Dr. Petra TSCHAKERT
State College, December 20, 2006

FY2 – FINAL REPORT ON SEMSOC (Spatially Explicit Modeling of Soil Organic Carbon)[1]

1. Introduction:

Due to increased human pressure on marginal lands and fragile resources in combination with persistent poverty in West African semi-arid to sub-humid regions, traditional management practices and coping mechanisms to buffer against a variety of stressors and shocks are often no longer sufficient to adapt to new and more severe risks, including climate change. Unsustainable land use and management practices together with ill conceived policies and weak structures of environmental governance have greatly induced land degradation. In some parts of West Africa, land degradation and resulting losses of soil organic carbon have reached alarming dimensions. At the same time, due to longer residence times of C in dryland soils and the fact that many soils have been degraded, drylands may well have a significant potential to sequester carbon.

Community-based resource management and land rehabilitation programs through carbon offset activities have been promoted to restore degraded drylands and improve the livelihoods of the rural poor. Afforestation and prolonged fallow periods in drylands, encouraged through increased water use during photosynthesis under elevated CO_2 concentrations as well as no- or reduced tillage which also prevents water losses have been put forward as most efficient land use and management practices. However, smallholders often face considerable constraints that reduce adoption rates. With the exception of the EDC/USGS pilot study in Senegal, there is very little systematic research on carbon stocks and trends in relation to land use and land cover changes as well as livelihood needs in Africa. A holistic assessment is needed to simultaneously evaluate the biophysical, socio-economic, institutional and policy context for long-term carbon sequestration programs in drylands. This project, SEMSOC (Spatially Explicit Modeling of Soil Organic Carbon) will provide detailed and experienced scientific input and capacity building in collaboration with researchers from Mali, Niger, Burkina Faso, and Ghana with respect to 5 key areas: 1) assessment of land use and land cover change based on a series of remotely sensed images and estimation of biomass for different land use/land cover classes; 2) soil and biomass carbon estimates and measurements in selected focus areas; 3) socio-economic and institutional assessment of management practices, technical knowledge, and adaptive capacity at the household and community level in selected focus areas; 4) biogeochemical modeling and evaluation of "best" management practices for water-constrained environments; and 5) capacity building, technical training, networking, and information exchange among all participants.

Objectives:
SEMSOC extends the feasibility and prototype work undertaken in Senegal through SOCSOM (Sequestration of Carbon in Soil Organic Matter) into other areas of semiarid and sub-humid Africa. It supports the further development of approaches to promote economically viable natural resource management and agricultural practices that promote soil fertility and result in soil or biomass carbon sequestration. SEMSOC addresses national concerns by developing integrated project activities with

[1] During workshops with the socio-economic groups members in August 2005, we discussed an alternative meaning for SEMSOC which would better encapsulate the socio-ecological linkages the project attempts to address: Here are proposition: Susatainability, Equity, and Mainstreaming while Sequestering Organic Carbon.

selected national participants. The activities shall address the potential biophysical potential for carbon sequestration and the policy constraints as well as the enabling socio-economic incentives. It includes training and capacity building and determines, develops, and promotes agricultural sustainability, analytical procedures for biomass and soil carbon sampling, and the potential of soil carbon sequestration. The overall objective of SEMSOC is to explore conceptual and empirical approaches to link climate change mitigation research and activities related to terrestrial carbon management with observed adaptation trajectories of rural populations which can serve as a base line for evaluating potential adaptive capacity under more stressful climatic, demographic, and economic conditions. The project will identify adaptation and mitigation opportunities derived from establishing the sensitivity of natural resources (incl. C stocks) to climate change and the response of appropriate land management options (document land degradation; quantify carbon losses; identify mitigation opportunities that shall lead to enhanced soil fertility, agricultural sustainability, and increased food security; evaluate the need for adaptation responses to climate change). The results from the study are envisioned to help the four countries to position themselves more efficiently in the international climate change debate and in the emerging market of environmental service provision through improved land use and management.

Geographical focus: Ghana, Mali, Niger, Burkina Faso

2. Establishment of contracts between SAIC and the 4 partner institutions:

Statements of work were developed by SAIC in February 2005 after the individual country planning meetings (see Section 3) and sent to each national agency. Finalization of individual contracts took much longer than expected due to the list of documents that were needed from the partner organizations as well as language problems in three out of the four partner countries understanding SAIC forms and requirements in English. Ghana signed her contract agreement first (in April) while it took several more weeks for Mali, Burkina Faso, and Niger. Actual work among SEMSOC team members started only when project funds arrived at the country level. The earliest was Ghana in June, the latest Mali end of August. This considerable delay in the availability of funds required some restructuring of project priorities for the remaining weeks during the first fiscal year. Due to the fact that Ghana was the first partner country to receive funds and, therefore, also to first to start project activities, it is not surprising that the Ghana team has already completed a substantial amount of the initial work plan. The delay in the other three countries is due primarily to the late arrival of funds.

3. Meetings and Workshops

3.1. Planning meetings in Ghana, Mali, Niger, Burkina Faso and development of national work plans for SEMSOC, January 2005

With the assistance of Amadou Moctar Dieye from the Centre de Suivi Ecologique (CSE) in Dakar and the logistical preparation through local organizers[2], I held four SEMSOC planning workshops between January 12 and 27, 2005. Exact dates and location are shown below:

[2] Emmanuel Tachie-Obeng, Environmental Protection Agency (EPA), Accra, Ghana;
Abdou Maiga, IER, Bamako, Mali
Moussa Sall, INRAN, Niamey, Niger
Patrice Sanou, Centre SIGET-A, Ouagadougou, Burkina Faso

Dates	National Agency	City	Country	Participants
January 11, 12	Environmental Protection Agency (EPA)	Accra	Ghana	16
January 18, 19	Institut de l'Economie Rurale (IER)	Bamako	Mali	18
January 22, 24	Institut National de Recherches Agronomiques du Niger (INRAN)	Niamey	Niger	16
January 26, 27	Institut National de l'Environnement et de Recherches Agricoles (INERA)	Ouagadougou	Burkina Faso	18

The main two objectives of the workshops were to explain the content of SEMSOC (Spatially Explicit Modeling of Soil Organic carbon) and guide discussions about possible activities, key experts, deliverables, and dead lines with the ultimate purpose of elaborating national SEMSOC work plans for the next 2 years. The task for local organizers was to invite a maximum of 20 key experts who had been previously identified through a national expert data base, including expertise in land use/land cover change assessment, remote sensing, soil and biomass carbon measurements, biogeochemical modeling, farming system analysis, socio-economic studies involving livelihood analysis and risk assessment, national climate change negotiators, and experts with respect to outreach and networking. The brief SEMSOC objective statement, the outline of activities and tasks as well as the more detailed workshop agenda were used in all 4 country meetings.

MAJOR PROJECT COMPONENT:
Activities with funding from USAID/EGAT/ESP (Petra Tschakert and Amadou Moctar Dieye)

Geographical focus: Ghana, Mali, Niger, Burkina Faso
Overall objective: Identify adaptation and mitigation opportunities derived from establishing the sensitivity of natural resources (incl. C stocks) to climate change and the response of appropriate land management options (document land degradation; quantify carbon losses; identify mitigation opportunities that shall lead to enhanced soil fertility, agricultural sustainability, and increased food security; evaluate the need for adaptation responses to climate change).

Task 1: Quantitative Evaluation of Land Cover/Use Change and Identification of Land Resource Improvement and Deterioration

Task 2: Quantification of Current Biomass and Soil Carbon Stocks and Changes over Time

Task 3: Evaluation of Effects of Land Management and Climate Scenarios on Soil and Biomass C Dynamics through Spatially Explicit Modeling and Sensitivity Analyses (Simulation)

Task 4: Assessment of Social, Economic, and Policy Drivers of Land Use/Land Management and Adaptation to Climate Change

Task 5: Information Exchange and Collaborative Workshops on Soil Carbon Research in the Sahel.

TO BE INTEGRATED with SOCSAB COMPONENT:
Activities and with funding from USAID/EGAT/NRM (Gray Tappan, Shuangan Liu, and Amadou Moctar Dieye):

Geographical focus: Sahel
Task 1: National land use/land cover change assessment through the regional center AGRHYMET, using a wall-to-wall approach

Task 2: Expansion of GEMS modeling approach (from Niamey workshop) to evaluate carbon status and assess the potential for carbon sequestration through selected windows of eco-regions

Task 3: Simulation of climate change scenarios with inherent variability

Task 4: Participatory needs assessment and planning workshops (incl. funding mechanisms)

JANUARY 2005 WORKSHOP AGENDA:

Day 1, morning (3 – 3.5 hours):

1) Brief introduction to SEMSOC and it's objectives (Petra Tschakert);

2) Summary of past, current, and upcoming activities and results of collaboration with the EROS Data Center within each country to identify potential synergies (mainly work with Gray Tappan on land use/land cover change and the SOCSOM activities through the Niamey workshop 2004); also, brief summary of other project activities related to climate change and desertification (national experts);

3) Summary of activities of national C team, if applicable (head of national carbon team)

4) Summary of SOCSOM, the pilot study carried out in Senegal between 2000 and 2003 (Amadou Moctar Dieye)

5) Detailed presentation and discussion of the objectives and 5 tasks of SEMSOC (Petra Tschakert and Amadou Moctar Dieye);

Day 1, afternoon (3 – 3.5 hours):

For each of the 5 tasks, the following 4 categories were discussed:
- identify and prioritize concrete and necessary activities to reach the objectives;
- identify the key people/national experts for every activity;
- list and evaluate existing data and identify data gaps that need to be filled to carry out the various activities;
- identify information/training needs

6) Task 1

7) Task 2

Day 2, morning (3 – 3.5 hours):

8) Task 3

9) Task 4

10) Task 5

Day 2, afternoon (3 – 3.5 hours):

11) design a work plan for the next 2 years of SEMSOC with an emphasis on this fiscal year (oct 2004 - sept 2005);

12) recap objectives for SOCSAB-WA Initiatives Panning Workshop (Ouagadougou, March 2005?)

13) discuss possibilities for grant proposals to various institutions (IFAD, GEF, LADA etc) and develop outlines for drafts based on identified SEMSOC activities;

14) discuss potential cooperation with leading institutions on carbon sequestration, mainly Carbo-Europe (Carbo-Europe has an interest in developing collaborations in W-Africa, mainly to set up a system of flux towers).
Background: a major workshop on C was held in Bejing (China) in Nov 2004 (Petra presented C and development components), NOT A SINGLE African researcher was present. The Global Carbon Project (GCP) realizes the need to establish links with African scientists and decision-makers – a fantastic chance for the 4 countries!

WORSHOP RESULTS:

Based on the discussions on each of the 5 tasks, the national teams respectively developed a work plan for the next 2 years, with emphasis on activities for the FY 2005/2006(see Appendix 1). A detailed master expert data base was created (see Appendix 2), a brief summary of tasks 4 and 5 composed, and recommendations formulated

Task 1: Land use/land cover
The following activities were identified by the 4 countries :

- collect available information: satellite images, maps, historical data, time series...
- study sites/sample frames – national coverage
- identify sites for detailed study and for extreme anomalies; this part of work will be done with all the national team;
- prepare raster maps for the entire country
- from there, identify "hotspots" (areas of + and – anomalies)
- interpretation of maps
- ground-thruthing/validation, also to get NPP/biomass estimates
- organize data in database
- prepare data for modeling

In all countries, data and products (land use/land cover, topographic, database…) are available, mostly resulting from previous work with EDC or other partners. However, for Burkina Faso, during our visit, it was hard to pin down where exactly to find the data and products obtained and processed through AGRHYMET. Therefore, it's needed to provide them with the necessary satellite data that might not have been distributed.

