed household have no alternate livelihood and has only a few sheep and goats or none and a small farm to crop as a source of food for its household. Such households are highly vulnerable when compared to others who have alternate livelihoods like drinking bars, owe a tractor or can afford the services of a tractor, shoe maker and a mason. The aged were not as vulnerable as those who do not have access to large farms to crop. They lease out their lands for the landless to crop and then share proceeds. The divorced female headed household is more vulnerable than the widow in the community.

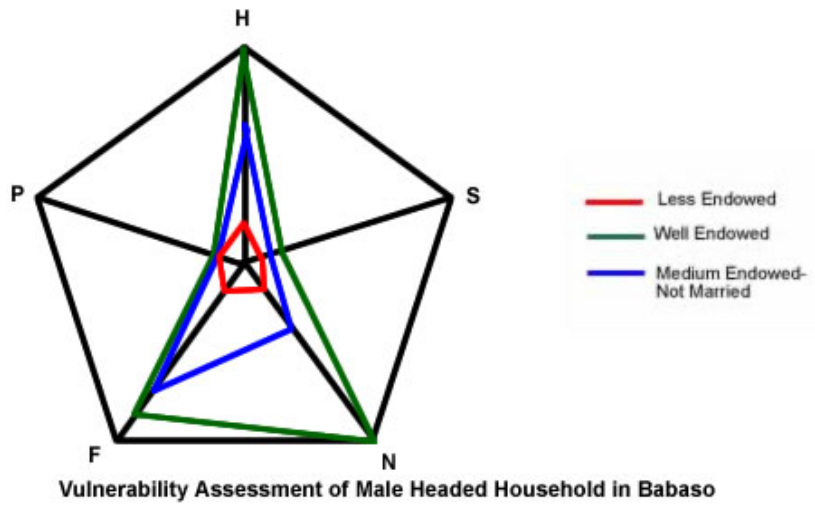


Diagram 5.5: Vulnerability as indicated by Male household heads in *Babaso*. H- Human assets; N - Natural capital; P - Physical assets; F – Financial assets; S - Social assets

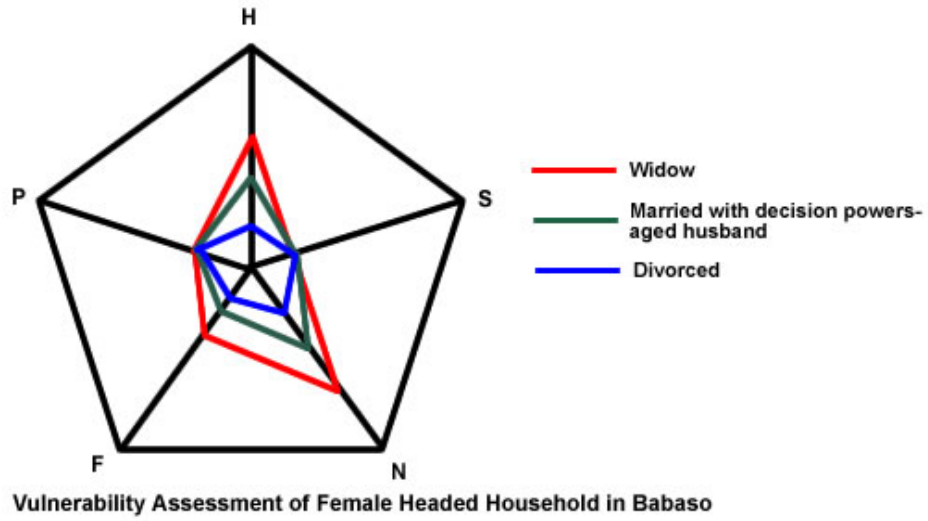


Diagram 5.6: Vulnerability as indicated by Female household heads in *Babaso*. H- Human assets; N - Natural capital; P - Physical assets; F – Financial assets; S - Social assets

Real world stressors

The real world hazards or stressors and risk were identified and analysed in a participatory mode using household heads from 2 communities (*Babaso and Nyamebekyere*) within the district. A list of problems, stressors or risk perceived or experienced within the last year were made by each household head and are as shown in appendix 5. These were ranked and their frequency and severity assessed by the household heads using pebbles scored between 1 (least severe) to 10 (most severe) and later statistically using Microsoft excel. Results were compared and discussed.

Risk assessment

This provide an information on the extent these problems or stressors affect their livelihoods. In all a total of 20 stressors were listed with a gender distribution of 40% for female headed households and 60% for male headed households (Table 5.1). Some stressors were found to be peculiar to male respondents while others related only to female headed households or both type of households within the limits of the study. The response indicates more number of stressors for male headed households than female headed households. Stressors common to both gender are as follows; Children upkeep, erratic rainfall, limiting access to farm inputs, small farm acreage, limiting labour, poor yields and sickness or ill health.

In assessing these stressors, severity, incidence and risk indices were calculated and mental models used to evaluate the effect of these stressors on the people and the environment. Participatory severity scores using pebbles were also averaged and results compared to the calculated risk indices. Results presented in the descending order on table 5.2 show similar findings. The highest 5 stressors with high severity scores and incidence above 45% were the same for both mode of evaluation. The lowest group of stressors with incidence below 10% have average participatory severity scores below 1 and risk index lower than 0.08. These stressors were peculiar to individual households or a particular gender. The highest stressors had a risk index of 0.54 and 0.5 representing a daily stress of extended family and children upkeep respectively. Most households have a problem of providing 3 meals a day, clothing, adequate shelter, education and providing medical care for their family and children.

The extended family upkeep which was a worry to most male headed households had widowed or aged parents or relatives to feed, cloth, shelter and provide medical care; thus increasing the number of persons to feed.

The cause of most of the stressors was lack of cash or due to low financial capital; whilst stressors such as family and children upkeep, ill health, poor management of farm and low access to labour will lead to a reduced human capital, inability to organised community members and emotionally disturbed due to absence of husband will lead to a reduced social capital. A situation peculiar to members of the *Babaso* community who due to lack of trust and confidence among themselves, tend to be less socially networked as compared to the other communities visited. Poor access farm roads, inadequate storage facilities at harvest and poor dilapidated homes are related to the physical capital of the communities.

Natural capital within the communities were found to be in abundant, however stressors that relate to this capital is inevitable. Poor degraded soils, poor farm yields, poor access to farm inputs, high tractor services, poor management of farms, erratic rainfall, small farm sizes and destruction of farm produce by livestocks are some of the stressors related to the natural capital of the communities. These stressors were found to be interrelated and are all due to the degraded soils, erratic rainfall and high population. With anticipated poor yields, farmers tend to crop small acreages of land and therefore would not need extra labour hence creating unemployment for the youth who don't have capital to start their own farms. Farmers tend to crop the same piece of land for a long time without adding any soil amendments because of scarcity of land; thus reducing the fertility and productive status of the field. Low financial capital exposes the farmers to a risk of not being able to access farm inputs for high yields and manage fields effectively hence being food insecure. Small farm holdings (R_j - 0.33) which are one of the high risk stressors would also result in continuous cropping without the necessary soil amendments; thus degrading the soils.

Table 5.1 Gender distribution of stressors within 2 communities in the Ejura-Sekyedumase district.

Stressors / Problems	Male Respondents	Female Respondents	Total
Children upkeep	6	5	11
Community Organization	1	0	1
No Job/ No cash / Inability to pay loan	0	4	4
Emotionally disturbed by livelihood.	0	1	1
Erratic rainfall	3	1	4
Extended family upkeep	7	0	7
Poor access to farm inputs	4	4	8
Management of farm	0	1	1
Poor access road to farms	2	0	2
Small farm sizes	3	4	7
Poor farm yields	1	1	2
Farm labour limiting or expensive	2	1	3
Marriage lacking / Absentee husband	0	3	3
Low market price for farm produce	2	0	2
Destruction of produce by livestock	1	0	1
Dilapidated homes	1	0	1
Poor degraded soils	3	0	3
Sickness/ill health	3	1	4
Inadequate storage facility at harvest	1	0	1
High cost of tractor services	1	0	1
TOTAL	**41**	**26**	**67**

Whereas the causes and processes of these stressors tend not to benefit both the community and the environment; they negatively affect the people making them more vulnerable economically, socially and environmentally. Coping strategies for stressors that affect natural and financial capital have been the presence of NGOs who organised them into capital formation groups on the basis of crop commodity and access loans from the bank. With poor yields as a result of unpredicted rainfall patterns, some members are unable to pay back loans. Other NGOs provide loans or grants in the form of farm inputs or tractor services. Crop and Land management practises to improve the productivity of the soils have been introduced to farmers by the Agricultural extension agents. And highly productive virgin lands are made available to farmers with no access to land but would want to crop food crops and trees together; a system being promoted by the Forestry Commission.

Table 5.2 Risk index and Severity (as scored by farmers) of stressors within 2 communities in the *Ejura-Sekyedumase* district.

STRESSORS / PROBLEMS	*Severity index (S_j)	Incidence index (I_j)	Risk index (R_j)	PSS**
Extended Family upkeep	1.14	0.62	0.54	5.0
Children upkeep	1.30	0.65	0.50	5.77
Poor access to farm input	1.71	0.62	0.36	4.08
Small farm size	1.61	0.53	0.33	4.69
No Job/ No cash / Inability to pay loan	1.50	0.46	0.31	4.15
Ill health	1.38	0.31	0.22	2.77
Erratic rainfall	1.78	0.31	0.17	1.54
Marriage lacking / Husband absence	1.33	0.23	0.17	2.08
Poor degraded soils	1.43	0.23	0.16	1.85
Farm labour limiting or expensive	1.57	0.23	0.15	1.92
Poor farm yields	1.25	0.15	0.12	2.77
Low market price for farm produce	1.80	0.15	0.08	1.23
Organization of community	1.0	0.08	0.08	0.69
Poor farm road	1.9	0.15	0.08	1.08
Dilapidated homes	1.50	0.08	0.05	0.77
Emotionally disturbed by livelihood	1.82	0.08	0.04	0.46
Management of farm	2.0	0.08	0.04	0.38
Farm produce destroyed by livestock	2.0	0.08	0.04	0.46
Inadequate storage facility at harvest	2.0	0.08	0.04	0.08
High cost of tractor services	2.0	0.08	0.04	0.54

***Severity index – (1 – most severe; 2 – least severe)**
PSS - Participatory severity scores using pebbles (1 – least severe; 10 – most severe)**

2.4. BAWKU EAST DISTRICT

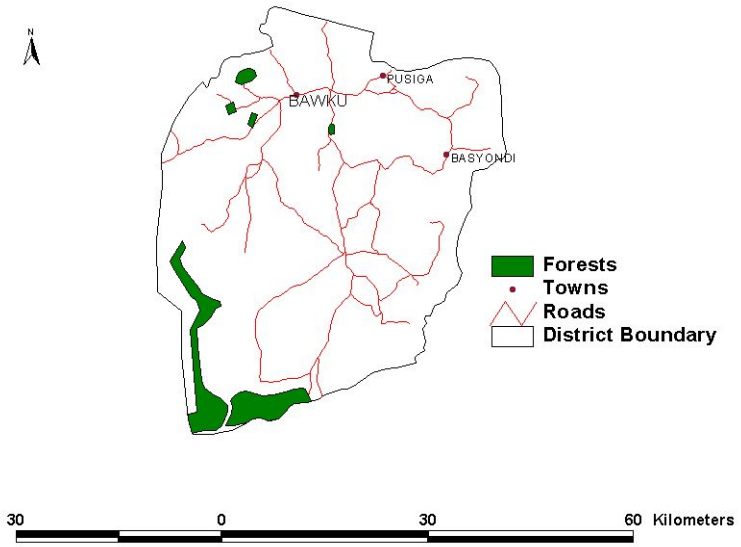
This section gives a brief description of *Bawku East* which is one of the 6 districts within the Upper East region of Ghana. Poverty is widespread and this has been partly due to socio-economic and agro-ecological conditions

Location
Bawku East district lies between longitude $0^o18'$W – $0^o06'$E and latitude $10^o40'$ – $11^o10'$N in the North Eastern section of the Upper East Region (Map 6.1). Burkina Faso, Togo, Bawku West District, and East *Mamprusi* District respectively mark the North, East, West and South boundaries of the district. The district occupies about 2067 km^2 with the district capital being Bawku.

Climate

The district experiences a unimodal rainfall between May to October each year with a mean annual total of 800mm. Rainfall pattern is extremely variable and unreliable among seasons and within seasons. With peak rainfalls often in the form of violent storms occurring between august and September. Dry season is between late November to March and the district has high evapo-transpiration rates and average daily temperature ranges between $26^{o} – 28^{o}C$. High temperatures of about 38° - $45^{o}C$ are recorded in March to May, rendering the district highly susceptible to bush fires during the dry season. The dry harmattan periods are characterized by dust laden winds from the Sahara. The Bawku East district compared to the other district within the Upper East region have poor rainfall distribution, low incidence of excessive rainfall and a high incidence of dry spell.

MAP 2: Map of Bawku East district showing the study communities.



Vegetation

This district is mainly a Sudan Savannah ecology, with an open savannah vegetation spaced with fire resistant deciduous tress, shrubs and grasses which are liable to burning during the dry season. Only economic tress like the mango, dawadawa (*Parkia filicoidea*) and the shea tree (*Butyrospermum* parkii) have survived. Intense cropping, prolonged grazing, burning and seasonality of rainfall have all influenced the vegetation. The most densely populated parts of the forest reserve are the *Morago* West, *Kuka* and the White Volta basin.

Geology

The district is an extension of the *Gambaga* scarp underlain by Birrimian and Granite rock formations separated in parts by thinly to moderately bedded sandstones. It also marks the highest relief point of the region; areas close to the White Volta and its tributaries are generally

low to slightly undulating with elevations of 120 – 150m. The rest of the district have a relief of a series of plateau surfaces which are ruminant of prolonged periods of weathering and erosion of the scattered hills. Minimum height of the plateau is 400m above sea level with isolated peaks in the case of *Zawse* hills being 430m above sea level (Adu, 1960).

Natural resources

According to the Upper East Regional Forest Services Division there are a total of 28 designated forest reserves covering an area of 154,000 ha. Bawku has 7 forest reserves which occupy an area of 291.51 km2 out of these 3 can be located in Bawku East district; these are the Morago West, Upper Tamne and *Zawse* plantation. The table below shows the distribution of reserves in the Bawku Forest Districts.

Table 6.1: Area of Forest Reserves

District	Reserves	Area (km^2)
Bawku	Red Volta East	217.60
	Morago West	**39.76**
	Upper Tamne	**17.25**
	Zawse Plantation	**10.12**
	Bumbugu Plantation	4.14
	Bumbugu Extension	0.46
	Bazua Bridge	2.18
Total		**291.51**

Source: Forest Services Department

These forests have undergone various levels of degradation due to human encroachment for fuel wood, poles for construction, farming, and bush meat and to bush fires and over grazing. In some cases woodlots are established in the off-reserve areas.

The trees of the reserves include Teak, *Dalbergia*, *Gmelina*, Mahogany, Ceiba, Albizia, *Anogeissus* and Neem. The Forestry Services Division operates nurseries in the district for the multiplication of Neem, Teak, Eucalyptus, Leucaena, Mango and Cashew.

Natural forest areas have been depleted by the clearing of land for farming, harvesting of fuel wood and poles for local construction, uncontrolled burning of rangeland and savannah woodland. The main fuel wood includes *Combretum spp, Acacia spp, Vitellaria paradoxa, Parkia spp, Anogeissus leiocarpus, Azadirachta indica* and *Lannea spp*. Deforestation is so severe that communities, such as *Kubongo* and *Bansi*, have had to fetch fuel wood from Burkina-Faso at a cost.

Non timber forest products such as shea nuts and dawadawa which is common in both reserve and off-reserve areas are harvested by women groups and processed.

Proper management of existing natural savannah vegetation wood and shrub is necessary for their sustained exploitation for various uses without undue environmental degradation. On the other hand, re-afforestation of degraded lands, and hillsides in all communities should be promoted to provide their fuel wood needs and protect the environment.

A number of initiatives including collaborative community forest management, tree planting through agro-forestry, individual and community woodlots and farm forestry by the Forestry Services Division (FSD), Savannah Resource Management Programme (SRMP), Environmental

Protection Agency (EPA) and Non Governmental Organizations (ADRA, TRAX, and Catholic Relief Services) are on-going in some parts of the district. These initiative need to be supported, strengthened and expanded to cover all the communities.
In promoting community based forest reserve management, there would be the need to develop local capacity to manage forest resources. Although resource management activities will vary from site to site, they may include production of seedling from private nurseries for rehabilitation of degraded areas, protection of headwaters and river banks, sustainable harvesting of forest products, the establishment and maintenance of firebreaks and the conservation of biodiversity. Training needs to facilitate the achievement of the community resources management goal should be assessed and implemented. Awareness creation of the benefits of natural forests should be an integral part of the promotion of community-based forest management.

Demography and ethnicity
In 1970, the District had a population of 175,154; growing at a rate of 3.02% per annum the population increased to 251,221 in 1984. Currently, the population of the District has reached 307,162 an increase of 22.3% of the population in 1984. Currently the growth rate of the District stands at 1.3%. This low growth rate is attributed to the division of the Bawku District into two Bawku East and Bawku West Districts in 1988.
The Population Structure is such that a substantial number of the District's population is under 15 years of age. As shown in the table below about 52% of the population is outside the working group. The dependency ratio is about 1:11 which implies a stress on the working population. Further more children between the ages 0-4 experience a high incidence of malaria and malnutrition. Lactating mothers have to combine childcare with income generating activities to support the family and these calls for the opening of early childhood development centres.

Table 6.2: Population Structure for Bawku East District

AGE (Years)	POPULATION	
	1984	**2000**
0-4	50,237	61,423
5-14	67,829	82,933
15-64	120,587	147,439
65+	12,568	15,367
TOTAL	**251,221**	**307,162**

Source: Population Census Report for 1984 and 2000

A significant feature of the settlement pattern within the district is the dominance of the rural population. Out of 466 settlements, it is estimated that only *Bawku* and *Garu* have populations of above 5000; qualifying them to be urban. Most of the settlements have populations below or just above 1000. Another significant feature of the settlement pattern is its dispersed nature. As farmlands are incorporated into the settlement structures, houses are built far apart from one another creating a dispersed scene. Such a pattern has other implications for the provision of water and sanitation facilities. A high cost is involved in extending pipelines to homes and between villages. To ensure convenience and shorter distances to water facilities, more wells and boreholes would have to be sunk thus making it more expensive. In the same vein more sanitary facilities have to be constructed to reduce walking distances to them.

Population growth and density have been key factors in determining the direction of socio-economic development of many parts of Ghana including Bawku East district. They have determined land holding and the rate of unemployment in agricultural areas such as Bolgatanga, Bongo, Bawku West and Bawku East in the Upper East Region (Population census provisional report 2000). Population density in the Upper East Region is generally high. The population density of Bawku East District in 1984 was 122 persons/km^2. Currently, the District has a population density of 149 persons/km^2. These leads to smaller land holdings and the associated excessive cultivation, contributes to a faster depletion of soil nutrients.

There are quite a number of migrants from other parts of the country, especially the south, (most of whom are civil servants), and the neighboring countries of Togo and Burkina Faso. The predominant tribes in the District are *Kusasis* forming the majority followed by the *Mamprusis*. Ethnic heterogeneity has had implications for harmony in the district. It is expected that intermarriages among the diverse ethnic groups will provide the impetus for peaceful co-existence.

Economy

Agriculture is the dominant occupation of the people of the District, accounting for about 62% of its employment. The major farm outputs are maize, millet, groundnuts, onions, watermelon and livestock such as cattle, sheep and goats. Poultry especially guinea fowl production is quite significant. The long dry season coupled with the inadequate number of dams for irrigation compel the youth of the district to migrate to the southern sector of the country during the lean season in search of menial jobs. This has adverse effects for constructional activities with respect to project implementation, since the elderly and the aged are left behind to provide labour for the execution of projects at community level.

Other areas which offer employment for people are public service (6.6%), food processing (9.3%), textiles and leather works (2.3%) and retail and wholesale trade (19.8%).

Bawku, the district capital, has the potential of becoming a vibrant commercial centre, which should stimulate and spur growth in the rural areas. However, the relative instability caused by ethnic conflict in the district has remained a draw back. The major challenge confronting the district is the need to consolidate the peace and harmony that have been achieved through building trust and confidence among the ethnic groups in the district.

Specific Economic Activities are: Onion cultivation and marketing in the dry season, Water melon production and marketing, Cattle trading, Smock weaving and production, Pottery, metal forgers and fabricators.

2.4.1. Results from the Households Surveys

This section focuses on population issues of the communities identified; examining population growth, ethnicity, religion and occupational characteristics including off farm activities and livelihood assessment.

a) *PUSIGA*

Pusiga is located in the eastern part of the Bawku Municipality and is about 14 km from the Municipality. This community is characterized by inter-annual crises such as erratic rainfall and persistent drought that lead to chronic food insecurity, often wide spread and severe. The beginning of the dry harmattan air mass which usually involves the entire district from late November to early March marks the end of the raining season. It is characterized by hazy climatic conditions leading to temperature fluctuation. Temperature falls to about 20° C during the night and rises up to about 38°C during the daytime. The area is drained mainly by a tributary that joins the White Volta towards the western part of the district. The topography is generally low and slightly undulating. Vegetation is mainly open Savannah with low grassland and widely spaced trees. There are a few cashew and mango tress.
The soil types range from clay soils to sandy loam.

Demographic characteristics
The population from 2000 – 2006 had increased from 6823 to 7243 and settlements in this area have crowded compound within the township but has dispersed compounds as one move out of town. Household sizes are fairly large, with an average of seven (7) persons per household. Though these large household could mean availability of labour, it has some financial implications in terms of feeding, healthcare, education and clothing among others. Migration is not prominent within the township out migration however exist; as you find a good number of the youth migrating to Bawku.
The *Kusasis* own the land but the predominant tribe is *Bissa (Busanga*). Other tribes such as the *Hausas, Mosis, Grushie (Yangas), Fulanis and Mamprusis (Yarsis)* co-exist in the community. The *Kusasis* mostly perform joint funerals after harvest. The Muslim and Christian communities perform their funerals according to their religions practices.

Occupational characteristics
The major economic activity is farming which includes; food crops, livestock and cash crops production. The main food crops produced are sorghum, millet, maize, rice, cowpea, soya bean and groundnuts. Cash crops produced during the rainy season are sweet potato and maize; and onions and leafy vegetables are cropped during the dry season. Another source of cash is the sale of fruits from the mango trees. Rearing of livestock such as pigs on commercial basis is common among the *Kusasis*. Inhabitants generally rear sheep, goat and fowls. Cattle and donkeys reared serves as source of traction for ploughing and transportation respectively. Gender disparity in crops grown and land ownership were observed during the study. Women accessibility to land size is very small because they do not owe land. They lack funds to buy

inputs like fertilizer hence their inability to crop onions and other main crops in the area. Women farmers therefore grow ground-nuts, pepper, tomatoes, okra and millet in very small areas. The male farmers crops sorghum, millet, maize, sweet potatoes, cotton, onions, tomatoes, cowpeas, bambara beans, cashew and rice among others.

Pusiga have two different farming periods: the rainy season farming which starts from May to October and the dry season farming normally around river basin and hand dug wells and dams and it is from October / November to April. Crops grown in the dry season are okra, tomatoes, onions and indigenous leafy vegetables.

Planting is done during the main farming season from May – June and harvesting ends in October / November. The land is left to fallow for 7 months or till the rains start again, the stalks from the harvest are either cut for firewood and/or stored for feeding the livestocks (leaving the land bare) or are left on the field for the animals to graze. With the exception of onions and water melon all other crops are grown during this period.

The community is endowed with indigenous economic trees like the shea, dawadawa and mango trees, which are normally harvested, processed and sold. The presence of a main tributary and some few valleys continued to be developed and utilized for irrigation purposes. The presence of the large market and its strategic location makes good potential for economic activities across border. The wide range of tribes with their various historical backgrounds is also being utilized for tourist e.g. the famous *Naa Gbewaa* shrine and history. Even though the community lacks social amenities and structures such as a Police Station and a community centre; the peaceful atmosphere enjoyed over the years serves as security which augers well for economic activities.

Income Generation Activities such as groundnut oil extraction, *kulikuli* (a delicacy made from the groundnut cake after oil extraction) making, *pito* brewing (local gin), malt processing and shea-butter extraction are some of the activities the people are engaged in as off farm employment. Other activities are smock weaving, petty trading, corn or rice millers, hairdressers, tailors, drivers and teachers. The presence of experienced motor bike fitters, blacksmith, building engineer etc are signs of good technological potential.

Annual festivals are observed in the community. These festivals are celebrated in each clan at the beginning of the harvest season. On these occasions, behind the merry making, libation is poured; first fruits and animals are offered to the gods of the land. This is done in acknowledgement of their blessings in the past and to implore their help and protection for the future.

The most widely spread festivals of the District are the *Samanpid*, *Ziisara*, *Bugumtor* and *Damba* of th*e Kusasis* and *Mamprusis*. These festivals, it is hoped, will increasingly serve as vehicles for uniting the people in the district.

Land use dynamics

The society is generally patrilineal and traditionally male dominated. Therefore land is owned by male members of the community and they are called *Tidani* – Land owner. Land is lease to community members for farming for a bowl or 2 of the produce cropped on the land and they are also sold outright for building purpose. Most farmers within the community farm on family lands. Land is left to fallow for about six to seven months depending on when it starts to rain and land scarcity. Land clearing within the community is done using simple implement like hoe and the bullock for ploughing. Debris left on fields from previous harvest are removed, heaped and burnt. Those who can afford the services of a bullock plough and ridge before planting whilst others plant on the bare. They then plant early millet and intercrop with late millet and

guinea corn and add on the other crops depending on land availability. Rice is cropped in valleys during the rainy period. Late millet has been replaced by maize which gives higher yields with the fewer amounts of rains being experienced. Soil amendments in the form of inorganic fertilizer or cattle and pig manure or compost from the household debris are applied. They also plant improved maize, cowpea and soya bean seeds developed by the Research Institutes in Ghana.

Livestock production has not changed much. Sanitation has improved because of their housing during the rainy season and feeding has also improved with supplementary feeds. Some cut and store farm residue at harvest and feed to animals, while others grow leuceana and cut to feed livestock. Livestock rearing use to be done in the open where the animals browse freely destroying plantations and field crops, but the need for its waste as manure has encouraged the provision of housing for these animals. The livestocks and poultry are now housed in kraals and pens or coops respectively during the rainy period and feed is cut and fed to them. Poultry which includes Guinea fowl are kept under the free-range system even during the raining season. Shepherd boys, normally their owe children or hired labour lead the livestock to fend for themselves during the dry season.

Land degradation

The following were identified as activities that cause land degradation.

- Bush fires in the dry season
- Farming along river banks resulting in siltation
- Continuous cropping with short and bare fallows.
- Land preparation which involves the use of brooms to virtually clear the land of all debris before planting; thus exposing the top soils to wind erosion.
- Most of the bunds erected to aid ploughing along the contour because of the undulating nature of land destroyed and therefore increasing soil erosion.
- Indiscriminate cutting of trees for firewood and charcoal production
- A myth that because crocodiles have been killed and are no longer in the rivers, has resulted in the drying up of streams.

Drivers of land use and land cover change

- Scarcity and infertile land limits the type of crops or farming system to practice
- Soil type and rainfall patterns were identified as factors that determines what to crop at a particular time
- Use of crop to feed family members. Every household crops the following traditional crops; Sorghum, millet, groundnuts and cowpea.
- The availability of capital in the form of loans or grant for the production of the commodity.
- Population growth as a result of in migration resulting in pressure on land or over exploitation.
- Marketability or marketing policy which is determined by the commodity price determines land use. Price of cotton in the area not profitable, farmers therefore changed to the cropping of maize which gives high yields and good price.
- Size of farm land or number of farms limits the number of crops and types to crops.

Livelihood assessment

This section discusses the livelihood assessment using the sustainable framework approach. It was done at community level involving the opinion leaders and some family heads. Five main factors that contribute to the livelihood were assessed. These include their physical, human social, natural and financial capital.

Natural capital

The community is endowed by land whose vegetation is mainly of the open sahel savannah type with fire swept farmland separating trees among which may be seen a few broad-leaved and thin leaf tree species. The present nature of the vegetation is a result of prolonged grazing, burning, and intensive cropping and seasonality of the rains. Land for farming is not fertile and it is obtained through the *Tindani*-landowner by personal contact and reasonable agreement between the two parties. Land is therefore owed by individual or family.

Pusiga has two streams, *Kolpelgo* and *Adaya* - they have a myth about the streams. The diminished fish stock and the drying up of the streams have been attributed to the inhabitants killing and eating the crocodiles in the river, which is believed to sustain the water in the streams. The *Naa Gbewa*a shrine which has a history that the high priest vanished into thin air some time ago now attracts a lot of tourist to the community. Some flora and fauna such as monkeys, snakes (cobras, python) birds, deer, antelopes and rabbits have become extinct. The community can boast of 1 forest reserve which is an established plantation.

Human Capital

Pusiga has a population of about 2000 people, mostly *Kusasis* with several migrant farmers and traders. It has a midwife, two nurses, four traditional birth attendants (TBA), some teachers and a police officer.

The highest level of education is university graduates, though they have a lot of school drop-outs due to poverty and the withdraw of female children from school to be given up for marriage has also had serious toll in contributing to high school drop-out. While some community members can afford the services of hired labourers; others use household members.

Generally the older people look frail and the community has large number of widows. They have traditional knowledge in tilling the land and other related activities such as smock weaving and oil and butter extraction. They also have the skills and the capacity to work and adapt new technologies.

Physical Capital

Pusiga has a teacher training school, 3 Junior Secondary Schools, 5 Primary Schools and 7 Nursery schools in terms of educational infrastructure. The community has one rural Bank (BEFA), a police station with no cells, a post office, three churches (The Catholic Church, The Assemblies of God Church and The Presbyterian Church of Ghana) and two Mosques. They do have trust and save with the rural bank, but complained of high interest rate of about 29%. Five percent of the households have electricity while the remaining has no electricity in their homes although they are connected to the National grid. Two cellular networks (*Tigo and Areeba* mobile phone operators in Ghana) operate in the community. And information are passed around the community through the beating of gong-gong, people go round to spread the information, announcement at churches or at the mosques using the loud speaker system that they have. The community has 6 stand pipes, 4 bore holes with a few homes connected to pipe borne water, it has 3 public toilets (Mozambican type) with some private homes having their own toilets and 2 clinics – a government and private clinic.

They have a vibrant market and it is operated every other third day. The market attracts people from Togo and Burkina Faso. The road networks in P*usiga* are motorable and their main means of transport is mainly by motor bikes and donkey carts. They have an asphalt road which articulator trucks ply from south of Ghana to Burkina Faso, Niger, Mali and Northern Togo. The road is also plied by taxis, bicycles, donkey-carts. Some of the people in the community own taxis.

Pusiga has four beer bars and several *pito* and *akpeteshie* bars. The community also has ten corn-mills and four rice-mills and 3 drugstores where they purchase drugs when ill.

Housing conditions in *Pusiga* cannot be described as poor because that is what the climate condition favors. Some of the houses are built of mud and thatch roof, others are built of blocks and aluminum roofing.

Financial capital

The financial resource in the community come form individual incomes derived from sale of farm produces, cattle, goats, sheep, pigs guinea fowls and fowls. Income from cash crop such as cotton is on a small scale as less people crop cotton.

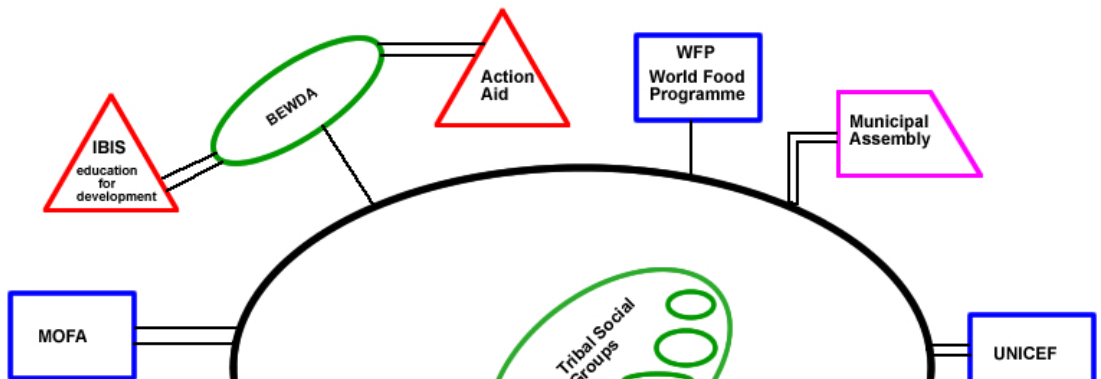
There is one rural bank in Pusiga. Community members who have relatives outside rarely receive remittances. Other source of financial capital is from the social groups these groups provide financial assistance to members in time of need or when a member is bereaved.