The players identified for this task have, in all countries, some experiences in mapping, data preparation and interpretation. However, more training is needed (the focus and topics vary according to country) in order to harmonize the approaches and methodologies. Gray Tappan (EDC) organized a workshop on image analysis at AGRHYMET, Niamey, at the end of June 2005. Participants of all four SEMSOC countries were present to acquire new skills in a wall-to-wall image analysis and to solidify other skills.

Task 2: Quantification of carbon in soil and biomass

For this task, the main activities identified are:

- collect existing data
- complement soil and biomass measurements
- get information on land use and management history (in conjunction with Task 3: Socio-economic aspects)
- proceed to soil analysis
- estimate C carbon in biomass using allometric equations
- make correlation between C and climate trends (in conjunction with Task 4: Biochemical modeling)

It exists in the 4 countries, soil and biomass studies and people have experience doing such work. However, training and assistance is needed to estimate quantitative changes in biomass and to translate this information into NPP and C.

Task 3: Socio-economic aspects

Participants identified the following components for assessing cultural, economic, political, institutional, and demographic drivers for a) household/community decision making regarding management and land use practices; and b) risk management at the household level:

- literature review (existing documents, reports, case studies, national data bases etc.)
- discussion of appropriate methods
- assessment of rural actors' perception on climate change and strategies/activities undertaken to deal with changes
- inventory of management practices, changes over time, their efficacy, and the impacts of these practices on natural resources (could be together with community transect, village resource mapping, crop calendars, etc.)
- impact of policies (land tenure), institutions, migration, population growth, displacement, market availability (non-traditional export promotion), prices, local knowledge, available technologies, etc on land use and management practices
- assessment of livelihood strategies and assets
- stratification of households based on their livelihood strategies and/or assets
- assessment of types of risks rural actors face, their vulnerability with respect to these risks, their strategies and responses to deal with these different risks, and their success/failure in doing so; also consider changes over time
- assessment of the adequacy of current policies and institutions in strengthening rural adaptive capacities
- practical information/exchange with rural actors on the concept of carbon sequestration adapted to local knowledge bases
- cost-benefit assessment of land use/management options related to CS with respect to household/livelihood stratification (maybe use economic models like Stella)
- data entry, cleaning, analysis
- discussion of investment/sponsorship priorities for pro-poor/sustainable development rural carbon markets.

There seems to be a wealth of fairly recent data available (census data, documents/national plans/strategies on poverty reduction, population projections; food security, also first vulnerability and adaptation assessments, etc), which certainly provide useful background information for the national level. To which extent data are available for specific study areas ("hotspots") will be assessed over the next couple of weeks.

In terms of training, it was considered important to harmonize the technical and actor-oriented understanding of carbon sequestration among the various group members. Training on participatory methods for livelihood/vulnerability/risk assessments should receive high priority since it is a fairly new field of inquiry (documents and approaches available through AGRHYMET based on a CARE study). Petra could be responsible for such a training workshop, potentially in May or June. Additional training would be needed for cost-benefit analyses; Possibilities should be created to include and train students. All in all, the socio-economists were well represented and seemed highly interested and competent to contribute to such an interdisciplinary assessment. There is a clear understanding now that development issues, poverty reduction, and climate change are linked, even if the linkages themselves are not always apparent. This component looks highly promising!

Task 4: Biochemical Modeling

For this task, the main activities identified are:

- collect data resulting from the other tree tasks
- collect complementary data if needed (land use, management practices …)
- get information on climate: historical data and climate change scenarios
- run, test, validate the model
- analyze the results (this will be done by all the country team)

In all countries, training is needed. Introduction to Century and GEMS to entire country team during 1-2 days (carried out by national experts already trained in the use of the models); more detailed training for experts. We need to consult all together (Liu, Gray, Amadou…) on how to organize this training, either a big 4-country modeling workshop or individual training sessions at the country level. The modeling task with all the data collected is programmed for early 2006.

Task 5: Information exchange, data bases, conferences, publications

- In terms of external information exchange, all 4 countries opted for an email network or a password-controlled page on the SEMSOC web site to communicate between the various national teams to exchange on methods, tools, results etc. This also includes ways of communicating with those who participated in the Senegal SOCSOM study to take advantage of existing experiences and lessons learned; AGRYHYMET could function as the sub-regional "hub";
- Another important point included the creation of "carbon literacy": national teams would like to have a better understanding of the multiple components of "pro-poor" carbon assessments and then improve outreach to various audiences/stakeholders through appropriate media, including political decision-makers (booklets, posters, brochures, multi-media CD-ROM, open days, TV/radio presence etc.); Some of these outreach tools can also be made available electronically on the SEMSOC web site;
- A series of regional workshops, ideally one mid-term and one final/synthesis workshop, have been proposed by all countries; these should complement internal group meetings and workshops to be held at the country level;
- Scientific publications are considered essential by all national SEMSOC teams; however, for most of them, it is extremely difficult to get access to current relevant publications. It was proposed to

provide regularly updated (2-4 times/year) CDs or a page on the SEMSOC web site with relevant pdfs (Petra will enquire at Penn State to get a student working on this as soon as possible). An alternative would be to subscribe to some key journals to be up to date on the scientific understanding of C-related issues (for example Elsevier). Manuscripts will have to be in English (same for communicating with DSEMSOC countries, at least when Ghana is involved)!

- The various SEMSOC activities should provide possibilities for student involvement and training at all levels (MS, PhD);
- Participants expressed strong interest in participating in sub-regional and international conferences on climate change, C sequestration, land use/land cover change etc.

3.2. Training Workshops on Spatial Analysis and Carbon Modeling (with GEMS), August 2005, and June 2006

In 2005, Amadou Moctar Dieye held a two-day workshop at IER, Bamako, to work with a small group of image analysts and modelers from Mali, Burkina Faso, and Niger (August 15 and 16). The main purpose was to solidify technical capacity among the leading groups members with respect to land use/land cover analysis and C modeling in CENTURY/GEMS. In Accra, Petra Tschakert worked with a small group from the Ghana team on the same topics one week later. The following steps were covered: classification of land use categories on available satellite images, creation of various additional layers in ArcGIS, merging of data sets through a joint frequency distribution (JFD) cover, introduction of the JFD into GEMS, model runs on GEMs, and input of model outcomes into final GIS layers.

In 2006, two Biogeochemical Modeling workshops were organized, in Accra, Ghana, June 5-9, 2006; and in Ouagadougou, Burkina Faso, June 25-30, 2006.
The objectives of the two workshops were to assist the countries in finalizing the land use/carbon models in their respective study sites. In Accra the participants came exclusively from Ghana's SEMSOC team, while the workshop in Ouagadougou was for the French speaking countries with participants from Burkina, Mali, and Niger.
In each country two sites were selected and prior to coming to the workshop, participants were asked to collect and prepare all necessary data for the model, including historical land cover and land use, climate (temperature and precipitation), soils (texture, drainage, and water holding capacity), socio-economic and land management (fertilizer, fire, grazing, tree removal…). However, the data brought by the participants was not ready for the model owing to an inappropriate format and the lack of consistency. Three days was

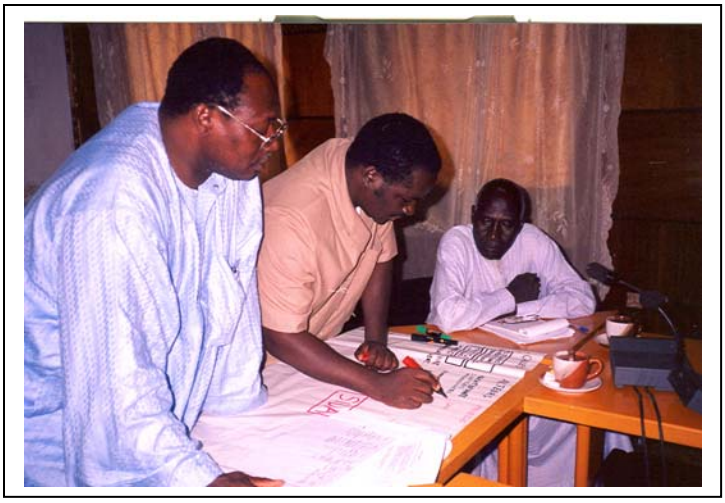
spent on reprocessing and reformatting the data. At the end, all countries were able to start the model for at least one site. Participants left with a clear plan to finalize the models in their two study sites, analyze the results, and write the reports.

3.3. Training Workshops on Participatory Vumnerability and Adaptation Assessments, August 2005

Petra Tschakert held two three-day workshops on participatory methods for vulnerability and adaptation assessments, one in Bamako (August 17-19) for the socio-economic team members from the francopohone partner countries (Mali, Niger, and Burkina Faso) and one in Accra (August 23-25) for the anglophone partners. This workshop was organized in response to the partners' requests expressed in January. The purpose was to provide a background on climate change and its effects on Africa, discuss the concept of vulnerability (exposure, sensitivity, and adaptive capacity), and introduce the team members to participatory methods of risk assessment, risk perceptions, and cognitive factors of risk and adaptation appraisals. Also covered were fundamental concepts of livelihood assessments and social capital. More specifically, the following tools were introduced:

- ongoing country work on NAPAs (trends, gaps, and achievements)
- multiple risk mapping
- sustainable livelihood framework (pentagon)
- stakeholder analysis
- Venn diagrams
- Mental models on causes, processes, actors, positive and negative impacts of "stressors" (preoccupations, threats)
- Introduction to a socio-cognitive model on risk perception and adaptive capacity
- Farmer-centered cost-benefit analysis of management options (in Ghana only)

All training material is available in English and in French on the SEMSOC web site. Also, there are some key articles in pdf form to download. All country teams felt well equipped to integrate the new methods into their methodology design for the fall and, as a next, step use the tools, as appropriate, in the field. Petra Tschakert will be available to provide further support, especially during the methodology design phase and data analysis phase. At the end of the workshop, new activity priorities and schedules were discussed with all partners involved in order to complete all project activities during the first half of 2006.



3.4. Synthesis Workshop, Accra, Ghana, August 2006

The final project synthesis workshop was held in Accra, Ghana from August 24 to August 26, 2006. A taotal of 26 participants were present, including 19 from Ghana, 2 from Niger, 2 from Burkina Faso, 1 from the USA, and the two project PIs (Tschakert and Gueye). The Mali colleagues were unable to attend to to last minute travel complications. The last day was devoted to next steps for the Ghana team, in anticipation of the Global Climate Change Grant (Project CC LONG).
The purpose of the meeting was to take stock of our achievements, discuss results, identify gaps and weaknesses, and agree on a final to plan analyze results and prepare a final synthesis. This was certainly the most productive of all meetings, even though it also clearly demonstrated the intellectual and methodological challenges the various sountry teams had been struggling with over the previous 14 months. Deficiences were made explicit and guidelines for addressing them provided. The biggest challenge was, without any doubt, to get the model running for each site and, once results were available, to interpret them in a critical and meaningful way. Once again, the Ghana team was ahead of the other teams in all aspects of the project.