Social capital

The community is a heterogeneous society with the *Kusasis* dominating. The head of Pusiga is referred to as *Naba*. Each ethnic group has a tribal head. The social capital again is seen in family relationship especially the patrilineal family system which provides the first opportunity for socialization. The other source of capital is seen in the various groups in the community. These groups are either agriculture/commodity, tribal occupational or religious in nature. These groups are not well defined, this is because they were once organized but it does not exist. It is only the youth tribal groups that exist.

The agricultural farmers have linkages with District Agriculture officers and the District Veterinary Extension Officers who offer technical assistance in the form of improved seeds and teach them composting and how to mange their livestock.

The community has linkages with the Municipal Assembly (Diagram 7.1) that support them in putting up infrastructure, such as KVIP toilets, bore-holes, schools and roads. They also sensitize them on conflict management and provided market stalls. Various Non-Governmental organizations operate in the community through the assembly and Community Development Agencies as shown in diagram 7.1.



FINANCIAL CAPITAL

The financial resource in the community come form individual incomes derived fro

Diagram 7.1: Social networks and institutional linkages that exist in *Pusiga*

The United Nations International Children Education Fund (UNICEF), through the municipal assembly which is the seat of the local government within the district provided toilets, portable water and bicycles for the Girl Child educational programs. UNICEF again gave supports to women's groups in form of loans for farming and groundnut oil and shea butter extraction.
The Integrated Social Development Centre (ISODEC) provided uniforms, exercise and text books for the needy children in selected schools within the community. The Bawku East Women's Development Association (BEWDA) which operates from Bawku organizes women groups and gives educational talks on HIV/AIDS, women rights and health issues and Girl Child education.
The Catholic Relief Services (CRS) and the World Food Programme (WFP) provides food to school children.

b) *BASYONDE SABZUNDE*

Basyonde Sabzunde is the fourth largest community within the *Basyonde* Area Council. This area council shares boundaries with *Zon-Natinga*, *Woriyanga* and *Bugri-Gagbiri* Zonal Area Councils to north, south and west respectively and to the east by the Republic of Togo. The community is about 18 km from the district capital, Bawku. It is characterized by the pronounced dry and wet seasons and is mainly drained by the White Volta and its tributaries. Relief is generally low and slightly undulating with heights of 120 – 150 metres above sea level. The present nature of its vegetation is a result of prolonged grazing, burning, intensive cropping and seasonality of the rainfall. The soil type in *Basyonde* and its environs is mainly sandy loams associated with hornblende and granites which are quite permeable. Crops grown in the area include millet, groundnuts, rice, bambara beans, cowpeas and vegetables. The area is also noted for livestock rearing including poultry. Natural resources of economic importance are as follows: Forest resources including shea nuts and dawadawa trees as well as herbs for treating

various ailment; Clay deposits as well as white sand and stones for construction and pottery; and relatively fertile soils.

Demographic characteristics

The population of *Basyonde* Sabzunde was below 1000 at 2000 and this has increased to 1140 as at 2006. Household size is fairly large, recording an average of seven persons per household. Though these large household could mean availability of labour, it has some financial implications in terms of feeding, healthcare, education and clothing.

Out migration especially for the youth is quite high during the dry season. The youth migrate to the southern part of Ghana and Togo in search of jobs. It is a heterogeneous community with the *Kusases* forming the majority of the ethnic group others include, *Mamprusis, Moshi, Busanga (Bissa), Fulani, Grushie* and *Akans* who mainly come as traders.

The settlements within the community are generally sparsely distributed with family farmlands surrounding their residential compounds.

Occupational characteristics

The major activities in *Basyonde Sabzunde* are crop farming and livestock rearing which employs almost 80% of the able-bodied men, women and youth. The farmers rely solely on rain fed agriculture. They till the land using hoes or bullocks to plough and ridge before planting. Land is scarce and generally not fertile due to harsh climatic conditions; they therefore practice compound farming and intercrop most of their crops.

Due to the fact that farmlands are incorporated into the settlement houses are built far apart from one another creating a dispersed scene. Such a pattern has some negative implications for the provision of water and sanitation facilities. A high cost is involved in extending pipelines to homes and between villages.

Crops grown in the area are maize, millet, sorghum, sweet potato, rice, groundnuts, cowpea, soya beans, bambara beans, okra, onions, pepper and leafy vegetables. The main source of income is from the sale of onions cropped in the dry season and livestock.

Gender disparity in crops grown and land ownership were observed during the study. Women accessibility to land size is very small, this is because land is own by men who are family heads and women are allowed to crop on small areas given to them by husbands or family heads. They lack funds to buy inputs like fertilizer hence their inability to crop onions and other cash crops in the area. Women farmers therefore grow sorghum, millet, groundnuts, pepper, tomatoes, okra and leafy vegetables but in very small quantities.

The male farmers mostly crops sweet potatoes, cotton, onions, tomatoes, cowpeas, bambara beans, soya beans, cashew, rice and maize.

Farmers in the community crop two times within a year. The main farming season is between June to July when they plant all crops and then harvest in November. The land is then left to fallow with the stalks which are feed to the livestock till the next farming season. Dry season farming which is the second farming season starts from November to April; cropping mostly okra, onion and other indigenous leafy vegetables using dams and boreholes as their main source of water for the crops. Most of the cereals are stored to feeding the households whilst surplus are sold in the market.

Some farmers raise livestock such as cattle, sheep goat, pigs and poultry which is sold for income. Non farm income generating activities are done in the dry season or throughout the year

for extra incomes are as follows; pottery making, shea butter extraction, pito brewing and petty trading.

Land use dynamics

The society is generally patrilineal and traditionally male dominated. Therefore land is owned by male and they are called *Tidane* – Land owner. Land preparation in the community is prepared for cropping by clearing with simple implement like hoe and those who can afford use bullocks for ploughing and ridging before planting. Land is normally left to fallow for less than six months due to scarcity of land and stalk from previous harvest are normally left on the land to fallow and feed to livestock.

They have 2 cropping season; the dry and the rainy season. During the rainy season the valley is used for rice cropping; while farms close to homes (compound farms) are first cropped with early millet and latter intercropped with late millet and sorghum. The periphery is then cropped with some vegetables. Organic and inorganic fertilizers like cattle and pig manure are now applied to improve fertility of the soil. Maize, soya beans are new crops which have been introduced into their cropping system because of the changing rainfall pattern and poor yields from the late millet. They use improved maize and soya bean seeds provided by the Extension agents of the Ministry of Food and Agriculture. They also mono crop maize now. During the dry season, onions, okra and some local and exotic leafy vegetables are cropped for sale at the dam sites.

Cattle-rearing is free range during the dry season, but are house and feed during the rains. This mode of rearing cattle has resulted in the destruction of the plantations. Some of the big time livestock owners send their animals beyond the boarder of Ghana for grazing. Sheep and goat are also left to fend for themselves under the free range system of managing livestock. Poultry, which includes Guinea fowls, are also raised under the free-range system even the raining season. Children who are mostly their kids or relatives or hired labourers are used as shepherd boys who lead the livestock for grazing.

Drivers of land use and degradation

The community perceived climate change as changes in their rainfall pattern and amount, low soil fertility because of continuous cropping, land erosion and the absence of trees in the environment. The study also revealed land is not being managed sustainably. The females identified lack of credit to purchase farm inputs such as inorganic fertilizers, poor access to manure because they don't owe livestocks and an ineffective extension services as some of the factors that hinder sustainable land management within the community. Land management practice which includes the planting of trees such as teak and mangoes among crops is not encouraging because of scarcity of land and the one season rains. Trees established in compound farms are not nurtured but left to the mercy of hungry livestocks during the dry seasons.

The following were identified as causes of land degradation within the community:

- Continuous farming on the same piece of land as a result of land scarcity. This increases land erosion and reduced fallow periods and fertility of the soil.
- Population increases also reduces the land area per person and therefore encourages continuous cropping.
- Indiscriminate bush burning caused by smokers and hunters also exposes the soils in the area to erosion by wind and rain. This also reduces the population of trees and has resulted in vegetation which is mostly shrubby with few scattered trees.

- Indiscriminate tree felling for fuel and charcoal has reduced and changed the pattern of rains and land cover change in the area.
- Lack of agricultural education on the proper tillage practises results in exposure of soils to erosion and reduced fertility.
- Deliberate bush burning was identified as a culture of the people so that with the early rains the fresh grasses that emerge is a major source of feed for the livestock.
- Erratic rainfall pattern has lead to the production of maize instead of late millet which was not part of the farming system some years back.

Livelihood assessment

Natural Capital
The natural resources available are land for farming and the produce from their farms which are barely adequate because of the one main farming period and poor soils. Land acquisition is mainly by inheritance. Migrant farmers acquire land for temporary use in exchange for crops grown, a bag of fertilizer or on goodwill relations. Water and aquatic resources are in adequate. The community has six (6) rivers which dry up in the dry season. They also have five (5) non functional man-made dams which use to be used for dry season farming. The changes in the volume of water are due to human activities, some of which are farming along the river banks especially dry season farming, siltation, the cutting of trees along the river banks and effect of erratic rainfall. Wild life, wild foods and most trees and forest products are near extinct because of the wild bush fires which occur annually. A few baobab, shea and dawadawa trees could be seen sparsely within the ecosystem.

Human Capital
Basyonde Sabzunde has a population of about 1140 persons, majority being *Kusasis*. The population is mostly farmers and is well distributed among males and females. In area of food crop market, the skills are not limited to the women; men are actively involved in the sale of onions and maize in addition to sale of livestocks. It was observed labour for weeding compound farms are provided by women, youth and children of the household; with few being able to afford hired labour. The community has the capacity to work during the farming season and have adaptation skills as exemplified by the farming patterns which includes new crop varieties and adoption of innovative ways of improving soil fertility levels. Inadequate interaction with extension agents was expressed by a section of the populace.
The highest level of education in the community is a National Diploma holder from the Polytechnic; others are certificates in agriculture, teaching, nursing and community health. The presence of a clinic and staff offers a labour capacity which is healthy

Physical Capital
Educational infrastructure in the community are inadequate they have no Junior Secondary School but have two primary schools and three nursery schools. Water and sanitation are also inadequate; 2 boreholes which provides drinking water for the whole community, eighteen (18) household toilets and one (1) public toilet for both male and female this seats only five people. *Basyonde* has adequate housing for the entire inhabitant; however most of the houses are mud with thatch roofing. The community is not connected to the national grid, electricity poles have

been erected. There are three (3) church building one each for the catholic, Presbyterian and the Assembly of Gods congregation. They have one (1) mosque.
They have a market which is not well developed but vibrant with trader coming from Burkina Faso and Togo. They have an abattoir which is deteriorated and has no post office making the only means of communication through the various mobile networks. They have one functional clinic with a midwife, a nurse and a community health attendant but have several traditional birth attendants.
Infrastructure in terms of transport which includes vehicles and road network is bad: There is one main road leading to *Garu* and then to Bawku and a diversionary that leads to Burkina Faso and Northern Togo with several unapproved routes. The entire road network is not tarred. Motors and bicycles are common means of transport, a few taxis and mini buses are available. Tools and technological capital for production are accessible. Bullock ploughing and ridging has been introduced to the farmers and cropping of improved maize varieties instead of late millet which gives poor yields are some of the technology demonstrated to them. Composting of household refuse and use of livestock manures are also new techniques to improve soil fertility.

Financial capital
Their main source of income is from their farming activities. Other source of income is from wages for those in the formal sectors such as teaching and nursing. Petty trading and the sale of *pito* or *shea* butter give them some income. The public servant in future benefit from the pension scheme.
Though they have relations outside the community, remittance from them is only when they visit home. Some members of the community save in banks outside the village. However *Susu* a local form of banking is largely patronize. Credit from either the formal or informal was said to be inaccessible by most of them; the directorate of MOFA claims credit is made available to various farmer groups through the Bank of Ghana.

Social capital
The generic social capital was access in relation to the formal and informal groups that exist within the community. The main informal groups based on the several ethnicities are the youth organizations formed on the basis of their tribal affiliation. Other groups are the Christian and Moslem groups formed on the basis of the religion; these groups are further grouped into smaller groupings like the women and men fellowships. The formal or productive social groups formed on the basis of crop commodity or livestock production and marketing exist in the community. These social groups are linked by the fact that they have common objectives and goals and there are persons who belong to more than one group. As members of the formal and informal groups, assistance in the form of cash or in kind is donated when one is bereaved, marriage and poor farm yields or fire disaster. The community has some relation of trust and mutual support for each other especially when in stress. They are also socially networked, having clear leadership and a mechanism for participation in decision making. A remarkable example is when the community together with the representative on Municipal Assembly (commonly referred to as Assemblyman), agreed to pay for the services of four teachers hired to augment that provided by Ghana Education Service. Payment was by the provision of bowls of millet, sorghum or maize by all households and these were sold in the market and the proceeds used to pay the teachers.

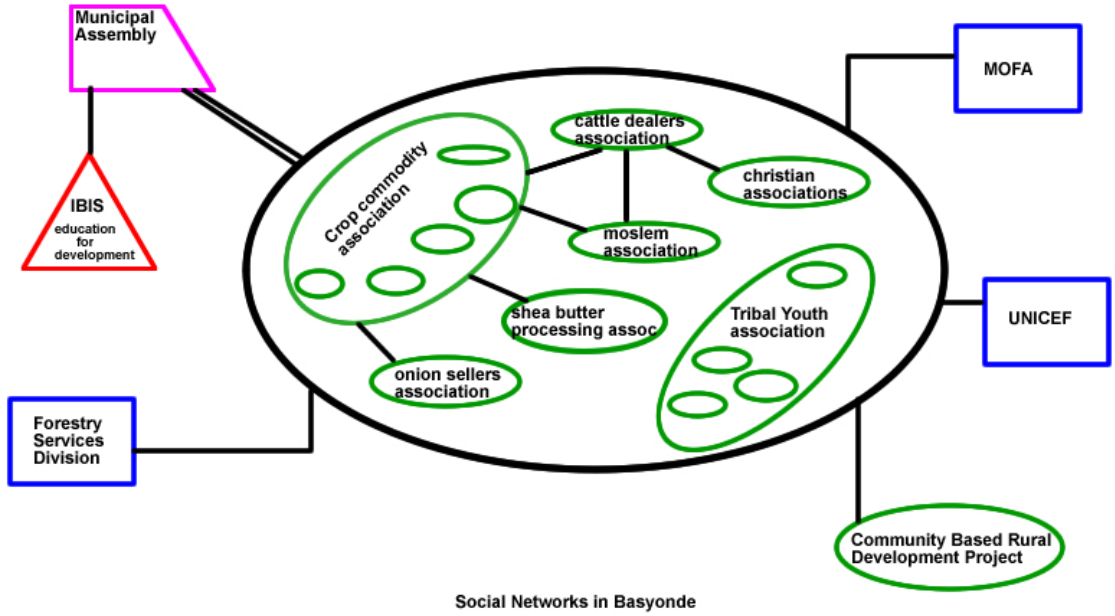


Diagram 7.2: Social networks within *Basyonde Sabzunde* showing linkages and institutional networks

Social networks and connections between institutions and Non Governmental Organizations (NGOs) that have interest in the community are as shown in diagram 7.2. The community also has linkages with the following: The District / Municipal Assembly which is the seat of the local government have structures in place that evaluates and design the developmental priorities of the community. They are linked to the community through the unit committee members and Assemblymen of the area and by the provision of school furniture, electricity poles, public toilets, market sheds, dams and bole holes.
NGOs and community development agencies such as Community Based Rural Development Project (CBRDP) , IBIS (Education for development), JICA and UNICEF all work in the community providing financial assistance for the construction of some physical capitals and sponsoring education on health issues, civic responsibility and human rights. The Forestry Services Division provided seedlings for plantation development, whilst Ghana Education Service provides teachers for the schools. Ministry of Food and agriculture has a stationed Extension Agent in the community who offers technical advice and services to the farmers within the community. They also organize the farmers into group to access loans from the banks.

2.4.2. Vulnerability and Risk Assessment

This section describes the perception of poverty or wealth within the two communities studied in Bawku East district. It also describes the generic degree of vulnerability and assesses the risk of some households within the community. This was done using the livelihood and socio-cognitive framework.

a) Perception of poverty – *Pusiga*

The community perceives a poor household as a home which is made of mud and roofed with thatch. Such homes have less than an acre of land to farm, have no access to bullock plough, and therefore plant on the bare and cannot afford to manure land. Yields from crop are generally poor and can therefore not feed family well. That household head has only a wife or none and has no livestock. They normally offer their services as farm labourers for a fee. The wealthy or rich household on the contrary has so many followers and command authority in the society. They have a lot of money, are able to cater for his family and have the following resources:

- So many farms - 10 acres and above
- Cattle - 50 and above
- Sheep and goats - 100 and above
- 4 block houses
- 10 wives
- Bullocks to plough and ridge
- Car
- Articulator truck

The medium household has some land to crop about 2 to 3 acres, owes a motor bike, has some few livestock (2-7 cows, some sheep and goats, some poultry), has about 3 wives can afford to cater for the family and has bullock to plough fields.

b) Vulnerability assessment - *Pusiga*

Vulnerability was assessed using household heads in a participatory mode. The households within the community were categorized into the various resource groups, three persons each were selected from these groups and their generic vulnerability assessed against a typical rich household in the district capital or an urban community. The female heads were assessed against the rich household heads in the community. A total of 15 household heads; 9 male and 6 females were used in the assessment.

A diagrammatic presentation of their vulnerability as indicated during the study is shown in diagram 8.1 and 8.2. Households under low resource endowment are highly vulnerable when compared with the others. Low resource households have farm lands from 1 acre to about 7 acres but do not have access to financial capital to crop all land. They have few livestocks and since they don't have bullock ploughs tend to have the most degraded land due to poor means of ploughing. They have an average of 8 household members; 3 males and 5 females to feed and cloth and most of the time cannot afford to feed the family at a point in time during the season because of poor harvest. The rich household although vulnerable is better than the medium and low resourced household. The rich has an average household size of 19; 10 males and 9 females have large farms and can afford to buy farm inputs to increase farm produce per unit area. They can also afford to pay for hired labour and have access to cash. The study revealed that access to natural assets such as land with no financial and human capital may make one vulnerable. Those who keep livestocks owe bullocks and they have access to manure to fertile soils and also plough along the contour to prevent land erosion on their fields. Those who hire the services of the plough have land erosion problems on field because of bad tillage practice.

The female headed households are mostly single mothers who are divorced or widows. The widows were found to be more vulnerable than the divorced. They were mentally frail and have

no other source of income apart from farming, few fowls and petty trading. They have an average household size of about 4 (3 females and 1 male) and have an average farm size of about ½ - 2 acres. They have no savings and have sold all livestocks to pay for school fees of kids. Although land is available for farming lack of cash to hire labour and buy farm inputs results in cropping just some few acres to feed the family which most of the time is not able to take them to the next season. Food in security is their main headache. The other female households who are normally divorced brew pito which is a local beverage brew from millet in addition to what the widows do. They have a larger household size of about 3 – 9 with an average of 5 persons. They are able to crop larger lands which are given to them by family heads whilst others do not farm at all but are mostly engaged in petty trading.

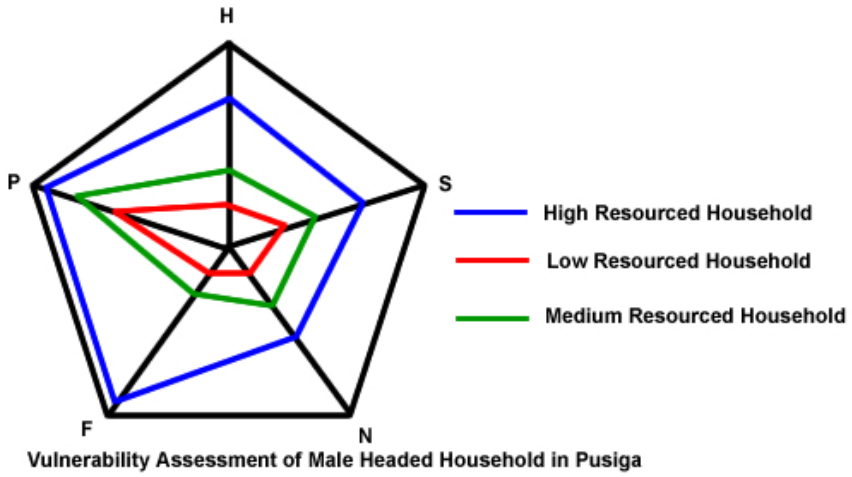


Diagram 8.1: Vulnerability as indicated by Male household heads in *Pusiga*. H - human assets; P – physical assets; N – natural assets; F- financial assets; S – social assets

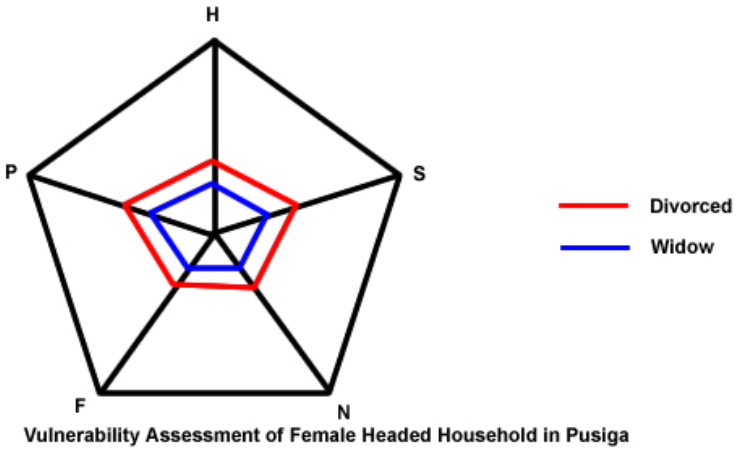


Diagram 8.2: Vulnerability as indicated by Female household heads in *Pusiga.* H - human assets; P – physical assets; N – natural assets; F- financial assets; S – social assets

c) – *Basyonde Sabzunde*

Poverty as perceived by both gender were different within the community; while the female talked about dirty clothing, no sandals, no food and can not feed kids as signs of poverty, the male in addition to those mentioned earlier also include shelter or a home to sleep, cannot educate children and not being able to purchase farm inputs and payment of hospital bills. This could be explained by the fact that cash crops which require soil amendments and the need to purchase improve seeds for high yields are mainly male crops.
The following were listed as the resources of a wealthy household within the community:

- A block house
- 25 or more cattle, sheep and goats
- 50 guinea fowls
- More than 50 poultry
- Donkeys with carte for transportation
- 10 ac or more farmland
- 4 wives
- Motor or a car
- Corn mill

It was surprising to note that members of these community within the district list wives as part of their resources and status of wealth. This may be explained by the fact that bride prices involve the payment of 4 cows and these are scarce commodities within the poor households who don't have cows or have few livestocks and therefore likely to have no wife or just one.

d) Vulnerability assessment of *Basyonde Sabzunde*

Vulnerability was assessed using household heads in a participatory mode. The households within the community were categorized into the various resource groups, three persons each were selected from these groups and their generic vulnerability assessed against a typical rich household in the district capital or an urban community. The female heads were assessed against the rich household heads in the community. A total of 15 household heads; 9 male and 6 females were used in the assessment.
Natural resources in terms of land for farming varied among the households assessed. Whilst rich households have large acreage of farm lands more than 10 ac; medium households have less than 10 ac and the poor households have a little less than 2 ac to feed large household. Most female headed households fall under the poor resource households within the district. Household sizes also varied as a result of number of wives one can afford or extended family dependence. Within this community, the rich have large herds of livestock so they can afford to plough their land using bullock traction and has access to large amount of manure to improve soil fertility. The poor who have no livestock cannot afford a bullock traction or manure for soil amendment, yields are therefore low and such homes are food insecure.
They do hire their services out as casual labourers on rich household fields for a fee. Technical services are available to all households in the community but household members in the well

endowed households have access to education to all level while the others can afford just the basic education or no education at all.
Socially, rich households have good standing, commanding respect and socially linked to most of the formal or productive and in formal groups. The poor are virtually no active members of the community.
Rich households have good yields and large herds of livestock, they are normally food secure and has a lot of cash so they are able to save some for use in case of disaster. The poor or low households have no cash to purchase soil amendments to improve yields or pay hospital bills which renders members in this household vulnerable.
With limited infrastructure, physical assets to households within the community is variable while the rich can afford toilets and water in their homes and live in a block house; the poor would have to queue for the use of such facilities and has a mud thatch house as a home. A diagrammatic presentation of their vulnerability as indicated by male households and female headed household heads during the study is shown in diagram 8.3 and 8.4 respectively.
Households under low resource endowment are highly vulnerable when compared with the others. Female headed households are less vulnerable when compared to the poor resourced household; this could be because most of the women have access to extra income from other non farm activities (shea butter production, pito brewing, petty trading etc.) which are encouraged technically and financially by Development agencies and NGOs.

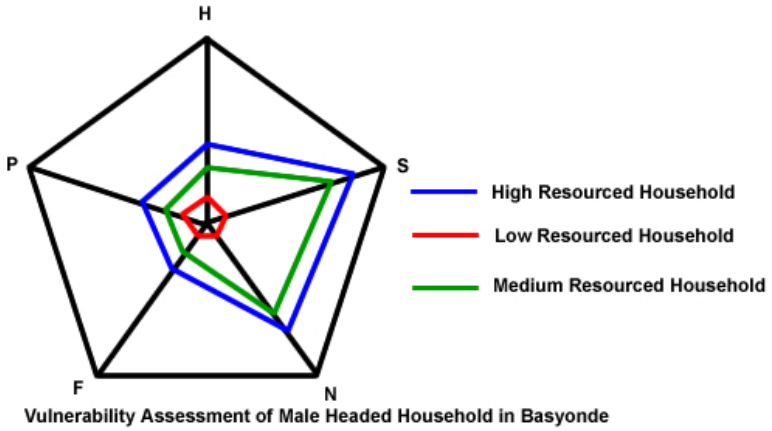


Diagram 8.3: Vulnerability as indicated by male household heads during the study; H – Human assets, P – Physical assets, S – Social assets, F – Financial assets, N – Natural assets.

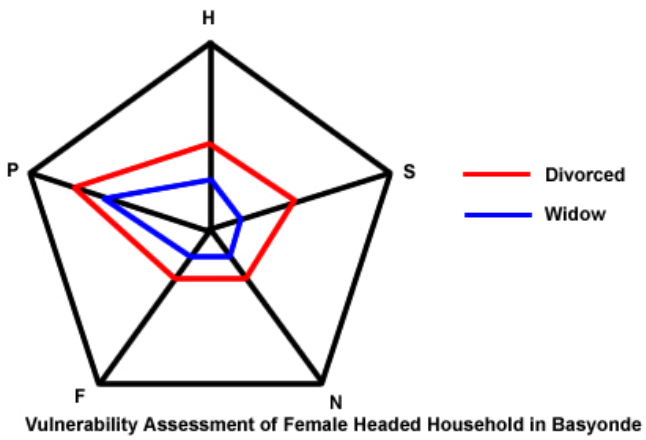


Diagram 8.4: Vulnerability as indicated by female household heads (Basyonde) during the study; H – Human assets, P – Physical assets, S – Social assets, F – Financial assets, N – Natural assets.

Real world stressors and risk assessment

The real world hazards or stressors and risk were identified and analyzed in a participatory mode using household heads; score of severity of stressors was done using pebbles. A list of problems or stressors perceived or experienced within the last year were made by household heads identified in the 2 communities (*Pusiga and Basyonde Sabzunde*) and presented in appendix 6. These stressors were later assessed statistically using the Microsoft excel programme and discussed.

A total of eighty seven (87) real world stressors or problems were listed during the study. Female headed households generally had less stressor, about 27 when compared to the male headed households who listed 60 stressors. The percent distributions by gender to the number of real world stressors within the 2 communities in the Bawku east district are as shown in figure 8.1. Distributions by communities are also shown in figure 8.2; Community members in *Pusiga* had more problems than *Basyonde Sabzunde.*

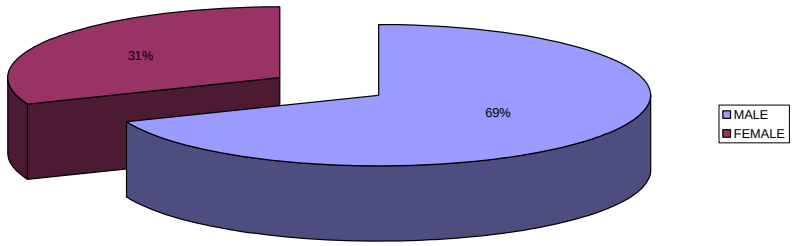


FIGURE 8.1: Percent contribution of gender to the real world stressors in the Bawku East district

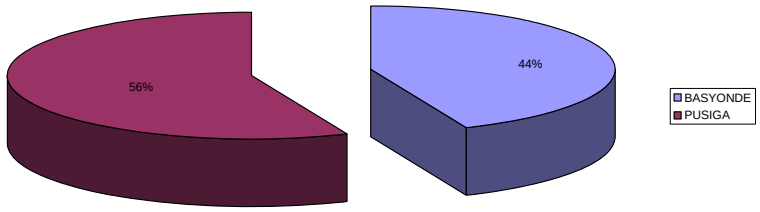


FIGURE 8.2: Percent distribution by the various communities to real world hazards in the *Bawku East* district

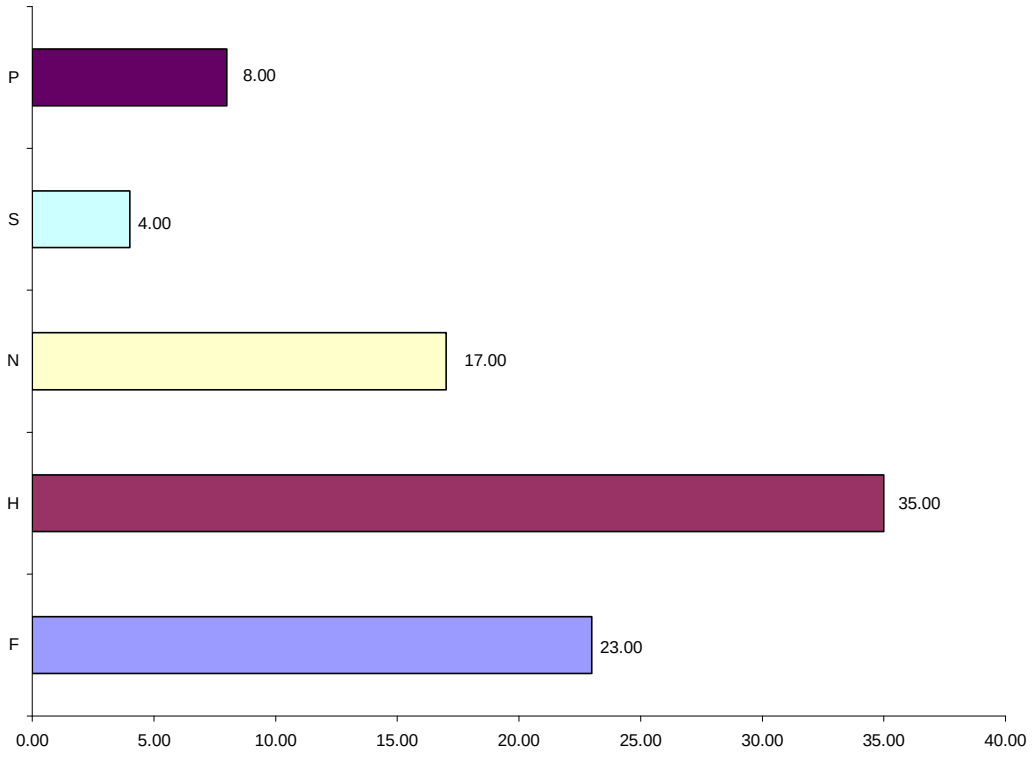


FIGURE 8.3: A bar chart showing distribution of livelihoods assets in relation to real world stressors; F- financial capital, H- human capital, N – natural capital, S – social capital, P – physical capital

The stressors were classified in relation to the various capital assets that affect livelihoods: Figure 8.3 shows the distribution pattern. The highest listed stressors affected human assets and these include stresses that affect human health, labour accessibility for farm and livestocks, education and food insecurity or nutrition. The least stressors affect the social assets of the communities. In all situations the study revealed an equal concern of issues for both gender. Stressors that affects financial assets was the second frequently listed; these were mainly access to credit to purchase farm inputs or expand farms, family and children upkeep and alternate employment or livelihoods for wives and girl child. It is interesting to note that most male household heads were worried about the vocation of their girl child but not the male child.
To further assess these stressors, severity, incidence and risk indices were calculated and averaged over the number of times it was mentioned during the study following the formulae used by Smith et al., 2000 and Quinn et al., 2003. Incidence of threats was determined by dividing the number of times a threat is mentioned by the number of respondents. Severity which is a measure of the degree of harm experienced as a consequence of the stressor was evaluated using the pebbles where 10 refers to most severe and 1 is the least severe.
The stressors were also evaluated using the following formula;
$Sj = 1 + (r-1) / (n-1)$ where Sj is the severity index; r is rank of threat and n is the total number of threats listed by respondents. Risk index was then determined as the ratio of incidence to severity incidence. The mean of the subset of household heads identifying a particular threat are as shown in table 8.1.
Access to credit or capital for farm expansion or to purchase farm inputs, problems related to ill health or health issues, food insecurity and alternate non farm employments for female members of the household had the highest risk index of 0.69 and an incidence of over 70%. Every household mentioned inaccessibility to credit as a source of worry and stressors with risk index less than 0.07 were problems or threats peculiar to individual households and forms about 46% of all stressors mentioned during the study.
Apart from inadequate housing and lack of fire tenders and personnels which had participatory scores of 3 and 1 respectively; the low risk threats had scores of above 6 with most of them being scored as the most severe threats (10). The fact that male household heads were disturbed about jobs for their female household members indicates that they do not accept farm employment as a good source of income for the females. This adds weights to the fact that women have less access to land and cash to crop and raise livestocks. It is also interesting to note that although *Basyonde* have no electricity they did not mention it has a threat or stress but this was mentioned at *Pusiga* which is connected to the national grid but then not all households have access to electricity hence a threat for such households. The same was observed for water; this was a worry for persons in *Pusiga* where they have access to many more bore holes and pipe than *Basyonde*.