An overview of the workshop with individual presentations is available at
http://www.epa.gov.gh/climate/SEMSOC/Report/index.htm

AGENDA

Opening Session

DAY 1

0900 - 0930	-	Registration
0930 – 0935	-	Introduction of chairman by **Mrs Angelina Mensah**
0935 – 0940	-	Chairman's Remarks
0940 - 0950	-	Welcome Address **Mr. Jonathan Allotey, Executive Director (EPA)**
0950 - 1000	-	Statement by **Dr. Larry Tieszen USGS International Programme Director**
1000 - 1020	-	Overview of Spatially Explicit Modeling of Soil Carbon (SEMSOC) Project – **Dr. Petra Tschakert Regional Project Coordinator**
1040 - 1150	-	End of Opening Session and Closing Remarks
1050 - 1100	-	Cocoa Break

Technical Session 1 SEMSOC Ghana

Chairman: **Mr. W. K. Agyemang Bonsu**

1100 - 1130	-	Land Use Land Cover Trends from 1972-2000 in Assin, and Ejura-Sekyedumasi Districts **Mr. Emmanuel Tachie-Obeng**
1130 - 1200	-	Socio-Economic and Policy drivers **Mrs Regina Sagoe**
1200 - 1300	-	General Discussions on project strategy and findings
1300 - 1400	-	Lunch Break

Afternoon session

Chairman: **Mr. W. K. Agyemang Bonsu**

1400-1430	-	Soil and Biomass carbon stocks **Dr Mike Abekoe and Dr. Stephen Bredu**
1430 - 1500	-	Networking of National and Regional SEMSOC Activities **Mrs Helen Asiamah**

1500 - 1530	-	Modeling **Mr. Zenia Minia**
1530 – 1630	-	General Discussions on project strategy and findings
1630 - 1700	-	Closing Remarks on Day 1

DAY 2 - Morning Sessions

Technical Session 2 SEMSOC Burkina Faso

Chairwoman: Petra Tschakert

Burkina Faso

0900 - 0930	-	SEMSOC Biophysical - Land Use Land Cover trends and Soil/Biomass Carbon stocks and modelling **Mr. Loius Blanc Troare**
0930 – 1000	-	Socio-Economic and policy drivers **Dr. Honore Some**

Technical Session 2 SEMSOC Niger

Chairwoman: Petra Tschakert

1000 - 1030	-	Cocoa Break
1030 – 1100	-	SEMSOC Biophysical - Land Use Land Cover trends and Soil/Biomass Carbon stocks and modelling **Dr. Mahamadou Gandah**
1100 – 1200	-	Socio-Economic and policy drivers **Mr. Moussa Boureima**
1200-1300	-	Country discussions

Afternoon session

1400-1530	-	SEMSOC Task Group discussions 1. Biophysical 2. Socio-Economic Regional Project Synthesis
1530 – 1545	-	Cocoa Break
1545 - 1645	-	Presentations from group discussions
1645 - 1730	-	Synthesis: lessions learnt from Sahel and West Africa
1730 – 1800	-	Closing Remarks on the Workshop

DAY 3 – NEXT STEPS

Morning Session

0930 - 1200	-	Core Team - Climate Change Learning and Observatory Network Ghana (CC LONG) - **Dr. Petra Tschakert**
1200- 1300	-	Lunch Break

4. Overview Country Activities and Reports

The following activities have been completed in the various SEMSOC partner countries. A detailed description of each country's achievements for this year can be found in Appendices 3 (a-d). It should be emphasized that the 4 countries have started project activities according to all five identified tasks with various levels of progress in each country (conditioned by arrival of research funds); Ghana was the first

to receive funds, and also the only country that had completed preliminary goals on time and, hence, requested two additional funds to expan the work into other study areas.

a. Selection of study sites:

All four countries have selected two or three study sites for detailed work with respect to tasks 1-4. The main criteria for selection were "hotspots" of either vegetation improvement or degradation, different agro-ecological zones, different farming systems, and possibly different ethnic grous. The sites are described in detail in the country reports (Appendix 3). However, not all sites were finally addressed in all countries in a level outlined at the planning meeting, mainly due to delays in getting the work organized and hanrmonized between the task forces.

- Ghana: Ejura-Sekyedumase District (severely degraded), Assin Disrict (fairly well managed), and Bawku East District (very northeast, semi-arid, degraded)
- Mali: Kaniko and Try (Plateau de Koutiala), Dotan et Missira (monts mandingues),and Tendjé et Alasso (Hodh).
- Niger: Koure with 3 specific sites: Dallol (ancient river bed, high population pressure, poor soil), Zigui (the area of the giraffes, open savanna), and Niger river area (with rain-fed agriculture and irrigated agriculture)
- Burkina Faso: Koumbia/Houndé in the Sudanian zone; Nouaho/Boulgou in the Sahel-Sudanian zone; and Kaya/Binogo in the Sahelian zone

b. Land use/land cover analysis:

Land use classification for identified study areas in Ghana and Burkina Faso completed; in Mali and Niger partially completed. Thank's to E. Tachie-Obeng for poushing this component forward.

c. Soil and biomass measurements:

Soil and biomass measurements were only carried out, as anticipated, in Ghana (all three study areas). Sample plots were established on the study sites and above ground biomass measured and soil samples taken. Samples were analyzed in the lab at the University of Ghana. Results are available for soil C, soil texture, particle size distribution, and above ground biomass content. The other countries relied on previously done soil classifivations (although no direct C measurements and often no values for bulk density) and available biomass measurements from other studies, were available. The Ghana results are clearly the most useful (because most precise) as input into the model. Thank's To Stephen Bredu, M. Abekoe, and S. Adiku for their outstanding work.

Biomass sampling in Kakum, Ghana.

d. Socio-economic and adaptation assessment:

As above, only the Ghana team completed a full suite of assessments and analysis of land use managements, socio-economic, policy and institiutional drivers for land use/management change as well as household and community level determinants of vulnerability/adaptive capacity to various

stressors and shocks. It was also the only team that had taken advantage of the participatory methods workshop and actually used a series of methods on the study stites that differ substantially from the methods undertaken in the other countries (classic household surveys or communuity group discussions). The report put together by Regina Sagoe is outstanding and provides a tremendous amount of information for the two study areas wewre populations play and active role in carbon dynamics (the third location is a national forest where populations are excluded).

Group discussion and participatory mapping in Ejura, Ghana

e. C modeling:

The modeling, the core of his project, proved to be a significant hurdle for all country teams. Despite several workshops through SEMSOC and other venues (SOCSOM), the participants felt not comepetent and sufficiently familiar with the model to run it without external assistance (A.M. Dieye). Much more practice would be required to prepare the necessary input input data for the model, understand its technical strenhgths and weaknesses, handle bugs, and critically interpret results. We certainly overestimated the learning curve for this component. Nonethesless, all countries did produce final moredl outputs, even though they vary in quality. While different land use/land management scenarios have been modeled over time, following the results from the image analysis, no model scenarios have yet been produced based on different future climate scenarios.

f. Information sharing and networking:

SEMSOC Ghana alone has produced a SEMSOC national link, thanks to the wonderful work of Helen Asiamah at EPA. (http://www.epa.gov.gh/climate/SEMSOC/semsoc.html). The site holds a wealth of information. Helen has also created an internal listserv for team members and a special SEMSOC email account.

5. Achievements on the Assessement of Carbon Stocks: Spatially Explicit modeling of impacts of land cover/land use change on carbon dynamics (GEMS Model)

As this was the core of the project, it deserves a more detailed synthesis in this final report. Country results can be found in the individual country reports. Carbon dynamics in vegetation and soils was simulated using GEMS (General Ensemble biogeochemical Modeling System) a model that integrates CENTURY, a well-established ecosystem biogeochemical model. As described by Parton et al. (2004), CENTURY is a generalized ecosystem model that simulates the dynamics of carbon, nitrogen, and phosphorus in grasslands, forest, savanna, and crop systems. It simulates the impacts of land use changes on ecosystem dynamics by using schedule that define the land use management practices for each month of the year during the computing process.

GEMS was developed at EROS (Liu et al. 2004) to extend the spatial context of CENRURY for simulating carbon dynamics in space ranging from landscape to the globe. GEMS has been applied to quantify the impacts of land use and climate change on carbon dynamics in terrestrial ecosystems in the United States, Costa Rica, and parts of Africa. The main inputs variables are climate (observed monthly precipitation and average monthly daily maximum and minimum temperatures), soil (soil texture, bulk density, drainage, water holding capacity), cropping systems and management practices (crop species, crop rotation, fallow lengths, bush fire…). Although various outputs come from the model (see appendix 1) in this work the variables of interest are soil organic carbon (SOC) in the top 20 cm layer and grain yields. Field measurements of soil and biomass provided C values that are used for model parameterisation and validation of C values simulated with the model. Both carbon dynamics in1900-2000 and potential carbon changes in the future, for 2000-2100, were simulated for various climate scenarios and land use options. Fig. 1 shows a diagram of information flow in GEMS model. A detailed description of GEMS can be found in Lui and Dieye (2004)

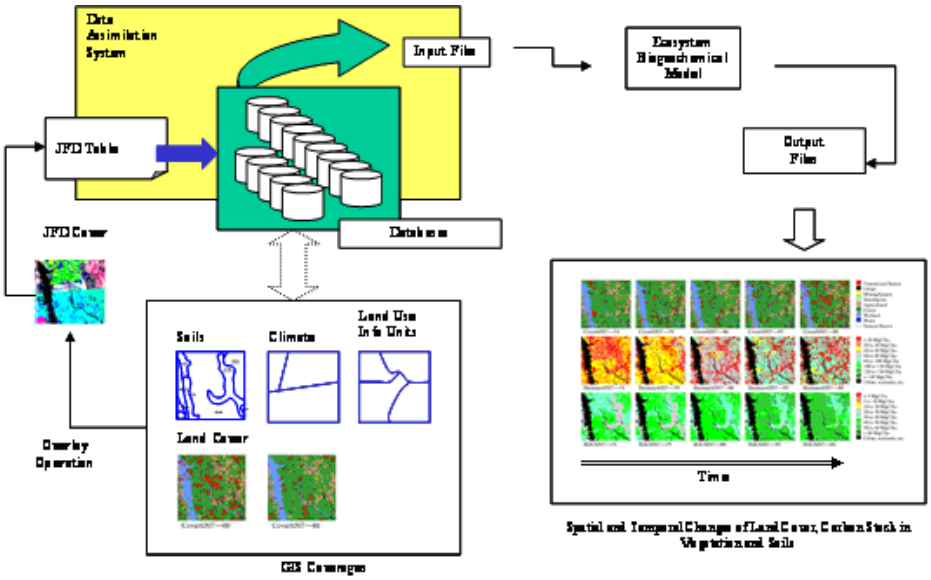


Fig 1. Diagram of information flow and data assimilation in GEMS model

5.1. Data preparation

The data needed to perform the model can be grouped in three categories: site specific data, management data, and plant characteristics. The site specific data illustrates the geographical settings and comprise: climatic data and soil properties. The management data tells about land used history and management practices, when and how long events took place.

<u>Climate data</u>
The climatic data required three files containing monthly precipitation, average monthly daily maximum and minimum air temperature. In this study historical time series climate data was used. Examples of these files are shown in tables 1, 2, and 3 below.

Table 1. Monthly precipitation (mm/month). Shown is just a part of the file.

ID	Year	J	F	M	A	M	J	J	A	S	O	N	D	
1	1961	0	0	0	0	0	94	250	259	184	18	0	0	

1	1962	0	0	0	0	0	61	270	278	124	38	0	0
1	1963	0	0	0	0	0	17	219	237	193	109	0	0
1	1964	0	0	0	0	0	109	256	267	145	16	0	0
1	1965	0	0	0	0	0	27	167	276	230	79	12	0
1	1993	0	0	0	0	0	92	266	300	227	102	12	0
1	1994	0	0	0	0	12	90	265	350	467	220	18	0
1	1995	0	0	0	0	2	48	218	343	305	76	0	0
1	1996	0	0	0	0	10	53	273	367	298	124	7	0

Table 2. Monthly minimum temperature (^{o}C). Shown is just a part of the file.

ID	Year	J	F	M	A	M	J	J	A	S	O	N	D
1	1961	160	179	211	230	251	249	237	233	229	227	191	155
1	1961	162	181	213	233	254	251	238	233	230	228	191	156
1	1961	163	183	216	235	257	252	239	234	230	228	191	156
1	1961	165	185	219	238	259	254	239	234	230	229	191	156
1	1961	167	187	221	241	262	256	240	234	231	229	191	157

Table 3. Monthly maximum temperature (^{o}C). Shown is just a part of the file. A scalar of 10 is applied to the data.