Table 8.1: Average severity (Sj), Incidence (Ij) and risk (Rj) indices of stressors in Bawku East district.

Stressors	**Sj****	**Ij**	**Rj**	**PSS***
Access to credit	1.53	1.00	0.69	9.30
General well being / ill health	1.34	0.90	0.69	8.56
Food insecure	1.21	0.80	0.69	7.25
Alternate livelihood	1.42	0.90	0.69	8.89

Children upkeep	1.68	0.70	0.45	9.50
Poor erratic rains	1.53	0.40	0.24	8.80
poor soils	1.78	0.50	0.28	8.20
Limiting labour	1.58	0.30	0.20	6.67
Family upkeep	1.15	0.30	0.27	8.67
No farm inputs	1.06	0.20	0.19	8.00
lack of potable water	1.85	0.30	0.16	8.00
Poverty	1.36	0.20	0.16	10.00
Limited farm land	1.36	0.17	0.11	6.00
Inadequate electricity	1.68	0.20	0.12	10.00
inadequate health personnel	1.75	0.20	0.12	9.50
no husband	1.00	0.10	0.10	8.00
perception by others	1.13	0.10	0.09	10.00
problematic children	1.18	0.10	0.08	7.00
Uncertain about future yields	1.36	0.10	0.07	8.00
inadequate housing	1.38	0.10	0.07	3.00
Fire tenders & personnel	1.46	0.10	0.07	1.00
Damaged dams	1.56	0.10	0.06	6.00
poor roads	1.56	0.10	0.06	10.00
No bullocks to plough	1.67	0.10	0.06	7.00
poor sanitation	1.78	0.10	0.06	10.00
General mood of despondency	1.91	0.10	0.05	10.00
understaffed schools	1.96	0.10	0.05	10.00
Insecurity in times of conflict	2.00	0.10	0.05	10.00

***PSS – Participatory severity scores: (1 – least severe; 10- most severe)**
****Severity index: 1 – most severe; 2 – least severe.**

2.5. Policies, Institutions, and Processes

Programs that support sustainable development are drawn by institutions which have structures and processes that affect the livelihoods of a community. This section describes and reviews such processes, policies and institutions within the 2 districts studied.

Development policies for poverty reduction

The limited impact of Ghana's Vision 2020 and the Medium Term Development Plan (MTDP) in laying the foundation for sustained poverty reduction led to attempts by the present government to formulate more poverty-focused initiatives. Consequently, the interim Poverty Reduction Strategy Paper 1(PRSP) for Ghana was prepared in June 2002 and the birth of the Ghana Poverty Reduction Strategy (GPRS I) document, approved in February 2003 and finally the Growth and Poverty Reduction Strategy II released in 2005. This document expresses Ghana's goal of ensuring growth, poverty reduction, and protection of the vulnerable within a democratic environment. In this regard, Government of Ghana is responsible for ensuring among others: Economic stability and sound regulatory framework for good governance (to promote participation in decision-making at all levels) thereby ensuring that resources are used efficiently.

The GPRS is currently the key development policy framework for the country. It is the country's response to addressing the issue of poverty and recognizes a casual link between poverty and the environment and therefore makes references to the need for Environmental Impact Assessment (EIA) and Audits and Strategic Environmental Assessment to ensure that the growth emanating is sustainable. The report also revealed a strong linkage between poverty, land tenure and rural development: And insecurity over access to land which leads to poverty and exploitation.

The five main thematic areas of the GPRS I and II are as follows: Macro- economy; Production and gainful employment; Human resource development and basic services; Vulnerability and exclusion and Good governance. This is linked to the 8 millennium development goals and is therefore an attempt to rationalize the millennium development goals. It therefore discusses the poverty profile dimension in Ghana and outlines programs of institutions (Ministries, Departments, Agencies and Private Sector) that need to be implemented to achieve poverty reduction or reduce vulnerability. Even though issues on the vulnerable and excluded which includes the rural poor, women, children, youth, aged and handicapped are crosscutting; there are no clear areas that the GPRS I & II focuses on the vulnerability and the excluded in relation to climate change.

The strategy on production and gainful employment to which agriculture is key, seeks among other things to improve public sector delivery of program and also provide sufficient incentives to stimulate the private sector. The activities are aimed at increasing and sustaining production for local consumption and export, and expanding employment especially in geographical areas that have high poverty profiles.

The GPRS identified a link between education, female headed households and income earning capability as a source of worry considering the fact that only 6% of females aged 15 years and above had attained higher than secondary school education. Nearly 35% of all household heads are female out of which about 61% fall in the poorest 20% of the population. It therefore outlines measures to help the vulnerable improve their activities in the agriculture sector. These include the following:

- Assistance for rural entrepreneurs to expand their activities, making it possible for them to work harder and make bigger contribution to production of goods and services in the country.
- Technical assistance for better production, processing, marketing and management skills have also been proposed.
- Making it easier for the rural communities to get access to credit, land and simple technologies.
- Support for agro-processing to be targeted to rural communities especially women who are in the extraction of oils and butter from crops like groundnuts, shea-nuts, palm fruits and other agricultural products with enormous potential for processing such as cassava, maize, cotton and fish, with particular attention to small and micro-scale producers. Support would be given in the form of processing equipment, which may be owned and operated by groups.
- With the indication of depletion in marine fish stocks, the promotion of inland fisheries like aquaculture will be supported.

The GPRS recognizes the preponderance of water-borne diseases and the vulnerability of 81% of the rural population and even among some urban districts who depend on untreated water. Research has also shown that water quality in the peri-urban areas have fallen due to increasing

demands on waste management systems that cannot cope with urbanization. As a result, pollution of water and the physical environment are increasing which may have serious health implication especially for women and children.
Access to potable water and sanitation has been identified within the GPRS as the key to promoting human health and in effect human capital for sustained poverty reduction. Strategies for providing safe water will focus on improving access through the following:

- Acceleration of rural water provision, emphasis on guinea worm endemic communities;
- Effective management of urban water systems;
- Safe liquid and solid waste management.

For land use, the policy proposes the provision of protection of land rights and prevention of abuse of traditional and institutional procedures, which place the poor, illiterate, and women at most risk. Land tenure reforms would be accompanied by close monitoring to detect adverse effects for which safety nets would be provided.
The provision of legal security of tenure will promote the transformation of the agricultural sector from subsistence farming into a dynamic and profitable entrepreneurial activity.

Human health was identified as a factor that makes most household vulnerable or fall short in human capital. This was found to be true especially in the Bawku east district where the risk index for human capital was high and the main contributing factor being health issues among others. According to the GPRS, improving the health status of the poor (especially women) is crucial for poverty reduction, since ill health is both a consequence and a cause of poverty.
The Health Ministry has highlighted three priority interventions namely:

- Bridging equity gaps in access to quality health and nutrition services;
- Ensuring sustainable financing arrangements that protect the poor and
- Enhancing efficiency in service delivery

Again, the Ministry of Health has identified malaria as a leading cause of outpatient morbidity in the country, and therefore one of the priorities targeted for control in the medium term. The Roll Back Malaria Program is part of a massive campaign in the use of insecticide-treated mosquito nets as a preventive measure against malaria. Finally, the recently launched National Health Insurance Scheme is suppose to help to improve financing of the health sector and provide access to quality health services to all Ghanaians. Most of the household studied in the Bawku east have started accessing the health insurance.

Institutions
Institutions that have structures and processes which affect the livelihood within the communities include the following:

- The Water Resources Commission is the agency that gives direction to water resources management. In addition to such official arrangements, there are also some customary laws and practices that encourages water conservation, pollution control and protection of catchments areas. Provision of portable drinking water for the communities is by such agencies through the District or Municipal Assemblies and non governmental organizations like World Vision, Community Based Rural Development Project in Bawku.

- Forestry Department which protects the forest and its natural resources within the district. And under the Ministry of Lands and Forestry and Mines.
- Ministry of Food and Agriculture, District Directorate which gives technical support for the production of food crops and animals.
- District or Municipal Assembly, which acts as the seat of the local government within the district and works in close collaboration with the various institutions in the district especially the NGOs.
- Non Governmental Organization like the German Technical Aid (GTZ), Adventist Relief Agency (ADRA), the Luke Society, Techno serve, the Roman Catholic Church sponsored Society for Mission in Africa (SMA), Islamic society and World Vision in the Ejura-Sekyedumase district contributes towards development, socially and economically through the provision of water and technical support for agriculture production. ISODEC (Education for development), Action Aid, Zuri Organic Vegetable Farmers (ZOVFA), UNICEF, CBRDP and BEWDA all based in the Bawku East District also contributes towards development.
- Ministry of Energy which is developing a national wood fuel policy.

The present government's concept of Golden Age of Business seeks to achieve an appreciable level of industrialization, which provides significant employment opportunities and economic diversification. Developing the human resource base for industrialization as well as sound rural livelihoods requires provision of broad educational opportunities to the population and developing rural infrastructure.
The rate of electrification presents the challenge of providing energy in a suitable form to a large population primarily rural but, increasingly urban, while at the same time minimizing Green House Gas (GHG) emissions and maximizing carbon sequestration.
Renewable energy program covers both biomass and solar energy. Under biomass energy, the production and use of wood fuels was to be made environmentally friendly and sustainable through the development of a National Wood Fuel Policy.
The District Assemblies could then adopt such policy guidelines as bye-laws. These guidelines are as follows:

- Conserving forest resources through improved methods for charcoal and firewood production;
- Decreasing consumption of firewood and charcoal by using more efficient cooking devices;
- Expanding the productivity and use of existing bio-energy sources such as biogas from organic, animal and municipal waste; and
- Production of briquettes from logging and wood processing residues.
- Planning for the future security of biomass supply through the implementation of a sustainable program of forest regeneration and afforestation.

With the exception of the guideline which expects the community to make use of biogas, all the other guidelines are being enforced within the *Ejura Sekyedumase* and Bawku East Districts. There is a program in place which encourages private developers to go into wood lot production in the district and the Taungye system where farmers are given access to the portion of the forest reserves and they are made to plant tress within their food crops. They take care of the trees while they crop food crops until they mature and then they leave the site. This is with support from the Forestry department. ZOVFA, the Zuri organic vegetable farmers association are also

being supported by the White Volta Basin Restoration project to plant trees along the river basins.
The LPG Program was initiated in 1990 to promote the wider use of Liquefied Petroleum gas as a substitute for charcoal and firewood in order to slow down the rate of deforestation caused partly by the production and use of wood fuels. However, due to the comparatively high cost the rural folk especially those communities studied prefer to patronize biomass energy for cooking. The direct solar radiation as a source of energy does not represent a major form of energy in Ghana. It is only used in its natural form in drying several items including agricultural crops, fish, sawn timber, clothing etc. The Ministry of Energy has, therefore, embarked on a program to assess, demonstrate and evaluate the technical, economic and social viability of promoting solar energy technologies in Ghana, especially with regard to the development of rural communities.

Linkages between national policies and district activities
There is a close link between the policies contained in the GPRS I and II and the program activities set out in individual district plans. This is because District or Municipal Assemblies are required to prepare their Medium-Term Development Plans in accordance with such guidelines. Review of the Ejura and Bawku East District Appraisals indicates that the Districts are giving the same level of priority to the five main themes of the GPRS. This confirms the effectiveness of the GPRS process but also suggests that any weaknesses in the national strategy are likely to be carried through to District Medium-Term Development Plans.
Polices developed by the various ministries are adopted by the Districts as guidelines in developing their bye-laws. In spite of all this, *Nyamebekyere* in the *Ejura-Sekyedumase* and *Basyonde Sabzunde* in the Bawku East districts has lest benefited from the Medium Term Development Plans.

Program for the Vulnerable and Excluded
The policies outlined in the GPRS on the vulnerable and excluded have strong linkages with activities being carried out at the district level. The District assembly has plans to provide jobs for the vulnerable and the excluded by making credit available to such groups (women and the youth) as outlined in their development plan: And encouraging high school enrolment by providing food, books and bicycles for the school children especially girls in the Bawku east district by some Development partners or NGOs.
An issue such as “support capacity for co-ordinated service delivery” have been translated at the district level by:

- Mainstreaming gender sensitivity in all activities,
- Encouraging NGOs to support the aged and the vulnerable and
- Providing support to NGOs involved in programmes for the vulnerable and excluded through the establishment of partnerships for social protection programmes with Non Governmental Organizations and Civil Society Organizations.

Examples of activities at the district level that protects them from disaster are:

- Training of fire volunteers, community forest guards to check environmental degradation (*Ejura – Sekyedumase*) and WATSAN members (*Bawku*) who check or maintain water and sanitation problems;
- Awareness creation on disaster;

- Establishing disaster volunteers associations like the community based surveillance volunteers who report of strange disease to the nearest health institutions and register births and deaths among others within the community;
- And the formation of social groups who help each other in times of crises like bereavement, credit to support farm operations and labour to manage fields.

Wherever environmental resources such as land, forest resources, water and others are scarce or poorly managed: it leads to competition and misunderstandings that may result in conflicts among communities.
The inseparability of the environment from social and economic implications of policies is not clearly stated in the GPRS: although land and forest resources are the main livelihoods for the majority of the rural folks. It rather attributes an overdependence on land and the forestry resources to lack of industries in rural communities. There is the need to develop policy actions that deal with the wide range of causes of conflicts including ethnic differences, competition for resources such as water, farmlands, forest products and mineral resources.
A study on adaptation measures to ensure good farm management practises with cost benefits should be undertaken to guide the agriculture sector in developing a sound and sustainable policy for mitigating carbon emission.

2.6. Implications and the Way Forward

The study did show that most households within the community have been characterised as poor based on lowness of income, malnutrition, ill health, illiteracy, lack of access to safe water and sanitation facilities, education, infrastructure and general food insecurity.
Even though some limited progress has been made in reducing poverty nation-wide the concentration of poverty within *Nyamebekyere* when compared with *Babaso* or *Anyinasu* is very high.
Patterns of economic development in the study areas, including logging and agricultural intensification, have resulted in significant environmental degradation. This in turn has had serious repercussions for the poor who are most dependent on natural resources for survival. Failure to give proper attention to the environment is also a serious threat to the achievement of sustainable economic growth because the country relies on its natural resources for almost half of its Gross Domestic Product.
Given the fact that not much study have been done in the communities in area of adaptation and costs, they can reduce the consequences of hazards by adapting to climate change. They can alter planting patterns; improve upon their physical assets such as information systems, health centres and make adjustments in the construction of houses among others.
However, adaptation measures do not consist only of physical measures; they also comprise a mixture of economic and social features such as personal savings and in some cases, insurance. There is the need for a policy to encourage people to diversity their sources of income through activities such as snail farming, mushroom cultivation, fish-farming and grass cutter domestication for persons living in the Ejura – Sekyedumase district. For Bawku East they should be encouraged to go into pottery in areas where clay is not limiting and small scale processing industries that use local raw materials like shea nuts and dawadawa. Farmers should be taught and encouraged to prepare hay silage to feed livestock in the dry season. And the

establishment of fire belts through established woodlots and forest resources. There can also be programs to support the development of practices that sustain or increase crop yields and reduce emission per crop yield.