ID	Year	J	F	M	A	M	J	J	A	S	O	N	D
1	1961	338	364	388	401	396	364	330	317	323	346	355	334
1	1961	338	365	389	402	397	364	329	317	323	346	356	334
1	1961	338	364	389	403	397	364	329	316	323	345	356	335
1	1961	338	365	390	404	398	364	329	316	323	345	357	335
1	1961	338	365	390	405	399	365	329	317	323	346	357	335
1	1961	338	365	391	406	400	365	328	316	323	346	357	335

<u>Soil</u>

Information on soil texture (that is % sand, % silt and % clay), drainage characteristics, and water holding capacity are important variables required for the model. The only soil database that was available in all four countries is the one from FAO. It was completed by national soil experts for additional information on soil texture and drainage characteristics. Examples of these files are shown in tables 4 and 5.

Table 4. Soil database composed of soil ID and percentages of sand, silt, and clay.

ID	sand	silt	clay
1	25	25	50
2	30	35	35
3	87	8	5

Table 5. Drainage classes associated with soil types. Soil drainage classes are defined using FAO criteria. Five classes ranging from poorly drained (=0) to overly well drained (=5) are used. Water holding capacity (WHC) is also ranked from high (clay=5) to low (sand=1).

soil_id	drainage	whc

1	3	4
2	3	3
3	4	3

Management practices

Several parameters are used by the model for integrating management practices. Some of them are described below

- Crop composition

  While remote sensing is useful to detect general land cover change such as major conversions from forest to non-forest, it is difficult to define crop species with solely remote sensed data. In order to use CENTURY it is necessary to downscale the general class of "agricultural lands" into crop species. The crop composition file is organized as shown in Table 6. The first column is just a place holder. The second and the third columns are the beginning and end of each time period that has experienced crop composition changes. In the rest of the columns, the cumulative aerial fractions of the major crops are recorded.

  Table 4. Example of crop compositions during different time periods.

Distr	Beg	End	Millet	Sorgum	Cotton	Groundnut	Maize	Rice
0	1	1975	0.18	0.21	0.50	0.85	0.94	1.0
0	1976	1982	0.26	0.35	0.51	0.76	0.88	1.0
0	1983	1986	0.11	0.29	0.61	0.76	0.92	1.0
0	1987	1994	0.10	0.32	0.47	0.63	0.90	1.0
0	1995	2004	0.07	0.34	0.46	0.75	0.93	1.0

- Manager data

  The data manager section is used to specify different practices such as bush fire, tree removal, and grazing.

- Harvest Change

  Often harvesting practices have changed over time. GEMS simulates the change of harvesting practices using three kinds of harvesting schemes. These harvesting schemes are specified in CENTURY. Therefore modification could be done to these schemes, if necessary. The definitions of these schemes are defined as follows:
  GH: harvesting grain and stalk
  G50: harvesting grain and 50% of stalk, the rest of stalk is left on site.
  G: harvesting grain only and stalk is left on site.

- **F**allow

  Fallow is a common agricultural practice in Africa. Depending on the locations, the years in fallow might vary. Fallow information is related to land cover mapping products. Hence, agricultural lands are classified into different classes according to the intensity of agricultural activities and fallow variability.

5.2. Scenarios

Climate change scenarios

Impacts of future climate change and changes in land use on carbon stocks are simulated for various climate change scenarios. Climate change scenarios from 2000 to 2100 are based on the simulated results of several global climate models (GCM) (Hulme et al. 2001). Based on previous works in Africa (Special issue of Journal of Arid Environments, volume 59, 2004) three scenarios were considered:

1. No Climate Change Scenario (NCCS): Climate conditions were based on observed precipitation and the maximum and minimum air temperatures during the period 1900-2000. These records were repetitively used during simulations.

2. Low Climate Change Scenario (LCCS): Changes in monthly precipitation and temperature based on their averages from 1900 to 2000 were calculated using the following equations derived from Hulme et al. (2001) for the study area:

   a. Precipitation : change% = 0.2125*year + 427.29; r^2= 0.99 (1)
   b. Temperature : change% = 0.0142*year – 27.71; r^2=0.99 (2)

3. High Climate Change Scenario (HCCS): Similar to LCCS, changes in monthly precipitation and temperature were calculated using the following equations derived from Hulme et al. (2001):

   a. Precipitation : change% = 0.525*year + 1043.9; r^2=0.98 (3)
   b. Temperature : change% = 0.0638*year + 126:8; r^2=0.99 (4)

Land Use Change Scenarios

The changes in management practices are based on the following assumptions:

1. Loss of biomass due to land use/land cover change and its associated cutting schemes with the same amount of cut , or less, compared to the situation in 2000
2. Agricultural intensification through addition of nitrogen (N) fertilizer:
   - N1: 1g N/m2
   - N3: 3g N/m2

5.3. Results

Ejura in Ghana

- Land cover change and carbon dynamics in the 20th century:
  The area experienced significant changes during the 20th century due to agriculture expansion and the associated deforestation. Satellite images and land cover land use change (LCLUC) map confirm this change (Ghana preliminary report, 2005) and show that agricultural development has increased significantly from 7 to 23 percent, between 1972 and 2000. The woody savanna only has reduced from 92 to 76 percent during this period with more than 50 percent of the land area are under mechanized farming.

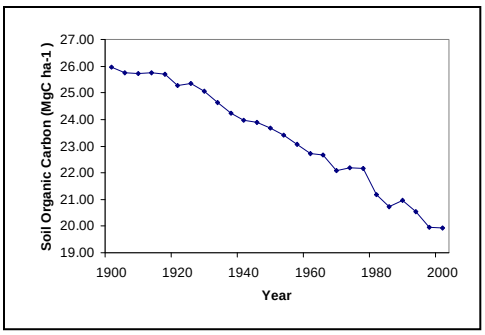


Figure 2 shows the dynamic of soil organic carbon (SOC) in Ejura (Ghana) from 1900 to 2000. The model-simulated changes of spatial patterns of SOC is displayed on Fig 3. SOC decreased from near 26 MgC ha^{-1} in 1900 to less than 20 MgC ha^{-1} in 2000, representing more than 30% of change.

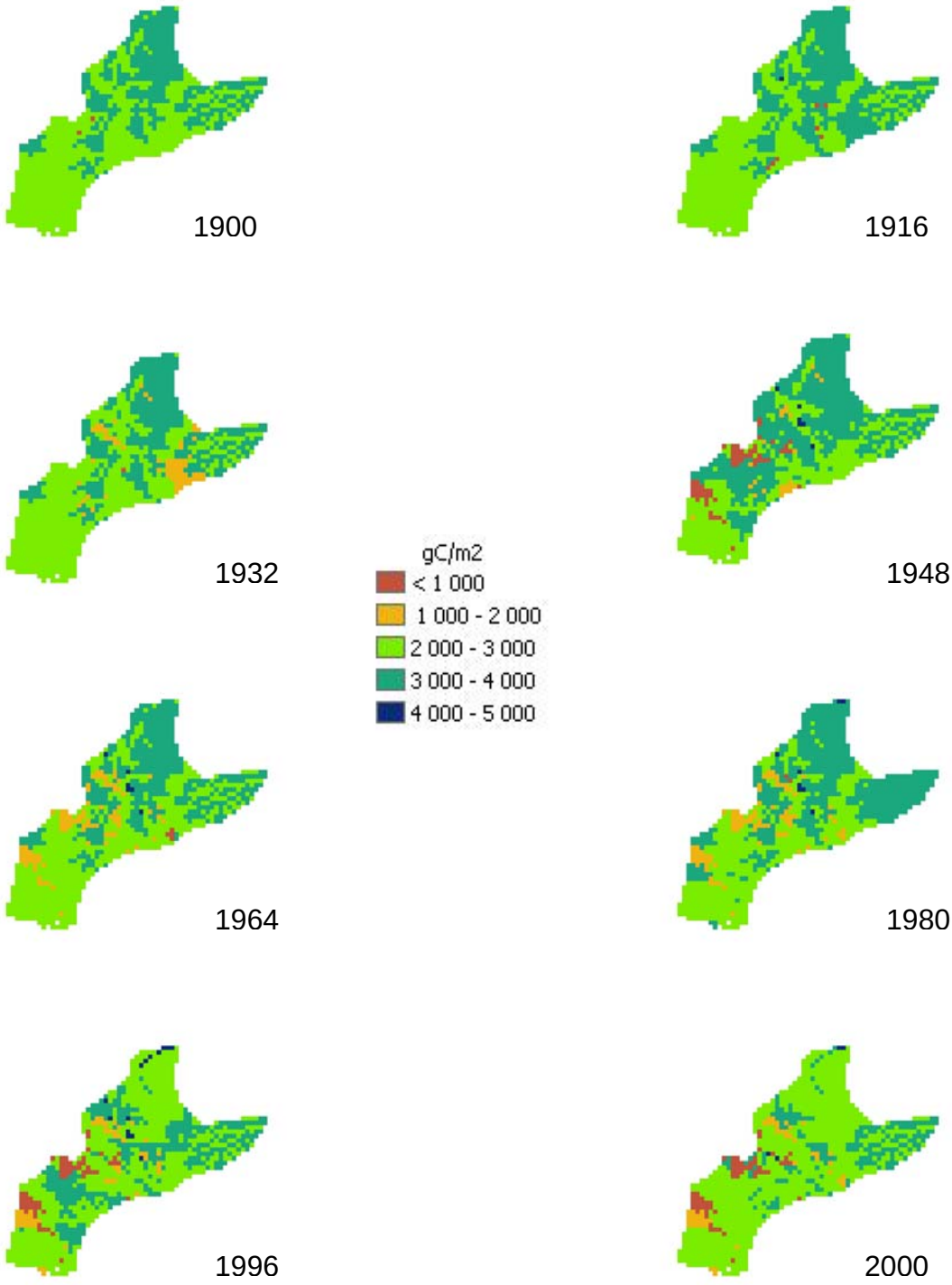


Fig. 3. Model-simulated changes of spatial patterns of soil organic carbon (SOC) in the top 20-cm layer in Ejura (Ghana) from 1900 to 2000.

- Carbon dynamics in the 21st century

Soil organic carbon

As explained above, simulation of carbon dynamics in the 21st century is performed according to the following scenarios:

- three climate change scenarios
  - NCCS: No Climate Change Scenario;
  - LCCS: Low Climate Change Scenario and;
  - HCCS: High Climate Change Scenario.

- two land use changes scenarios, on one hand (LCUT) with the same amount of tree cut, or less, compared to the situation in 2000, and on another hand, agricultural intensification through two cases of addition of nitrogen (N) fertilizer:
  - N1: 1g N/m2
  - N3: 3g N/m2

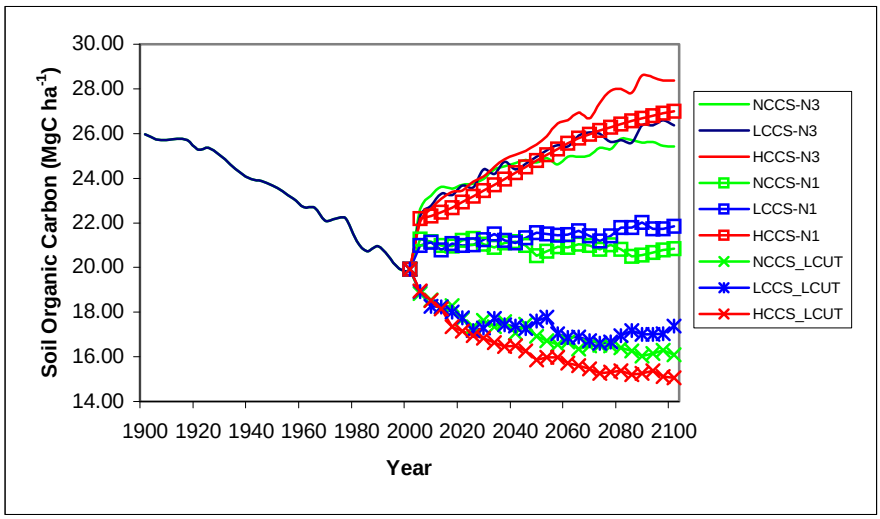


Fig. 4. Soil organic carbon (SOC) dynamics in MgC ha^{-1} in Ejura (Ghana) from 1900 to 2100 under various climate change and management scenarios.