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Appendix 1: List of Near Extinct Trees in the *Ejura – Sekyedumase* district

Local Name	Botanical Name
Odum	*Milicia excelsa*
Wawa	*Tripolchiton scleroxylon*
Mahogany	*Khaya grandifolia*
Onyina	*Ceiba pentandra*
Framo	*Terminalia superba*
Mpupuo	*Celosia trygyna*
Esa	*Celtis sp.*
Emire	*Terminalia ivoriensis*
Asanfra	*Aningeria robusta*
Kokrodua	*Afromosia elata*
Gyama	*Alchorina cordifolia*
Ciba	*Ceiba pentandra*

Appendix 2: List of Near Extinct Fauna / Animal Species

Local Name	Biological / Common Name
Adowa	Royal Antelope
Kokote	Bush pig
Oyuo	Black duiker
Wasane	Bush buck
Abidee	Red antelope
Kotoko	Porcupine
Apese	Brush tailed duiker
Kwakuo	Monkey
Ofo	*Colobus* - monkey
Apraa	Pangolin
Owam	Pelican

Appendix 3 List of Near Extinct Birds

Local Name	Biological / Common Name
Asee	Black canary
Asirewa	Yellow-green canary
Akokohwedee	Ahanta francolin
Ako	Parrot
Asokwaa	Grey-head guinea fowl
Asaw	Wild guinea fowl

Akyekyena	Horn bill

Appendix 4: Social groups identified in *Anyinasu*

Name / Type of Group	Objective
Frafra (Ethnicity)	To assist members in times of sickness, death and child delivery
Dagomba (E)	Same as above
Grumah (E)	Same as above
Moshie (E)	Same as above
Nyame behwe wo(Social)	Same as above
Nyame beak(S)	Same as above
Boafo yena(S)	Same as above
Yeni yeho(S)	Same as above
Nokwaredie (S)	Same as above
Nkosuo(S)	Same as above
Bowohomoden (S)	Same as above
Anidaso wo kristomu(S)	Same as above
Adoye kuo (S)	Same as above
.	To assist members in times of sickness, death, child
St Theresa of the Child Jesus(Religious)	birth and to share the knowledge of God
Christian Mothers association (R)	Same as above
Catholic men society(R)	Same as above
SDA women Fellowship(R)	Same as above
Presbyterian Men fellowship(R)	Same as above
Methodist Men Fellowship(R)	Same as above
Islamic Anuado Kuo(R)	Same as above
Susanna Wesley Mission Auxiliary (R)	Same as above
Marketing groups based on agricultural product one sells (tomatoes, plantain, maize, fish and others.	To assist members in times of sickness, death, child birth and to promote business interest in the market.
Producers Association (Maize-6, groundnut-2 beans- 4, cocoa-1 and cattle-1	To assist members in times of sickness, death, child birth and to seek production assistance from Ministry of agriculture and marketing of their produce

GPRTU (D)	“To seek the welfare of its members and control of the transport sector

*(R) – Religious group; (E) – Group formed on ethnicity; (s) – social group (every person has the right to join; (D) – drivers and transport owners.

APPENDIX 5: REAL WORLD STRESSORS AS LISTED BY HOUSEHOLD HEADS

RANK per household	PROBLEMS/STRESSORS	FREQUENCY	Severity - participatory	SEVERITY INDEX	INCIDENCE (Ij)index	RISK INDEX (Rj)
NYAMEBEKYERE MEDIUM RESOURCED MALE HEADED HOUSEHOLD (30%)						
1	ill health	daily	9	1	0.31	0.31
2	Children upkeep	daily	9	1.1	0.69	0.627272727
3	Poor degraded soils	daily	10	1.2	0.23	0.191666667
4	Family upkeep /feeding	daily	8	1.3	0.62	0.476923077
5	Capital for alternate livelihood	daily	8	1.4	0.46	0.328571429
6	Farm acreage small	yearly	7	1.6	0.53	0.33125
7	Limiting access to farm inputs	yearly	6	1.7	0.62	0.364705882
8	Labour limiting	yearly	9	1.8	0.23	0.127777778
9	Poor farm roads	yearly	7	1.9	0.15	0.078947368
10	Produce destruction by livestocks	yearly	6	2	0.08	0.04
LOW RESOURCED MALE (60%)						
1	Family upkeep /feeding	daily	7	1	0.62	0.62
2	Children upkeep	daily	6	1.3	0.69	0.530769231
3	Farm acreage small	daily	9	1.7	0.53	0.311764706
4	Limiting access to farm inputs	yearly	8	2	0.62	0.31
HIGH RESOURCED MALE (10%)						
1	Ill health	daily	10	1	0.31	0.31
2	Family upkeep /feeding	daily	9	1.1	0.62	0.563636364
3	Children upkeep	daily	9	1.3	0.69	0.530769231
4	Poor degraded soils	daily	10	1.4	0.23	0.164285714
5	Labour limiting for harvest	yearly	7	1.5	0.23	0.153333333
6	Limiting access to farm inputs	yearly	7	1.6	0.62	0.3875

7	Low market price for farm produce	yearly	7	1.8	0.15	0.083333333
8	Poor farm roads	yearly	7	1.9	0.15	0.078947368
9	High cost of tractor service	yearly	7	2	0.08	0.04
FEMALE HEADED HOUSEHOLD-ABSENTEE HUSBAND						
1	Children upkeep	daily	10	1	0.69	0.69
2	Husband's absence	daily	10	1.2	0.23	0.191666667
3	Labour limiting for farm maintenance	yearly	9	1.4	0.23	0.164285714
4	Limiting access to farm inputs	yearly	5	1.6	0.62	0.3875
5	Emotional disturbed with type of livelihood	daily	6	1.82	0.08	0.043956044
6	Farm acreage small	daily	7	2	0.53	0.265
FEMALE HEADED HOUSEHOLD-AGED HUSBAND						
1	Family upkeep /feeding	daily	10	1	0.62	0.62
2	Farm acreage small	daily	9	1.5	0.53	0.353333333
3	Limiting access to farm inputs	yearly	7	2	0.62	0.31
FEMALE HEADED HOUSEHOLD-WIDOW						
1	Children upkeep	daily	9	1	0.69	0.69
2	Farm acreage small	daily	9	2	0.53	0.265

BABASO HOUSEHOLD RISK ASSESSMENT

MEDIUM RESOURCED HOUSEHOLD

1	Family upkeep/ feeding	daily	10	1	0.62	0.62
2	Limiting access to farm inputs	yearly	8	1.3	0.62	0.476923077
3	Poor farm yields /no yields	yearly	8	1.5	0.15	0.1
4	Low market price for farm produce	yearly	8	1.8	0.15	0.083333333
5	Erratic rainfall	yearly	5	2	0.31	0.155

LOW RESOURCE MALE HEADED HOUSEHOLD

1	Farm acreage small - limiting cash to expand	daily	10	1	0.53	0.53
2	Family upkeep/ feeding	daily	6	1.2	0.62	0.516666667
3	Children upkeep	daily	6	1.3	0.69	0.530769231
4	ill health	daily	10	1.5	0.31	0.206666667
5	Poor degraded soils	daily	4	1.7	0.23	0.135294118
6	Erratic rainfall	yearly	2	1.8	0.31	0.172222222
7	Storage facilities at harvest	yearly	1	2	0.08	0.04
HIGH RESOURCED MALE HEADED HOUSEHOLD						
1	community organisation	daily	9	1	0.08	0.08
2	Family upkeep/ feeding	daily	5	1.5	0.62	0.413333333
3	Erratic rainfall	yearly	4	2	0.31	0.155
MALE HEADED HOUSEHOLD – AGED						
1	Family upkeep/ feeding	daily	10	1	0.62	0.62
2	Home dilapidated / collapsing	daily	10	1.5	0.08	0.053333333
3	Cash	daily	10	2	0.46	0.23
FEMALE HEADED HOUSEHOLD-SINGLE PARENT						
1	Marriage	daily	10	1	0.23	0.23
2	Children upkeep	daily	8	1.3	0.69	0.530769231
3	Limiting access to farm inputs	yearly	7	1.7	0.62	0.364705882
4	Needs employment	daily	9	2	0.46	0.23
FEMALE HEADED HOUSEHOLD-WIDOW						
1	Poor farm yields /no yields	yearly	10	1	0.15	0.15
2	Payment of loans	daily	10	1.2	0.46	0.383333333
3	Erratic rainfall	daily	9	1.3	0.31	0.238461538
4	Farm acreage small - limiting cash to expand	yearly	10	1.5	0.53	0.353333333

5	Children upkeep	daily	8	1.7	0.69	0.405882353
6	Limiting access to farm inputs(tractor services	yearly	5	1.8	0.62	0.344444444
7	Management of farm	yearly	5	2	0.08	0.04
FEMALE HEADED HOUSEHOLD - YOUNG WIDOW						
1	Children upkeep	daily	10	1	0.69	0.69
2	Needs employment	daily	9	1.3	0.46	0.353846154
3	Cash for farming	daily	8	1.5	0.46	0.306666667
4	Marriage	daily	7	1.8	0.23	0.127777778
5	Sickness	daily	6	2	0.31	0.155

APPENDIX 6: REAL WORLD STRESSORS AS LISTED BY HOUSEHOLD HEADS IN THE BAWKU EAST DISTRICT

BASYONDE SABZUNDE MEDIUM RESOURCED HOUSEHOLD						
RANK	**STRESSORS**	**PSS**	**GENDER**	**Severity index Sj**	**Incidence Ij**	**RISK INDEX Rj**
1.00	HEAITH ISSUES	10.00	M	1.00	0.90	0.90
2.00	FOOD INSECURITY	7.00	M	1.13	0.80	0.71
3.00	CHILDREN EDUCATION	8.00	M	1.25	0.70	0.56
4.00	SECURE JOB FOR WIFE	9.00	M	1.38	0.90	0.65
5.00	VOCATION FOR GIRLS	9.00	M	1.50	0.90	0.60
6.00	ALTERNATIVE JOB	10.00	M	1.63	0.90	0.55
7.00	LAND INFERTILITY	9.00	M	1.75	0.50	0.29
8.00	ERRATIC RAINS	10.00	M	1.88	0.40	0.21
9.00	ACCESS TO CREDIT	10.00	M	2.00	1.00	0.50
BASYONDE SABZUNDE POOR RESOURCED HOUSEHOLD						
1.00	FOOD INSECURE	9.00	M	1.00	0.80	0.80
2.00	HEALTH ISSUES	7.00	M	1.20	0.90	0.75
3.00	ALTERNATE LIVILIHOOD	10.00	M	1.40	0.90	0.64
4.00	No farm input	10.00	M	1.60	0.20	0.13
5.00	ERRATIC RAINS	10.00	M	1.80	0.40	0.22
6.00	LAND INFERTILITY	9.00	M	2.00	0.50	0.25
BASYONDE SABZUNDE HIGH RESOURCED HOUSEHOLD						
1.00	JOB	8.00	M	1.00	0.90	0.90
2.00	HEALTH ISSUES	8.00	M	1.11	0.90	0.81
3.00	Food to eat	5.00	M	1.22	0.80	0.65
4.00	alternate livelihood	10.00	M	1.33	0.90	0.68

5.00	erratic rainfall	5.00	M	1.44	0.40	0.28
6.00	Broken down dams	6.00	M	1.56	0.10	0.06
7.00	capital to increase livestock	7.00	M	1.67	1.00	0.60
8.00	poor sanitation	10.00	M	1.78	0.10	0.06
9.00	kids education	10.00	M	1.89	0.70	0.37
10.00	insufficient teachers	10.00	M	2.00	0.10	0.05
BASYONDE SABZUNDE FEMALE HEADED HOUSEHOLD						
1.00	HUSBAND	8.00	F	1.00	0.10	0.10
2.00	NO FARM INPUTS	6.00	F	1.33	0.20	0.15
3.00	ACCESS TO CAPITAL	8.00	F	1.67	1.00	0.60
4.00	KIDS UPKEEP	10.00	F	2.00	0.70	0.35
BASYONDE SABZUNDE FEMALE HOUSEHOLD – WIDOW						
1.00	CAPITAL TO WORK	10.00	F	1.00	1.00	1.00
2.00	perception by others	10.00	F	1.13	0.10	0.09
3.00	feeding family	7.00	F	1.25	0.80	0.64
4.00	credit to farm	10.00	F	1.38	1.00	0.73
5.00	health services	7.00	F	1.50	0.90	0.60
6.00	Land infertility	10.00	F	1.63	0.50	0.31
7.00	erratic rains	10.00	F	1.75	0.40	0.23
8.00	upkeep of kids	10.00	F	1.88	0.70	0.37
9.00	cash to educate kids	10.00	F	2.00	0.70	0.35
PUSIGA POOR RESOURCED HOUSEHOLD						
1.00	Inability to feed family	5.00	M	1.00	0.80	0.80
2.00	Labor to take care livestock	7.00	M	1.09	0.30	0.28
3.00	Problematic children	7.00	M	1.18	0.10	0.08
4.00	alternative livelihood	10.00	M	1.27	0.90	0.71
5.00	Farm yields	8.00	M	1.36	0.10	0.07
6.00	Inability to cloth family	8.00	M	1.45	0.30	0.21
7.00	Inability to pay health bills	8.00	M	1.55	0.90	0.58
8.00	Inability to pay for labor	7.00	M	1.64	0.30	0.18
9.00	Poverty	10.00	M	1.73	0.20	0.12
10.00	No access to credit	10.00	M	1.82	1.00	0.55
11.00	General despondency	10.00	M	1.91	0.10	0.05
12.00	Limited land	10.00	M	2.00	0.20	0.10
PUSIGA MEDIUM RESOURCED HOUSEHOLD						
1.00	Poverty	10.00	M	1.00	0.20	0.20
2.00	Inadequate food	10.00	M	1.08	0.80	0.74
3.00	Lack of cash to pay kid fees	8.00	M	1.15	0.70	0.61
4.00	General well-being i.e. health	7.00	M	1.23	0.90	0.73
5.00	Lack employment	4.00	M	1.31	0.90	0.69
6.00	Inadequate housing	3.00	M	1.38	0.10	0.07

7.00	Lack of fire personnels	1.00	M	1.46	0.10	0.07
8.00	Un motorable roads	10.00	M	1.54	0.10	0.07
9.00	Lack of electricity	10.00	M	1.62	0.20	0.12
10.00	Infertile land	5.00	M	1.69	0.50	0.30
11.00	Capital for farm inputs	10.00	M	1.77	1.00	0.57
12.00	Lack of portable water	6.00	M	1.85	0.30	0.16
13.00	Under staffed schools	10.00	M	1.92	0.10	0.05
14.00	Inability to feed family	5.00	M	2.00	0.80	0.40
PUSIGA HIGH RESOURCED HOUSEHOLD						
1.00	General well-being	8.00	M	1.00	0.30	0.30
2.00	Inaccessibility to credit	9.00	M	1.13	1.00	0.89
3.00	Inaccessibility to land	5.00	M	1.25	0.20	0.16
4.00	Inadequate pasture land	3.00	M	1.38	0.10	0.07
5.00	Inadequate health personnel	10.00	M	1.50	0.20	0.13
6.00	Inadequate health services	10.00	M	1.63	0.90	0.55
7.00	Inadequate electricity	10.00	M	1.75	0.20	0.11
8.00	Inadequate portable water	10.00	M	1.88	0.30	0.16
9.00	Insecurity in times of conflict	10.00	M	2.00	0.10	0.05
PUSIGA FEMALE HEADED HOUSEHOLD - SINGLE PARENT						
1.00	General well being	10.00	F	1.00	0.30	0.30
2.00	Lack of employment	10.00	F	1.17	0.90	0.77
3.00	Cash to feed educate kids	10.00	F	1.33	0.70	0.53
4.00	access to health service	10.00	F	1.50	0.90	0.60
5.00	No access to credit	9.00	F	1.67	1.00	0.60
6.00	Inadequate portable water	8.00	F	1.83	0.30	0.16
7.00	Inadequate Health personnel	9.00	F	2.00	0.20	0.10
PUSIGA FEMALE HOUSEHOLD - WIDOW						
1.00	Food insecure	10.00	F	1.00	0.80	0.80
2.00	Trainee/Capital to farm	10.00	F	1.17	1.00	0.86
3.00	Accessibility health services	10.00	F	1.33	0.90	0.68
4.00	children upkeep	10.00	F	1.50	0.70	0.47
5.00	No bullocks to plough	7.00	F	1.67	0.10	0.06
6.00	Infertility of land	8.00	F	1.83	0.50	0.27
7.00	Cost of hiring labourers	6.00	F	2.00	0.30	0.15

3. Soil and biomass carbon stocks

3.1. Introduction

Carbon exists as an inseparable component of vegetation, litter and soil organic matter, and is primarily lost as an invisible gas (CO_2). Carbon stored in soil organic matter is important in mitigating global climate change, improving the livelihoods of resource-poor farmers and also improves soil properties such as nutrient supply, moisture retention and as a consequence, increase land productivity and crop yields and contribute to the restoration of degraded agro-ecosystems (Lal et al. 1999; FAO, 2001; Woomer et al. 1994).