LCCS:	Low Climate Change Scenario
NCCS:	No Climate Change Scenario
HCCS:	High Climate Change Scenario
LCUT:	Same cut as in 2000
N1:	Addition of 1g N per square meter
N3:	Addition of 3g N per square meter

The simulations based on the three different climate change scenarios and same amount of tree cut or less compared to the situation in 2002, predict continuously decline of soil organic carbon SOC (Figure 3). Thus, in 2100, from the near 20 MgC ha^{-1}, SOC would be reduced by about 2.5 to 4.9 MgC ha^{-1} representing a decrease of 13 to 24 percent (Table 5).

In contrast, agricultural intensification predict SOC. Addition of 1g per m2 of nitrogen will stabilize the SOC at the level of end of 1990s in case of NCCS or LCCS and will provide a dramatic increase of SOC in case of HCCS. Addition of 3g per m2 of nitrogen will grant equally a dramatic increase of SOC, whatever will be the climate change scenario.

Table 5. Soil organic carbon (SOC) in MgC ha^{-1} in Ejura (Ghana) from 1900 to 2100

Year	NCCS-N3	LCCS-N3	HCCS-N3	NCCS-N1	LCCS-N1	HCCS-N1	NCCS_LCUT	LCCS_LCUT	HCCS_LCUT
1900	25.96	25.96	25.96	25.96	25.96	25.96	25.96	25.96	25.96
1920	25.27	25.27	25.27	25.27	25.27	25.27	25.27	25.27	25.27
1940	23.97	23.97	23.97	23.97	23.97	23.97	23.97	23.97	23.97
1960	22.71	22.71	22.71	22.71	22.71	22.71	22.71	22.71	22.71
1980	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17	21.17
2000	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92
2020	23.70	23.69	23.44	21.22	20.99	22.92	17.69	17.75	17.15
2040	24.67	24.40	25.05	21.16	21.09	24.23	17.08	17.39	16.49
2060	24.95	25.42	26.60	20.88	21.46	25.57	16.66	16.87	15.72
2080	25.78	25.69	28.01	20.81	21.78	26.41	16.40	16.96	15.36
2100	25.41	26.36	28.38	20.85	21.85	27.00	16.08	17.39	15.06
Change*	5.49	6.44	8.45	0.93	1.93	7.07	-3.84	-2.53	-4.87
% change	28%	32%	42%	5%	10%	36%	-19%	-13%	-24%

Carbon in grain

Carbon in grain presents similar patterns of change as for SOC. It will continue to decrease if the situation of 2000 prevails, will stabilize with addition of 1 g per m2 of nitrogen (N1), or will increase with addition of 3 g per m2 of nitrogen (N3) (Figure 5). However, with HCCS and N3, carbon in grain will double during the first 50 years from 0.9 to 1.8 MgC ha^{-1} $year^{-1}$ and then starts declining and attains 0.45 MgC ha^{-1} $year^{-1}$ in 2100; a decrease of about 50% of its value in 2000. This situation can be explained by the predicted decrease by 58% in precipitation during the 21st century in case of HCCS.

Fig. 5. Grain yield in MgC ha^{-1} year^{-1} in Ejura (Ghana) from 1900 to 2100 under various climate change and management scenarios.

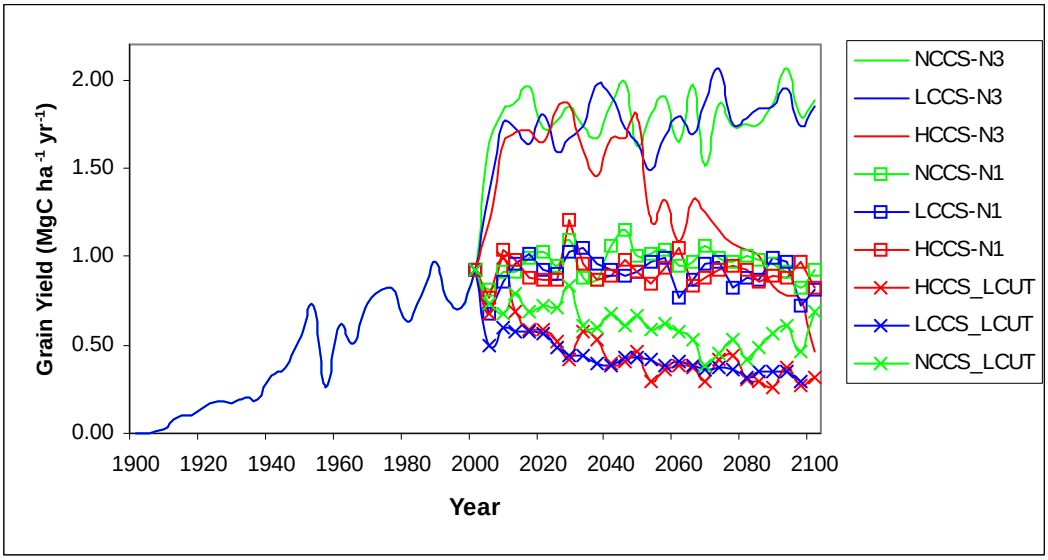


Table 6. Grain yield in MgC ha^{-1} year^{-1} in Ejura (Ghana) from 1900 to 2100 under various climate change and management scenarios

Year	NCCS-N3	LCCS-N3	HCCS-N3	NCCS-N1	LCCS-N1	HCCS-N1	NCCS_LCUT	LCCS_LCUT	HCCS_LCUT
1900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1920	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1940	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
1960	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
1980	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
2000	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
2020	1.73	1.80	1.65	1.03	0.92	0.87	0.59	0.56	0.72
2040	1.86	1.91	1.67	1.07	0.92	0.89	0.39	0.39	0.68
2060	1.64	1.80	1.09	0.94	0.77	1.05	0.38	0.41	0.57
2080	1.75	1.78	1.03	1.01	0.87	0.93	0.31	0.32	0.41
2100	1.88	1.85	0.46	0.93	0.82	0.83	0.32	0.33	0.69

Change*	0.96	0.92	-0.47	0.00	-0.11	-0.10	-0.61	-0.60	-0.24
% change	103%	99%	-51%	0%	-12%	-11%	-66%	-64%	-26%

6. Additional Achievements:

- Petra Tschakert and Larry Tieszen participated in UNCCD CRIC-3 meeting in Bonn, Germany (May, 2005) and organized the side event "Integrated 'Pro-Poor' Ecosystem Service Provision in Dryland Africa: National Capacity Building and Project Implementation in Land Cover Assessment, Carbon Sequestration, and Adaptation to Climate Change";
- In collaboration with Amadou Moctar Dieye (CSE), Tim Mendele (EDC) and Michelle Anthony (EDC), and myself, a SEMSOC web portal was designed, one in English (http://edcintl.cr.usgs.gov/SEMSOC/) and one in French (http://www.cse.sn/semsoc/); one of my undergraduate students (Ryan Updike) significantly improved and maintained the site in 2006.
- An extensive reading list (articles in pdf format) for SEMSOC partners was prepared covering state-of-the-art knowledge in carbon sequestration, soil and biomass carbon stocks, field methodology, analysis, modeling, climate change, adaptation, and sustainable livelihoods (the list is available on the web portal); Ryan added several more readings to the site throughout 2006;
- Guidelines for publications were also added to the SEMSOC site; these are supposed to provide structure for planning scientific outputs from this project;
- Petra Tschakert and Larry Tieszen prepared proposals for additional funding to IFAD/Global Mechanism ("Integrated Pro-Poor Ecosystem Service Provision and Agro-ecological Sustainability in Africa") and UNDP ("Carbon Specialist Team, Land Cover Change, and Climate Change in Africa");
- Petra Tschakert submitted an NSF proposal ("Marginality and Multiple Stressors: Understanding Risk Perception, Adaptive Capacity, and Decision-Making among Africa's Poor") to attract more research funds for adaptation component of SEMSOC with supporting letters from all four partner countries; the proposal did not get funded the first time (which is not uncommon with NSF), but will be resubmitted at a later state;
- Petra Tschakert initiated contacts with WARP (Accra) to discuss future funding possibilities;
- Amadou Moctar Dieye and Petra Tschakert produced documented training materials (CENTURY/GEMS modeling, land cover change analysis, participatory methods for vulnerability/adaptation assessments) for follow-up and in-depth training workshops.
- Provided research and education opportunities for one African scientist (Amdou Moctar Dieye) at the new EROS-S.D. State University Geographic Information Science Center of Excellence (GIScCE).
- Petra Tschakert presented "Detection, Drivers, and Dynamics of LULCC in the Sahel: Linking Scientist with Local Decision-Makers" at the International Human Dimensions (IHDP) Meeting in Bonn, Germany, October 9-14, 2005.
- Petra Tschakert discussed "CDM and Equity: A Southern Perspective" at the University of Antwerp, Belgium, November 28, 2005.
- Tschakert Petra, Elisabeth Huber-Sannwald, Dennis Ojima, Michael Raupach and Erich Schienke (2007). Principles for Holistic, Adaptive Management of the Terrestrial Carbon Cycle at Local and Regional Scales, through Multi-Criteria Analysis. Global Environmental Change (in press).
- Tschakert Petra (2007). Viwes from the Vulnerable: Perceptions on Climatic and Other Stressors in the Sahel. Global Environmental Change (in press)
- Tschakert Petra presented "Wetter or drier? Climate change perceptions, risk, and vulnerabilities in the Sahel" at the 102nd Annual Meeting of the Association of American Geographers, Chicago, Illinois, March 7-11, 2006.
- Dieye Amadou submiited "Land use, Land cover change and Carbon dynamic in the Sahel" for the 6th African Association of Remote Sensing of the Environment (AARSE) Conference, Cairo, Egypt, 30 October—2 November 2006. Theme: Earth Observation & Geoinformation Sciences in Support of Africa's Development.

7. Next Steps

Two new projects have emerged out of the SEMSOC project and both will be in Ghana. This makes sense as the Ghana team was the most progressive and best organized country team and has produced scientifically valid results.

- Tschakert Petra (PI), "Climate Change Collective Learning and Observatory Network in Ghana", funded through the USAID Global Climate Change Program the (with M. Mann and W. Easterling as Co-PIs and various collaborators from Ghana); this proposal focuses on creating a collective learning and observatory network on climate change that brings the science and the implications for people and the environment to a level that is understandable, accessible, and beneficial to a range of stakeholders in Ghana; $760,00 over 3 years;
- Tschakert Petra (Co-PI), Samuel Nii Codjoe (PI), "Food Security and Adaptation to Climate Change in the Afram Plains of Ghana; accepted concept note to ACCCA (Advancing Capacity to Support Climate Change Adaptation), supported by UNITAR and START. The purpose of this proposed project is to design and implement successful and sustainable climate change adaptation strategies that address food security, livelihood sustainability, and the reduction of poverty in rural areas of Ghana. Food security is key for adaptive capacity since poorly nourished social actors are usually too weak to carry out otherwise effective adaptation strategies. The Ghanaian counterparts (Codjoe and Sagoe) are now invited to an ACCCA workshop in Ouagadougou, January 2007, to enhance their skillis in climate change adaptation assessments. $70,000, 18 months.

Moreover, we will pursue two additional activities over the next couple of months:

- Assist in preparing high-quality scientific manuscripts on the results of SEMSOC research activities and identification of appropriate outlets for publication (early 2007);
- Present the project results in a visually pleasing format (poster or brochures).

Overall, the SEMSOC Project was a highly useful learning oppoutunity. Compared to the initial pilot project in Senegal (SOCSOM), where more continuous presence allowed us to interact more effectively and achieve better results, the quadruple task of working with four countries siumltaneosly was certainly a challenge. Nevertheless, all teams received equal technical and methodological support (in English and in French), even though the Ghana team did receive more funds as a result of timely completion of initial objectives. Climate change mitigation and adaptation assessments are still relatively new in many West African countries. Most collaborating agencies have become quite sophisticated in terms of land use/land cover assessments through satellite imagery (mainly due to long-term collaboration with the USGS EROS Data Center, the work of Gray Tappan, and funding from USAID), which is clearly reflected in the individual country reports. The same is true for GIS representations of land use/land cover patterns and dynamics at the community level (cartographie du terroir). However, utilizing these tools as an input into a much more complex modeling excerise rather than stand-alone products does require more training and practice. On the methodological side, there certainly is tremendous potential for more effective use of participatory methods, especially for vulnerability and adaptation assessments. Institutional inertia in many West African institutions does not necessailry encourage a radical shift to more participatory and empowering methods. In this respect, the results from Ghana are even more encouraging and the two follow-up projects will show to which extent we can use and expand on the lessons from SEMSOC.

Mali

I.Introduction générale

Conformément aux activités planifiées, les travaux ont porté sur la cartographie de l'occupation des terres, le diagnostic socio-économique, la collecte des données climatiques des 30 dernières années et les sols. En raison des moyens disponibles les missions de terrain prévues ont été groupées pour minimiser les frais mais surtout pour permettre le dialogue entre les différents spécialistes qui composent les équipes.

II. Diagnostic socio-économique

Les sites retenus dans le cadre des activités de recherche du projet SEMSOC sont Kaniko et Try dans la zone agro-écologique du plateau de Koutiala, Dotan et Missira dans la zone agro-écologique des monts mandingues et Tendjé et Alasso dans la zone agro-écologique du Hodh. Ces sites ont fait l'objet d'une enquête de reconnaissance pour une caractérisation sommaire des modes d'existence.

1. Zone agro-écologique du Plateau de Koutiala (Kaniko et Try)

1.1 Caractéristiques des UPA

Les villages de Kaniko et Try sont localisés dans la zone du bassin cotonnier du Mali. Les densités de population ont varié de 28.57 à 50 et de 5.18 à 7.41 pour les vingt dernières années respectivement au niveau des villages de Kaniko et Try. Au cours de la même période, les nombres d'unités de production agricoles (UPA) ont passé de 84 à 110 pour Kaniko et de 50 à 75 pour Try dénotant un processus d'éclatement des UPA. On note également une tendance d'évolution des UPA vers les types A et B possédant plus d'animaux de trait et de troupeaux d'élevage et une réduction des types C et D qui n'ont pas d'équipement dans la zone (figure 1).

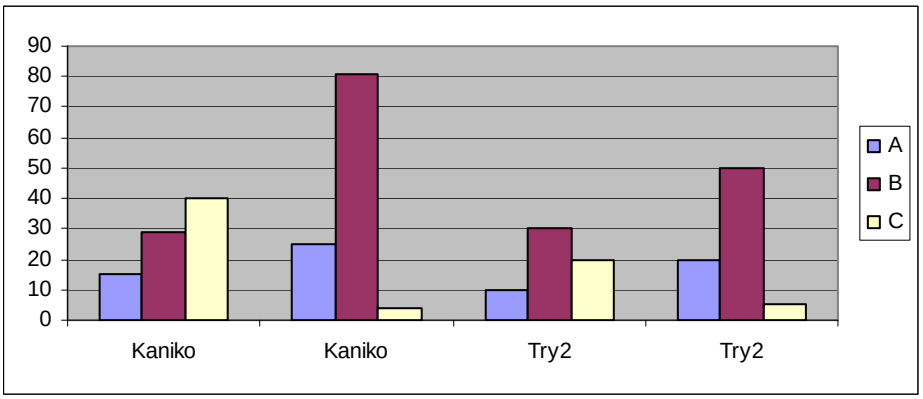


Figure 1 : Importance des types d'UPA dans les villages de Kanika et Try

Les UPA du type A ont le plus nombre de personnes et leur taille a augmente au cours des dernières passant 16 a 29 personnes (tableau 1). Ce qui n'est pas le cas pour les UPA de types B et C ou note une tendance a la réduction de la population totale. Le nombre de personnes au niveau des UPA de type B a passe de 16 a 8 personnes et celui des UPA de type a passe de 40 a 7. La diminution du nombre de personnes au niveau des UPA de type B et C pourrait s'expliquer par l'éclatement au niveau de ces types. Toutefois, ce phénomène nécessite une étude plus approfondie.

Tableau 1 : Evolution de la taille des UPA au niveau de Kaniko

Periodes	Types UPA	Population totale	Hommes	Femmes	Total Actif	Actif homme	Actif femme
1	A	16	3	13	7	3	4
1	B	16	6	10	8	5	3
1	C	40	15	25	35	15	20
2	A	29	20	9	12	7	5
2	B	8	5	3	4	2	2
2	C	7	2	5	4	1	3

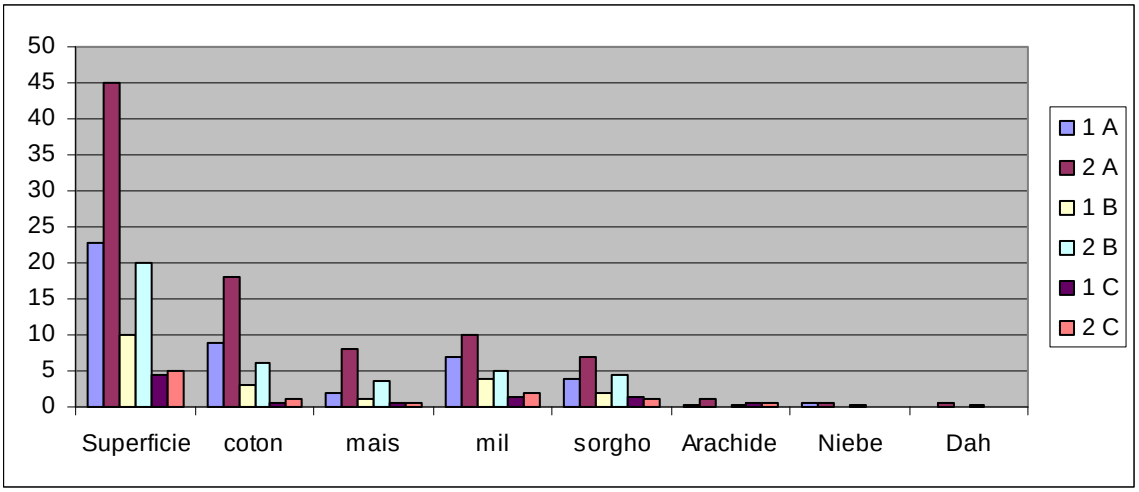
La même tendance existe au niveau du village de Try ou on note un accroissement du nombre des personnes dans les UPA de type passant de 50 a 85 personnes. Les nombres de personnes par UPA de types B et C ont diminue passant de 30 a 20 et 12 a 5 respectivement (tableau 2)..

Tableau 2 : Evolution de la taille des UPA au niveau de Try

Periodes	Type UPA	Population totale	Hommes	Femmes	Total Actif	Actif homme	Actif femme
1	A	50	34	16	16	6	10
1	B	30	23	7	9	6	3
1	C	12	9	4	6	4	2
2	A	85	70	15	32	20	12
2	B	20	12	8	10	5	5
2	C	5	2	3	2	1	1

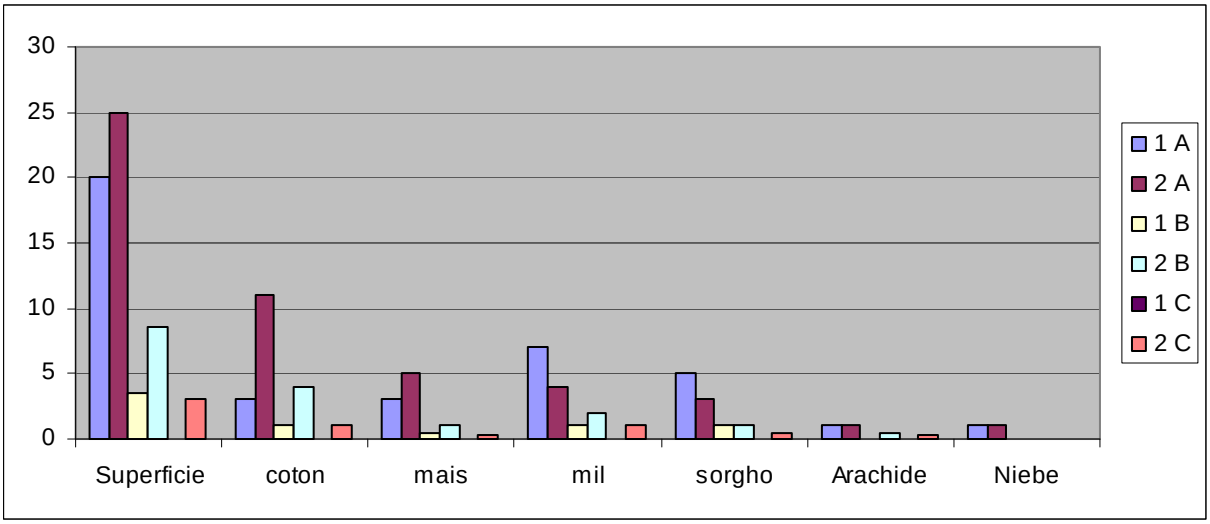
Les types de terres disponibles au niveau de Kaniko incluent les terres sableuses (60%), l'argile rouge (27%), les gravillons (25%) et les terres noires (8%). Les superficies cultivees varient selon les types d'UPA. Avant les annees 1992, elles variaient de 23 ha pour les types A, 10 ha pour les types et moins de 5 ha pour les types C et D respectivement.. Apres les annees 1992, la superficie moyenne cultivee varie de 45 ha pour les types A, 20 ha pour les types B et 5 ha pour les types C et D respectivement (Figure 2).

Figure 2 : Evolution des superficies cultivées par type d'UPA au niveau de Kaniko avant (periode 1) et après (periode 2) 1992



Les principaux de sol au niveau du terroir de Try sont les sols sableux (40%), les sols gravillonnaires (30%), les sols argileux appelés « terres noires » (20%) et les sols latéritiques (10%). Les cultures peu diversifies dans les années 1992 montrent une tendance a l'augmentation de la diversité. Au début des années 1992, les principales étaient le coton, le mais, mil et le sorgho. A ces cultures, s'ajoutent actuellement l'arachide, le voandzou, le niébé et le sésame.

Figure 3 : Evolution de la superficie cultivée par type UPA avant (période 1) et après 1992 (période 2)



1.2 Rotations culturales

Les UPA exploitent plusieurs parcelles pour réduire les risques de mauvaise récolte et les rotations culturales pratiquées dépendent des parcelles. A Kanika, il existe 3 types de rotation.
Le coton, le sorgho et le mil occupent les têtes de rotation (année 1). La parcelle de coton de l'année 1 (P1) est divisée en sous parcelles (P1.1) et (P1.2) en année 2. Les sous parcelles reçoivent le mais (P1.1) avec apport d'engrais minéral et le sorgho (P1.2) sans apport d'engrais minéral. En année 3, les 2 sous parcelles sont regroupées et reçoivent le coton avec apport de fumier et d'engrais minéral. La parcelle ayant reçu le sorgho (P2) en année 1, reçoit le coton en année 2 avec apport de fumier et d'engrais minéral. En année 3, cette parcelle est divisée en 2 sous parcelles (P2.1) et (P2.2) qui reçoivent respectivement le mais avec fumure minérale (P2.1) et le mil (P2.2) sans fumure minérale.
La parcelle 3 (P3) qui reçu le mil en année 1, reçoit le sorgho en année 2 et le coton en année 3.