Soil carbon levels are generally low in West Africa. This may be due to several reasons, some of which are: rapid decomposition and, therefore, a low residence time for organic matter in tropical soils (Tiessen et al., 1998), overgrazing, agricultural mismanagement, deforestation and over-exploitation of the natural resources (Batjes, 2001). In West Africa, the concentration of organic carbon in the topsoil was reported to average 24 kg ha^{-1} for the forest zone, 14 kg ha^{-1} for the Guinean zone, 8 kg ha^{-1} in the Sudanian zone and 4 kg ha^{-1} for the Sahel under conditions of undisturbed climax vegetation (Breman, 1998). In Senegal, an average soil and woody biomass carbon contents were reported to be 11.3 and 6.3 t C ha^{-1} (Tschakert et al., 2004). In Ghana, fairly representative soil organic carbon values to average depth of 20 cm reported for forest, forest/savanna intergrade and savanna soils were 11.3 g kg^{-1}, 11.1 g kg^{-1} and 6.31 g kg^{-1} respectively (Acquaye and Oteng, 1972) which translates approximately to 28.5 t ha^{-1} for forest, 27.8 t ha^{-1} for the forest/savanna intergrade and 15.8 t ha^{-1} for savanna soils. Data on soil and biomass carbon sequestration in Ghana is scarce. There is, therefore, the need for several well-documented long-term research in the forest, forest/savanna intergrade and savanna agro-ecologies in the country in order to establish soil/biomass C database which would enable researchers to relate the contribution of carbon stored to climate change.

Since January 2005, Ghana has established various initiatives for Spatially Explicit Modelling of Soil Organic Carbon (SEMSOC) project to study various contributory factors that affect carbon sequestration in the country. The work reported here is part of a bigger study and its objective was to feed a CENTURY, a biogeochemical model, with the current soil and biomass carbon stock. The model would be used to simulate and quantify soil/biomass C over a period of time under a series of land use and management options.

3.2. Materials and Methods

Site description

Temporary sampling plots were established in three agro-ecological zones in the country for the study. These are Kakum Forest reserve (Assin District) in the Moist Evergreen forest zone, Awura Forest Reserve (Ejura Sekyidumase District) in the Dry Semi-deciduous forest zone and Upper Tamne Forest reserve (Bawku District) in the Savannah zone at Upper East Region. The sites were selected in consultation with the Land Use Land Cover team. The Kakum Forest reserve is located within 5° 21’ N, 1° 23’W. It experiences bimodal rainfall with an annual mean of over 2000 mm. The reserve has been protected for over a period of 95 years and has been protected against wildfires. The reserve is therefore intact. The Awura Forest reserve is located within 7° 19’ N, 1° 22’ W. It experiences bimodal rainfall with an annual mean of 1300 mm. The forest reserve experiences occasional bush fires and also suffers from illegal entry by the surrounding community for game, timber and charcoal burning. The Upper Tamne Forest is located within 11° 00’ N, 0° 15’ E. It experiences a tropical continental or interior savanna climate, mostly influenced by the tropical continental air mass. Rainfall is uni-modal with an annual rainfall of about 1000 mm

Sampling

Four land-use types were identified in each of the three sites. These are the natural forest, teak plantation, fallow land and cultivated land (farms). Four temporary sampling plots (TSP) were established in natural forest, two each in teak plantation, fallow land and cultivated land in each of all the three different sites, namely Kakum forest, Awura forest and Upper Tamne forest. The TSPs were established randomly. The size of the plots was 25 by 25m giving rise to an area of 0.0625ha. The coordinates of the plots were taken using the Global Positioning System (GPS) readings.

All trees in the natural forest and plantations were inventoried and tree size assessed. The tree size was assessed by measuring diameter at breast height of 1.3m. In addition, three or four sub plots of size 1.0 m by 1.0 m were established in all the TSPs. All herbaceous and woody plants on the sub plots as well as the litter were removed. Fresh weights were then weights immediately determined. Samples of the herbaceous plants, woody tissues and litter were collected for dry weight determination. Sub-samples were also reserved for carbon and nitrogen content analyses.

Soil samples (0-20 cm and 20-40 cm) were collected from the 1.0 m by 1.0 m areas within the quadrates for texture and organic carbon determinations in the laboratory. Accompanying bulk density samples were collected from 0-20 cm and 20-40 cm depths, allowing C contents to be expressed on an area basis.

Organic carbon was obtained in the laboratory by Walkley and Black (1934) method and particle size distribution was measured using Bouyoucos Hydrometer. The bulk density was determined from oven-dried core samples at 105°C for 24 h. Soil carbon was calculated using the formula below which allows the data to be standardized on hectare basis.

Soil C (t ha^{-1}) = C content (kg/kg x Bulk density (kg/l) x 10 depth (1/m^2) x 10000 m^2/ha x 1t/1000 kg)

This equation may be further simplified as:

Soil C (t ha^{-1}) = C content (kg/kg) x Bulk density (kg/l) x depth (cm) x 100

A conversion factor of 0.47 was used to reflect the proportion of C in all biomass pools. This factor represents the mean of the 0.45-0.5 range recommended to infer carbon content of biomass and intact litter from mass (Woomer et al., 2001).

The diameter at breast height measurements were used to estimate aboveground biomass of individual trees in the stand. The allometric equation used for the estimation of aboveground biomass was given as (Brown 2002);

$$Y = \text{Exp}\ (2.119 + 2.525 \times \text{Ln}(X),$$

where Y is aboveground biomass of an individual tree and X is the corresponding diameter at breast height.

Below ground biomass was estimated from the above ground biomass based on a review by Cairns et al. (1997) on 160 studies as being 26% of above ground biomass.

3.3. Results and discussion

Table 1. Land use type and soil carbon stock in Ejura-Sekyedumase district of Ghana

Land use type	silt + clay %	silt + clay %	soil C t/ha	Total soil C t/ha

	0-20 cm		20-40 cm		0-20 cm		20-40 cm	0-40 cm
Awura forest reserve			27.59	25.49	18.21	12.67	30.88	
	(9.73)	(8.60)	(6.52)	(5.33)	(10.76)			
Teak plantation			21.79	27.35	33.93	13.64	47.57	
	(0.99)	(5.61)	(15.69)	(4.90)	(19.70)			
Cultivated field			23.52	22.66	16.12	12.15	28.37	
	(2.57)	(3.19)	(2.84)	(2.25)	(4.45)			
Fallow plot		50.38	50.48	31.09	25.69	56.72		
	(4.76)	(4.95)	(12.89)	(4.85)	(20.02)			

Table 2. Land use type and soil carbon stock in Assin district of Ghana

Land use type	silt + clay		silt + clay		soil C		Total soil C	
	%	%	t/ha					
	0-20 cm		20-40 cm		0-20 cm		20-40 cm	0-40 cm
Kakum forest reserve			25.72	27.93	52.02	41.45	93.47	
	(6.28)	(6.20)	(15.29)	(18.52)	(32.50)			
Teak plantation			26.51	25.87	48.87	38.34	87.21	
	(4.03)	(3.80)	(17.22)	(9.62)	(26.67)			
Cultivated field			36.41	39.15	40.82	31.88	72.30	
	(12.75)	(13.68)	(10.38)	(9.07)	(19.40)			
Fallow plot		27.22	34.24	47.29	39.66	86.95		
	(5.08)	(7.28)	(13.84)	(7.41)	(24.43)			

Table 3. Land use type and soil carbon stock in Bawku district of Ghana

Land use type	silt + clay		silt + clay		soil C		Total soil C	
	%	%	t/ha					
	0-20 cm		20-40 cm		0-20 cm		20-40 cm	0-40 cm
Forest reserve		24.70	26.65	22.28	9.86	32.14		
	(5.29)	(5.49)	(6.24)	(2.74)	(7.86)			
Teak plantation			26.19	36.37	15.33	8.31	23.64	

	(10.13)	(17.22)	(5.42)	(1.09)	(6.46)	
Cultivated field		26.95	35.70	21.45	10.57	32.02
	(9.98)	(15.04)	(2.00)	(1.54)	(2.59)	
Fallow plot	27.60	28.98	22.89	11.16	34.05	
	(5.44)	(11.04)	(4.19)	(2.20)	(6.08)	

Table 4. Average carbon accumulated by different plant type at the different sites

Site	Data	Herb	Litter	Wood	Aboveground	Belowground
Bawku	Average	2.30	0.23	0.80	25.97	6.75
	StdDev	2.15	0.17	0.34	9.47	2.46
Ejura	Average	1.83	1.85	1.28	112.42	29.23
	StdDev	1.23	0.50	0.64	74.79	19.45
Kakum	Average	1.35	2.69	2.20	146.84	38.18
	StdDev	0.86	1.45	1.03	82.23	21.38

Table 5. Average Biomass Carbon stocks under various land use types at the three differents sites

		Biomass (Mg C ha^{-1})			
Site		**Fallow**	**Farm Land**	**Forest Stand**	**Teak Stand**
Bawku	Average	5.30	1.17	31.49	44.57
	StdDev	3.86	0.02	6.56	17.43
Ejura	Average	7.34	2.49	195.66	45.77
	StdDev	0.36	0.17	68.62	10.92
Kakum	Average	8.48	2.81	253.06	67.74
	StdDev	3.70	0.05	46.62	29.31

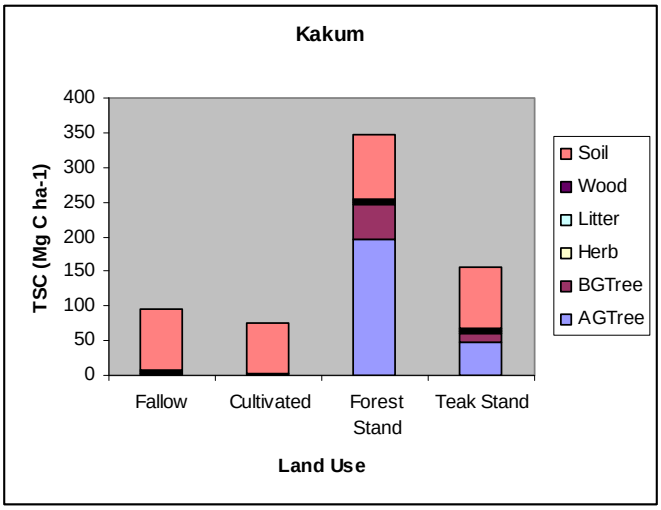

Fig. 1a. Total system carbon accumulated under various land use systems at Kakum.

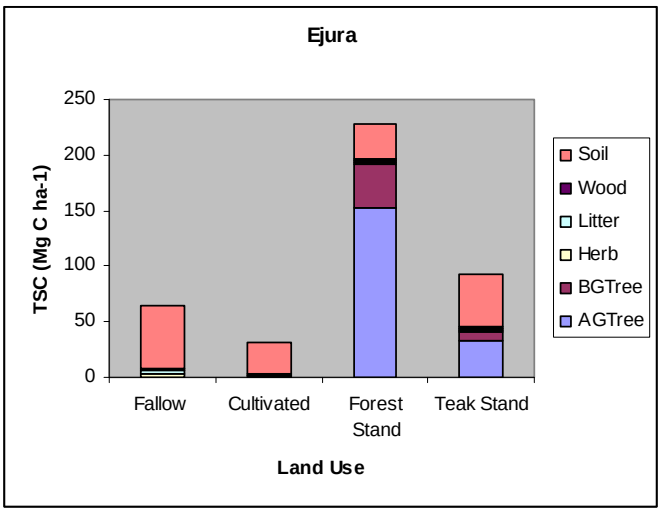

Fig. 1b. Total system carbon accumulated under various land use systems at Ejura.

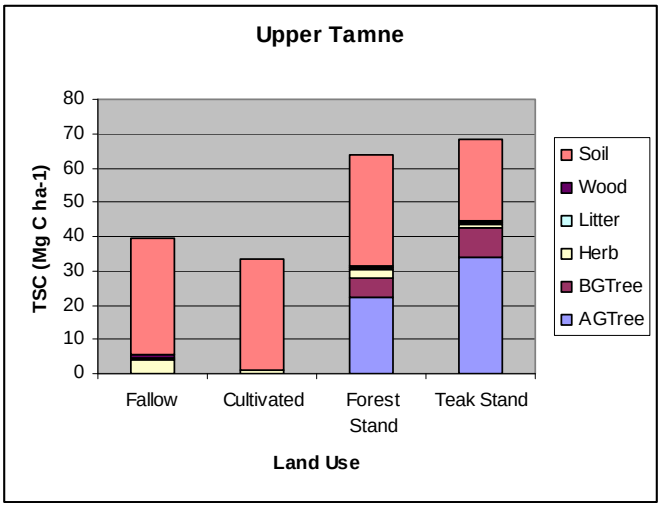

Fig. 1c. Total system carbon accumulated under various land use systems at Upper Tamne.

Soil texture

The importance of soil textural (clay and silt) properties for organic C content of soils has been stressed repeatedly as clays are an important component in the stabilization of organic molecules and microorganisms (Greenland and Nye, 1959, Feller et al., 1992). Apart from topography, the texture determines largely the drainage pattern of soils. In the three study areas, the silt + clay content of the soils indicated the presence of high percentage of sand, hence, the soils were predominantly coarse-textured (Tables 1-3). Except for the silty clay soils encountered in the fallow plots in the Ejura Sekyidumase district, drainage is likely to be high in the rest of the soils in the study areas. The coarse-textured nature of the soils suggested a rapid decline of organic carbon in the soils.

Soil carbon stock

At the study sites, soil organic C accumulated more in the 0-20 cm depth than in the 20-40 cm depth. This is expected since organic matter acts a source of energy for microbes and, therefore, microbial activity is high at the rooting zone (0-20 cm depth). Total soil C stock in the Ejura Sekyidumase district ranged from 28.37 Mg C ha^{-1} in the cultivated field to 56.72 Mg C ha^{-1} in the fallow plot. The forest reserve which experiences annual bush fires had a total soil C of 30.88 Mg C ha^{-1} compared to

the teak plantation (Table 1). In the Assin district total soil C ranged from 72.3 Mg C ha^{-1} in the cultivated field to 93.47 t ha^{-1} in the Kakum forest reserve (Table 2). Both the fallow plot of 11 yr and teak plantation of 11-15 yr had similar amounts of total soil C. In the Bawku district, apart from the teak plantation, total soil C stock was similar in amounts in the rest of the land use types (Table 3). Even though the teak plantation was over 50 years its growth was heavily affected by bush fire. Invariably, land use type greatly influenced the total soil C stock in the study areas. Both the forest reserves and fallow treatments showed promising soil C accumulation compared with the other land use types in the Ejura Sekyidumase and Assin districts. There is evidence in literature to show that four years of fallow after 16 years of cultivation had lead to large increases in organic C and a reduction of annual organic C losses to 0.5% (Bationo and Buerkert, 2001). The cultivated fields gave the least total soil C storage in both Ejura Sekyidumase and Assin districts, suggesting a rapid decline of organic C levels with continuous cultivation.

Biomass carbon

Carbon content of the various plant types, namely woody tissue, herbaceous and litter was analysed. The carbon content of the woody tissues ranged between 37.85 and 49.4 % of the dry biomass, with the mean value being 46.92% (± 2.85% SD), that of the herbaceous tissues ranged between 20.13 and 48.0% with a mean value of 37.46% (±6.33% SD), while that of litter was between 16.5 and 40.25%, with the mean value being 29.98% (± 6.06% SD). There was no clear differentiation of the carbon content among the various sites.

The average biomass of the various plant types, namely litter, trees and other woody tissues, increased among the three sites in the order Upper Tamne (Savannah), Awura (Dry Semi-deciduous) and Kakum (Moist Evergreen). However, reverse of the trend prevailed for that of the litter (Table 4). This can be attributed to the prevalent annual fire in the Savannah leading to the burning of the litter cover. The fire also encouraged the growth of herbs and retarded the growth of the woody plants. This is also aggravated by the amount of rainfall and the severity of the dry season.

Carbon accumulated in the biomass under the various land use systems changed in an increasing order among the various sites from Upper Tamne, Awura to Kakum. With regard to carbon accumulated in the various land use systems, the trend was an increasing order from cultivated land, fallow land, teak stand to natural forest stand. However, that of the Upper Tamne was an exception. The teak stand accumulated more carbon than the natural forest. This can be attributed to greater disturbance of the natural forest (Table 5).

The soil component of the total system carbon was highest in fallow system land use, between 86.2 and 91.1% of the total. It decreased from Upper Tamne, Awura to Kakum forest. The soil component was the lowest in natural forest land use in both Kakum and Awura, but in the Upper Tamne the lowest was exhibited by the teak stand. The total system carbon accumulated under various land uses for the various sites has been presented in Figure 1.