Au niveau de Try, la rotation suivie est le coton en année 1 avec apport de fumures organiques et minérales, le mais avec apport de fumure minérale en année et le mil ou sorgho sans fumure et souvent le coton en année 3 avec apport de fumure.

1.3 Gestion des récoltes

La gestion des résidus de cultures de culture au niveau de Kanika est dominée par le recyclage (pâture in situ, compostage, alimentation des animaux, etc.).

Tableau 3 : Gestion des récoltes au niveau de Kanika

Cultures	Grains/fibre/gousses	chaumes	fanes
Mais	stocke	Ramassage et stock Pature in situ	
Coton	vente	Ramassage et compostage Pature in situ[3]	
Mil	stocke	Pature in situ Ramassage et compostage	
Sorgho	stocke	Pature in situ Stockage Ramassage et compostage	
Niébé	Stocke		Stocke et alimentation des animaux

[3] La fabrication de potasse a partir des résidus de culture est interdite à Kanika. Les gui de karité sont utilisées a cette fin.

Arachide	Stocke		Stocke et alimentation des animaux
Sésame	stocke	Fauchage et stockage Pâture in situ	

Toutefois au niveau de Try, on observe une mise a feu des résidus de coton (tableaux 3 et 4).

Tableau 4 : Gestion des récoltes au niveau de Try

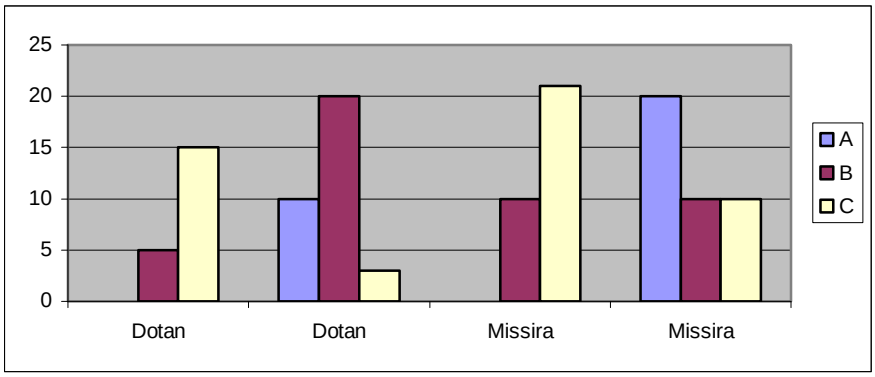
Cultures	Grains/fibre/gousses	chaumes	fanes
Mais	stocke	Ramassage et stock Pâture in situ	
Coton	vente	Ramassage et compostage Pâture in situ Mise a feu	
Mil	stocke	Pâture in situ Ramassage et compostage	
Sorgho	stocke	Pâture in situ Ramassage et compostage	
Niébé	Stocke		Stocke et alimentation des animaux
Arachide	Stocke		Stocke et alimentation des animaux

2. Zone agro écologique des Monts Mandingues (Dotan et Missira)

2.1 Caractéristiques des UPA

Les villages de Dotan et Missira sont localisés dans la zone de l'ancien bassin arachidier bassin cotonnier du Mali. Les densités de population sont faibles et ont varié de 4.33 à 6.20 et de 1.28 à 2.27 pour les vingt dernières années respectivement au niveau des villages de Dotan et Missira. Au cours de la même période, les nombres d'unités de production agricoles (UPA) ont passé de 20 à 33 pour Dotan et de 31 à 50 pour Missira dénotant aussi une tendance à l'éclatement des UPA. On note également une tendance d'évolution des UPA vers les types A et B possédant plus d'animaux de trait et de troupeaux d'élevage et une réduction des types C et D qui n'ont pas d'équipement dans la zone (figure 4).

Figure 4 : Importance des types d'UPA dans les villages de Dotan et Missira avant et apres 1992



Les mêmes tendances d'évolution de la taille des UPA s'observent au niveau des monts mandingues dans les villages de Dotan et Missira (Tableaux 5 et 6).

Tableau 5 : Evolution de la taille des UPA au niveau de Dotan avant et après 1992

Periode	Type UPA	Population totale	Hommes	Femmes	Total Actif	Actif homme	Actif femme
1	A	41	20	21	20	12	8
1	B	30	10	20	18	10	8
1	C	30	10	20	16	10	6
2	A	48	20	28	21	16	5
2	B	21	11	10	8	6	2
2	C	22	14	8	11	7	4

Tableau 6 : Evolution de la taille des UPA au niveau de Missira avant et apres 1992

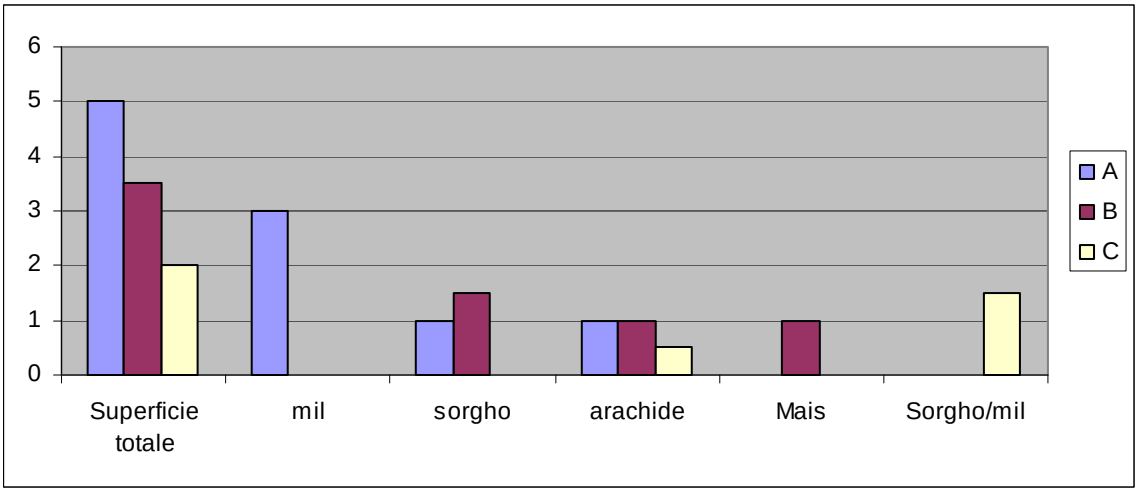
Periode	Types UPA	Population totale	Hommes	Femmes	Total Actif	Actif homme	Actif femme
1	A	32	15	17	10	7	3
1	B	6	3	3	3	2	1
1	C						
3	A	30	13	17	7	5	2
3	B	12	6	6	6	4	2
3	C	5	4	1	4	3	1

Les types de terres de Dotan incluent les gravillons (60%), le sable (24%), la latérite (13%) et l'argile (13%). Les terres sont diversifiées a Missira ou l'on principalement les terres sableuses (67%) et les terres argileuses (23%).

Les principales cultures sont le mil et le sorgho qui concernent 60% des surfaces cultivées, le mais, l'arachide et le riz 30%, et enfin le fonio et le niébé 10%. Ces proportions ne semblent pas avoir varie depuis les années 1992. Les principales cultures a Missira incluent le mil et le sorgho (60%), le mais (10%), l'arachide (20%) et diverses culture telles que le voandzou, le niébé et le gombo (10%).

Les superficies moyennes cultivées varient de 5 ha pour les UPA de type A, 3.5 ha pour les types B et 2 ha pour les types C (Figure 5).

Figure 5 : Superficies cultivées par type UPA a Missira



2.2 Rotations culturales

La monoculture des céréales telles que le mais, le mil hâtif et le sorgho sont pratiquées a Dotan au niveau des champs de case et/ou proches du village. Toutefois, on observe les rotations arachide-sorgho et mil-sorgho-sorgho/arachide.

Tableau 7: Rotations culturales a Dotan

Numero parcelle	Année 1	Année 2	Année 3	Année 4
1	mil	sorgho	Sorgho/arachide	Sorgho avec apport de compost
2	arachide	sorgho		
3	mais	mais	mais	
4	Mil hatif	Mil hatif	Mil hatif	
5	sorgho			

Au niveau Missira, deux types de rotations sont pratiquées. La rotation 1 est pratiquée par 70% des UPA et la rotation 2 par 30% des UPA respectivement.

Tableau 7: Rotations culturales a Missira

Numero parcelle	Année 1	Année 2	Année 3
1	Mil ou sorgho	arachide	Mil ou sorgho
2	Arachide	Mil ou sorgho	Arachide

2.3 Gestion des récoltes

Au niveau de Dotan, les graines de céréales sont récoltées, stockées et utilisées pour l'alimentation familiale. La gestion des pailles de céréales est variable (tableau 8).

Tableau 8 : Gestion des récoltes a Dotan

Cultures	Grains/fibre/gousses	chaumes	fanes
Mil	stocke	Pâture in situ, mise a feu	
Sorgho	stocke	Stockage pour confection hangar Pâture in situ	
Mais	stockage	Pâture in situ	

		Laisse au champ	
Riz	Stocke	Stockage pour les animaux Confection de matelas	Stockage pour alimentation des animaux
Arachide	Stocke		Stockage pour alimentation des animaux

La paille de mil est brûlée après la pâture in situ, les pailles de mais sont laissées au champ. La paille de riz est utilisée pour la confection de matelas et pour l'alimentation des animaux

Au niveau de Missira, la gestion des résidus de culture concerne la pâture in situ, la mise a feu pour les céréales (tableau 9).

Tableau 9 : Gestion des récoltes a Missira

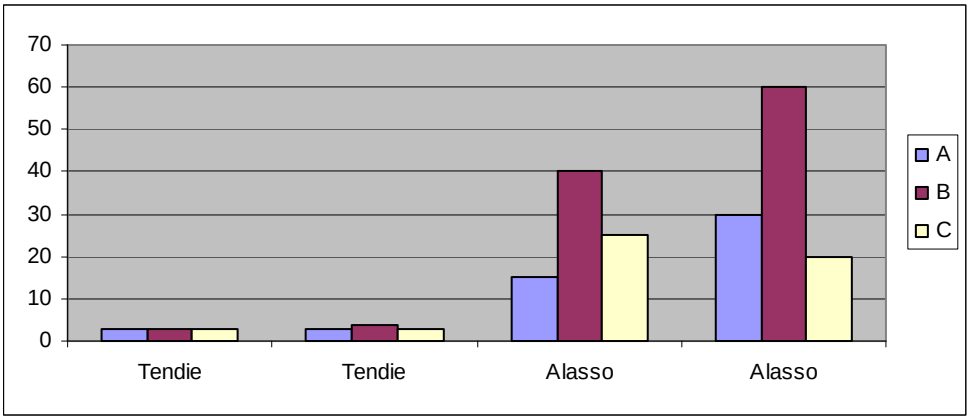
Cultures	Grains/fibre/gousses	chaumes	fanes
Mil	stocke	Ramassage et stock Pâture in situ, mise a feu	
Sorgho	stocke	Ramassage et stockage, Pâture in situ Mise a feu	
Mais	stockage	Pâture in situ Utilise les épis sans grain pour faire la potasse	
Voandzou	Stocke		Stockage pour alimentation des animaux
Arachide	Stocke		Stockage pour alimentation des animaux

3. Zone agro-écologique du Hodh (Tendie et Alasso)

3.1 Caractéristiques des UPA

La zone agro-écologique du Hodh aux deux zones précédentes se caractérise par la prédominance du pastoralisme. Compte du tenu du climat aride, l'agriculture est marginale. Les densités de population faibles ont varié de 1.68 à 2.80 et de 1.97 à 3.37 durant les vingt dernières années respectivement au niveau des villages de Tendie et Alasso. Au cours de la même période, le nombre d'unités de production agricoles (UPA) est constant à Tendie. Par contre il est passe de 80 a 110 au niveau de Alasso. La tendance existe vers un accroissement des UPA de types A et B possédant plus d'animaux de trait et de troupeaux d'élevage et une réduction des types C et D qui n'ont pas d'équipement dans la zone (figure 6).