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4. Spatially Explicit Modelling of Soil and Biomass Carbon

Main Task
To evaluate, by the use of an appropriate model, the effects of Land Management and Climatic effects on Soil and Biomass Carbon Dynamics through Explicit Modeling and Sensitivity Analyses.

Study Area
Three (3) areas, that is Bakwu in the Sudan savanna, Awura forest reserve in the transitional zone and the Kakum forest reserve in the forest ecological zone of the country.

4.1. Methodology

As indicated in the title, a biogeochemical model together with suitable input data has been used to model the effects of Land Management and Climatic effects on Soil and Biomass Carbon Dynamics.

Model:
The model used is known as GEMS, which is an extension of a model known as CENTURY. CENTURY is the key underlying biogeochemical model for the General Ensemble of biogeochemical Modeling System (GEMS). While CENTURY simulates Carbon (C) and nutrient cycling at a point (i.e. at the plot scale), GEMS is developed for the simulating carbon dynamics in space ranging from landscape to the global scale.
This model has been used in assessing the impacts of land use and climate change on available carbon in terrestrial ecosystems in some countries including the United States, Costa Rica and some parts of Africa, for example Senegal.

Data:
Data for the running of the model include the following:

- Land cover and land use information
- Information on Reserve and Protected areas

- Information on soil texture (that is % sand, % silt and % clay). Associated with these will be information on the drainage characteristics of the soil types.
- Information on land management practices (crop/forest management practices in the study area.)
- Climate data of the study area such as mean maximum and minimum monthly temperatures as well as mean monthly rainfall. Model projections of values of these climatic variables have also been made for the period between 2001 and 2100.

Simulations:
To run GEMS, the main input files of the model for each of the three (3) versions of GEMS, (GEMS POT), for simulations for the period prior to 1900, (GEMS 20) for the period 1900 to 2000 and GEMS 21, used for simulations for the period 2001 to 2100, were created for each of the three (3) areas. Some of these files for Ejura area are shown below:

- **eju_soil.txt**, which contains information on soil data

- **eju_drain.txt**, contains soil drainage data

- **eju_rain.txt:** Monthly total rainfall for the area from January 1975 to December 2000.

- **eju_mint.txt:** Contains mean daily minimum temperatures for each month of the year for the period 1975 to 2000

- **eju_maxt.txt:** Contains mean daily maximum temperatures for each month of the year for the period 1975 to 2000.

- **croprotate_eju.txt:** This file contains information on crop rotation probability at the Ejura area.

- **crop_comp_eju.txt:** This provides information on the types of crops cultivated and the percentage of area that they cover. The main crops/century codes are Maize (850, Improved variety), Cassava (870) and Yams (860). Fallow code is 300.

- **fallow_eju.txt**, this contains information on the length of time land is cropped or left fallow.

- **manager_eju.txt,** contains information on bush fires, that is, the frequency of bush fires in the area. Here bush fires occur on annual basis. This file also contains information on forest harvests, whiles it is assumed that gracing does not occur.

- **lc2cent.map file**: This file combines land use and management practices to crop/tree species. This makes it possible for such information to be linked to GEMS. Essentially, this file combines all the land cover classes, tree and crop species as well as all management practices, such as irrigation, addition of fertilizer or organic matter.

- **JFD file:** The Joint Frequency Distribution files which represents the stratification of the study area using information on climate, soil and land cover maps of the three (3) periods 1986, 1990 and 2000, which is required to run GEMS, were then developed for the study areas.

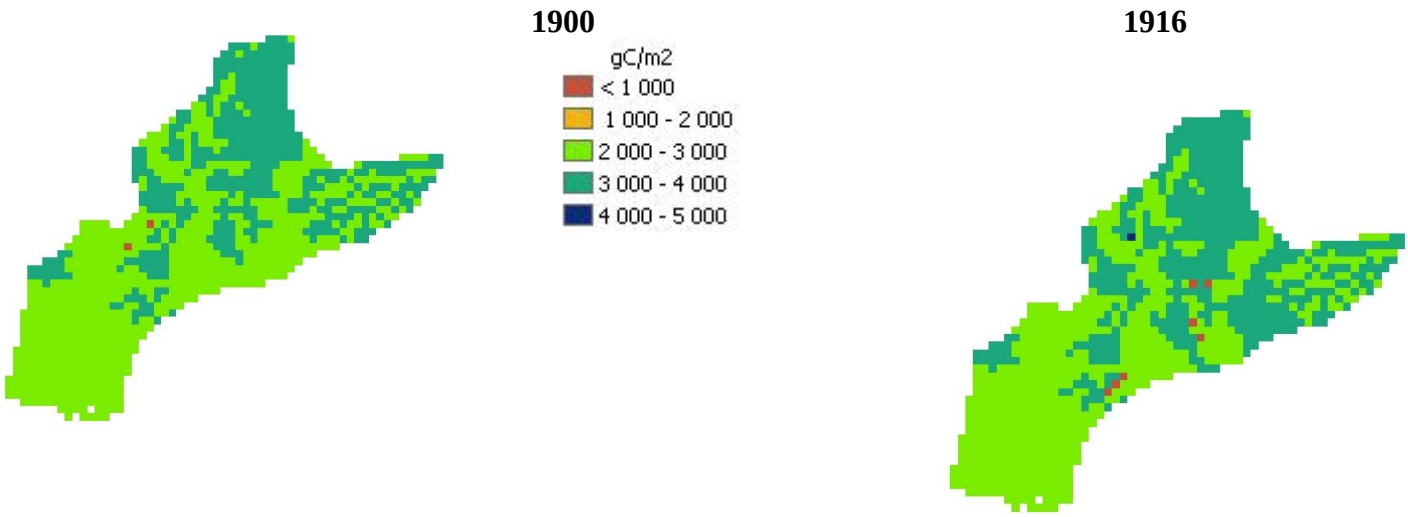
- With the complete set of necessary files for each of the areas, the model was run for the period prior to 1900, 1900 to 2000 and 2001 to 2100, to obtain pre-defined output variables for each of the three (3) study areas. In particular, the following output variables were calculated.

- Economic yield of Carbon in grain + tubers for grass/crop (g/m2)
- Annual accumulator of Carbon production in grass/crop + forest = net primary production (g/m2/year)
- Sum of Carbon in forest system live components (g/m2)
- Total Carbon in forest system i.e. sum of soil organic matter, trees, dead wood, forest litter
- Carbon in forest system large wood component (g/m2)
- Total Carbon removed during forest removal events (g/m2)
- Sum of Carbon in wood components of forest system (g/m2), and
- Total soil C including belowground structural and metabolic (g/m2)

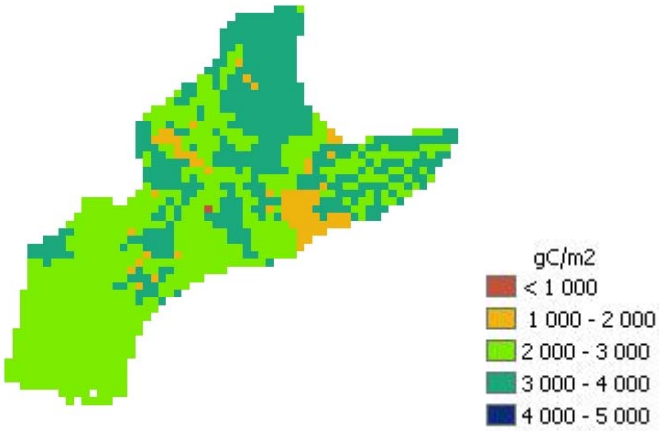
4.2. Results

The model simulation of total soil carbon, which include belowground structural and metabolic carbon, for the Ejura study area for the years 1900, 1916, 1932, 1948, 1964, 1980, 1996 and 2000, have been presented here as maps in figures 1a to 1h. For comparison, in figures 2a and 2b, we provide the land-cover maps obtained by remote sensing for 1986 and 2000 for the Ejura area. Table 1, shows the average total carbon in tons per hectare from 1900 to 2000.

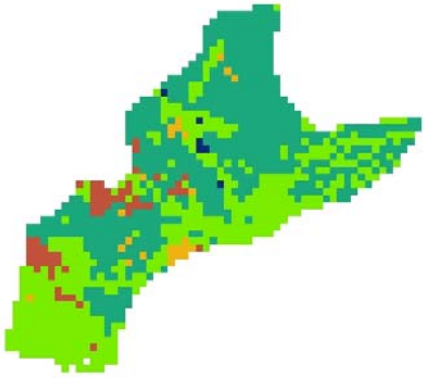
Figure 1a: Modeled total soil carbon, Ejura as at 1900 Figure 1b: Modeled total soil carbon, Ejura as at 1916



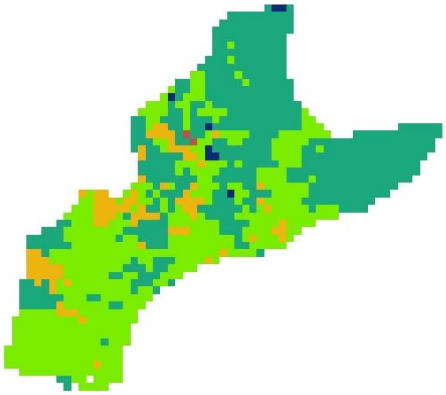
1932



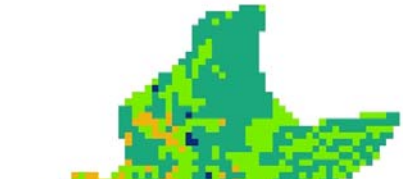
1948



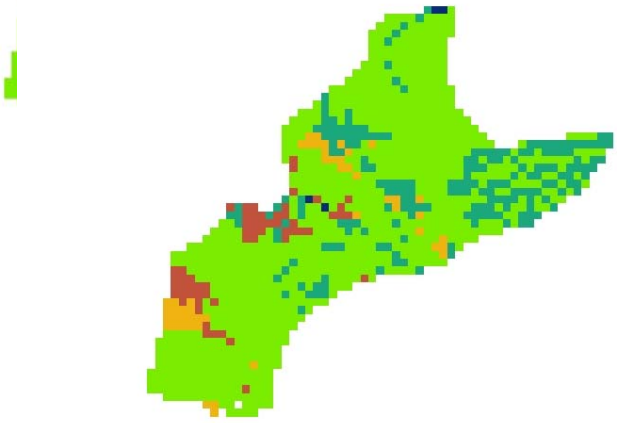
1964



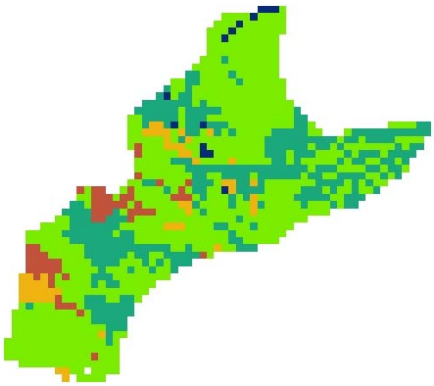
1980



1996



2000



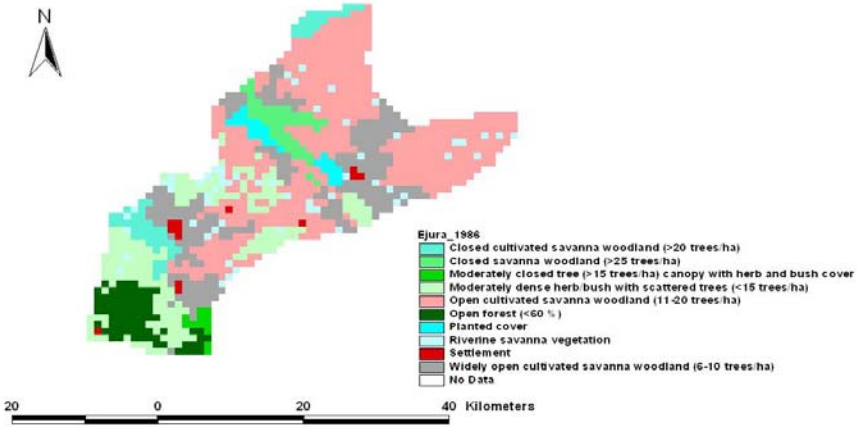


Figure 2a: Observed landcover – Ejura, 2000

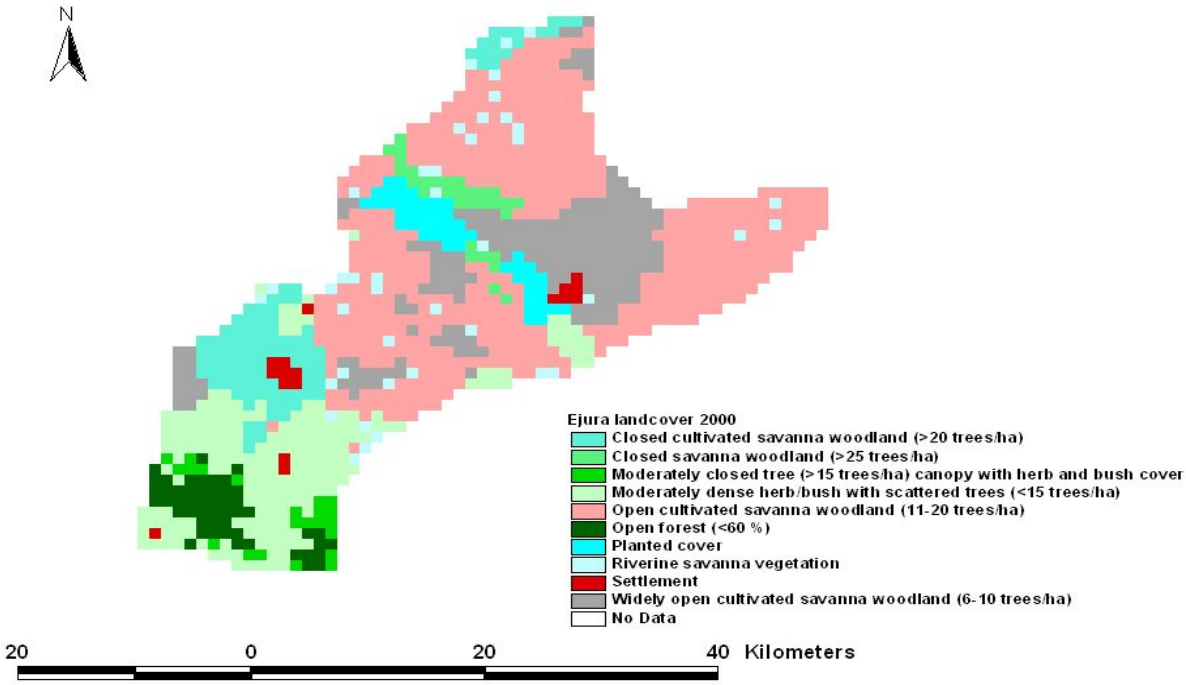


Table 1: Modeled average total soil carbon per hectare, Ejura.

YEAR	SOMTC* (tha-1)
1900	24.8
1916	28.1
1932	25.2
1948	24.2
1964	26.1
1980	27.2
1996	26.4
2000	27.1

4.3. Discussion and Conclusion

From the results above it is clear that there has been in general a decreasing trend in soil carbon in the Ejura study area from the start of the simulation up to 2000, the end of the simulation. As at 1900 soil carbon content in almost every where in the Ejura area, were in excess of 2000 g/m^2 (fig. 1a). By 1948, however, figure 1d, some portions within the area were showing soil carbon content of less than a 1000g/m and even though there appeared to be some recovery by the 1980s(fig. 1f), soil carbon in both 1996 and 2000, again showed values of less than 1000g/m^2 in some areas.
The model results appear consistent with the observed land cover changes for the area. For example the landcover information for 1972, 1986 and 2000, indicate reductions in open forest cover while there are increases in the areas covered by both closed and open savanna cultivated woodlands, indicating a possible reduction in soil carbon content as a result of increased farming activities. Climatic trends for the area since the early 1960s, has been that of reducing rainfall and increasing temperatures, which could affect vegetation and plant growth and thus impacting negatively on available carbon stocks.
The next step of the investigation is to run the model for the period 2001 to 2100 using climate change scenarios that have been developed for assessing climate change impacts on the country. The model outputs for the two other study areas are yet to be completed and analyzed, and this will also be done.
The main reason for the delay is the initial difficulty in getting the model to run. There was also the problem of waiting for data from the other groups involved in the project. The pledge is that the work will continue until it is fully completed.
Mean while, the necessary information for the Kakum area in the Assin District have been obtained and are being processed as was done in the case of the Ejura, in order to run the model for this area as well.