Figure 6 : Importance des types d'UPA dans les villages de Tendie et Alasso avant et après 1992



Le nombre de personnes par UPA a passé de 17 a 25 personnes et de 12 a 18 personnes respectivement pour les UPA de types A et B au cours des périodes 1, avant le 26 mars) et 2 après le 26 mars (tableau 10) au niveau de Tendie.

Tableau 10: Taille des UPA a Tendie avant et après 1992

Périodes	Type UPA	Population totale	Hommes	Femmes	Total actif	Actif homme	Actif femme
1	A	17	5	12	13	5	8
1	B	12	3	9	7	3	4
2	A	25	10	15	18	3	15
2	B	18	8	10	13	6	7
2	C	8	4	4	4	2	2

La même tendance existe pour les UPA de type A au niveau de Alasso (Tableau 11)

Tableau 11: Taille des UPA a Alasso avant et apres 1992

Périodes	Type UPA	Population totale	Hommes	Femmes	Total Actifs	Actif homme	Actif femme
2	A	20	7	13	10	6	4
2	B	6	4	2	3	2	1
2	C	5	2	3	2	2	0
3	A	25	5	30	7	5	12
3	B	6	4	10	2	2	4
3	C	7	3	4	3	3	0

Les types de sols qui existent à Tendie sont respectivement les sols sableux 60%, les sols argileux (25%) et les sols latéritiques (15%). Les sols de Alasso concernent exclusivement les sols sableux.

3.2 Rotations culturales

Les monocultures de sorgho, d'arachide/dah et de mil/niébé sont les plus courantes a Tendie (Tableau 12). La durée des parcelles est de 3 ans et la mise en jachère est aussi de 3 ans.

Tableau 12 : Pratiques culturales a Tendie

Rotations	Année 1	Année 2	Année 3
1	Sorgho	sorgho	Sorgho
2	Arachide/dah	Arachide /Dah	Arachide/dah

4	Mil niébé	Mil niébé	Mil niébé

Au niveau de Alasso, la durée de culture est de 1 an suivi de 3 années de jachère Tableau 13).

Tableau 13 : Pratiques culturales a Alasso

Rotations	Année 1	Année 2	Année 3	Année
1	Sorgho	Jachère	Jachère	Jachère
2	Arachide	Jachère	Jachère	Jachère

3.3 Gestion des récoltes

Au niveau de Tendie et Alasso, les grains de sorgho et de mil sont récoltes et utilises pour l'alimentation de la famille. Une partie des pailles est récoltée pour la confection de hangars. La plupart de la paille est pâturée in situ par les animaux de l'UPA, du village et/ou les animaux transhumants et des terroirs voisins. Les fanes d'arachide sont récoltées et stockées pour l'alimentation des animaux (tableaux 14 et 15).

Tableau 14: Gestion des récoltes a Tendie

Cultures	Grains/fibre/gousses	chaumes	fanes
Sorgho (Gadiaba)	stocke	Pâture in situ Ramassage et stockage sur hangar	
Sorgho (Kenike)	stockage	Pâture in situ Ramassage et stockage pour confection hangar	
Mil (sanio)	stockage	Pâture in situ Ramassage et stockage pour confection hangar	
Arachide	Stocke		Stockage pour alimentation des animaux

Tableau 15 : Gestion des récoltes a Alasso

Cultures	Grains/fibre/gousses	chaumes	fanes
Sorgho (Gadiaba)	stocke	Pâture in situ Ramassage et stockage	
Sorgho (Kenike)	stockage	Pâture in situ Ramassage et stockage pour confection hangar	
Arachide	Stocke		Stockage pour alimentation des animaux

III. Cartographie des terroirs

EVOLUTION DE L'OCCUPATION DES TERROIRS

Pour L'analyse de l'évolution de l'occupation du sol dans les terroirs d'étude on s'est référé aux données de 1991 et 2000.

Zone de Nara.

Les villages concernés sont Alosso et Tiendé.

Terroir d'Alasso.

Pour le terroir d'Alasso on retrouve quatre type d'occupation du sol à partir des données de 1991. C'étaient :
Les cultures continues qui occupaient 3% du terroir,
Les cultures ou jachères très importants couvraient au total 74%,
Les savanes arborées réprésentaient 10%,
Les savanes arbustives constituaient 13%.
Le traitement des données recentes (année 2000) du satellite TM permet de dégager cinq classes d'occupation du terroir. Ce sont :
Les cultures continues sont à 4% de terroir, les zones de cultures ou jachères avec steppe arborée dans les bas plateaux occupent 47% de la surface du terroir, les zones de cultures ou jachères avec steppe arbustives dans les vallées à 28%, la savane arborée et steppe sur des basses croupes sont à 18% et la savane arbustive sur des formations dunaires à 3%.

1991 2000

N°	Occupation du sol	%	N°	Occupation du sol	%
1	Les cultures continues	3	1	La savane arbustive	3
2	Les cultures ou jachères recentes	74	2	Les zones de cultures ou jachères avec steppe arborée	47
3	Les savanes arborées	10	3	Les zones de cultures ou jachères avec steppe arbustive	28
4	Les savanes arbustives	13	4	La savane arborée et steppe	18
			5	Les cultures continues	4

Terroir de Tiendé.

Cinq Unités d'occupation ont été trouvées sur le terroir de Tiendé selon les données de 1991. Ce sont : Les cultures ou jachères récentes qui représentaient 8% du total des surfaces du terroir, les savanes arborées 14%, les savanes arbustives 27%, les steppes arborée ou arbustives 7% et les steppes arbustives 44%. Les Unités les plus importantes étaient Les steppes arbustives, les savanes arbustives et les savanes arborées.
En 2000 on retouve le même nombre d'unité d'occupation du sol mais avec avec des différences dans la reconstitution. L'Unité d'occupation du sol la plus importante est les cultures continues. Elles constituent 31% du total des superficie du terroir ensuite se situent en seconde position les savanes avec29% suvient des steppes arbustives et jachères avec 18% et enfin les steppes arborées avec 13% du total des superficies du terroir.

1991 2000

N°	Occupation du sol	%	N°	Occupation du sol	%
1	Les cultures ou jachères récentes	8	1	Les savanes arbustives arborées	29
2	Les savanes arborées	14	2	Les steppes arborées	13
3	Les savanes arbustives	27	3	Les steppes arbustives et jachères	18
4	Les steppes arborée ou arbustives	7	4	Les savanes arborées et steppes	9
5	Les steppes arbustives	44	5	Les cultures continues	31

Terroir de Missira

En 1991 on dénombrait au total sept unités d'occupation du sol sur le Missira. L'unité la plus importante était les savanes vergers avec des dégradations antérieures. Elle réprésentait 49% du total des surfaces du terroir ensuite par ordre décroissant les savanes arborées avec 27% du total des superficies du terroir, les savanes

boisées 8%, les cultures ou jachères récentes et les savanes ou steppes arborées à 6%, les savanes vergers à boisées 2% et les steppes arbustives à 1%.
En 2000 on retrouve cinq classes d'unité d'occupation du sol. Les savanes boisées la plus importante unité couvre 40% du total des surfaces du terroir suvient des steppes vergers à boisées avec ses 24%, les savanes arborées avec 23%, les cultures continues avec 11% et enfin les ultures et jachères avec 2%.

1991			2000		
N°	Occupation du sol	%	N°	Occupation du sol	%
1	Les cultures ou jachères récentes	6	1	Les cultures continues.	11
2	Les savanes arborées	27	2	Les cultures et jachères	2
3	Les savanes boisées	8	3	Les savanes boisées	40
4	Les savanes ou steppes arborées	6	4	Les steppes vergers à boisées	24
5	Les savanes vergers à boisées	2	5	Les savanes arborées	23
6	Les savanes vergers, dégradation antérieure	49			
7	Les steppes arbustives	1			

Terroir de N'Dotan

On retrouve autant d'unités d'occupation du sol en 1991 qu'en 2000 à N'Dotan ; au total cinq. Selon les périodes d'acquisition des données et compte tenue de l'evolution de l'occupation du sol il a été difficil de rétrouver exactement les mêmes unités aux deux dates. Pour l'année 1991 les unités identifiées étaient par ordre d'importance les savanes arborées et bowé nus avec 47% du total des surfaces du terroir, les cultures ou jachères récentes avec 22%, les savanes à steppes arborées, arbustives avec 21%, les savanes arborées ou arbustives avec 9% et enfin les savanes vergers, dégradation antérieure avec 1%.
Pour l'année 2000 les unités discriminées sont les savanes arborées et bowé nus avec 37% du total des superficies du terroir ensuite viennent les cultures et jachères avec 29%, les cultures continues 20%, les savanes arborées ou arbustives 10% et enfin les savanes vergers 4%.

1991			2000		
N°	Occupation du sol	%	N°	Occupation du sol	%
1	Les cultures ou jachères récentes	22	1	Les savanes vergers	4
2	Les savanes à steppes arborées, arbustives	21	2	Les savanes arborées et bowé nus	37
3	Les savanes arborées et bowé nus	47	3	Les cultures et jachères	29
4	Les savanes arborées ou arbustives	9	4	Les cultures continues.	20
5	Les savanes vergers, dégradation antérieure	1	5	Les savanes arborées ou arbustives	10

Terroir de Kaniko

Kaniko présente plus de contrast que les autres terroirs retenus dans le cadre de l'étude. En 1991 selon les données disponibles il a été recensé cinq classes qui sont selon par ordre d'importance : les cultures ou jachères récentes représentaient 59% du total des surfaces, suivi des savanes arbustives qui avaient 22%, puis des savanes arborées 10%, des galeries de type soudanien et des savanes vergers, dégradées qui faisaient chacune 4%.
En 2000 le terroir est complètement exploité. Il a été identifié seulement trois classes qui sont : les cultures continues elles representent 89% du total des surfaces du terroir, les savanes arbustives font 7% et les galeries de type soudanien 4%.

1991		2000	
Occupation du sol	%	Occupation du sol	%
Les cultures ou jachères récentes	59	Les cultures continues.	89
Les galeries de type soudanien	4	Les savanes arbustives	7
Les savanes arborées	10	Les galeries de type soudanien	4
Les savanes arbustives	22		
Les savanes vergers, dégradées	4		

Terroir de Trie

Pour le terroir de Trie on ne dispose des information que pour une seule date (1991). Pour cette période il a été identifié quatre types d'occupation du sol qui étaient : les cultures ou jachères récentes avec 45% du total des surfaces du terroir, les savanes arbustives avec 40%, les savanes arborées avec 15% et les savanes et bowé à 1%.

IV. Les sols

Kanico

Ko-1: longitude 5° 22' 433 N, latitude 12° 19' 185 W

Géomorphologie : Bas-glacis
Type de sol : Plinthic haplustalfs
Sols ferrugineux lessivés à pseudoley ou tâches et concrétions
Drainage : Imparfait
Utilisation actuelle : Agricole

Données d'analyses physico-chimiques :

N° Horizon	Ko- 1-1 (0-20 cm)	Ko-1-2 (20 – 50 cm)	Ko-1-3 (70-100)
% C	0.27	0.28	0.34
Sable % > 0.05 mm	72	56	43
Limon fin % 0.05-0.002mm	24	30	33
Argile % < 0.002 mm	4	14	23
Classe texturale	LS	LS	L

LS : Limon sableux /Sandy loam
L : Limon /Loam

Ko-2: longitude 5° 22 ' 932 N, latitude 12° 279 W

Géomorphologie : Glacis colluvial
Type de sol : Oxic haplustults
Sols ferrugineux lessivés sur grès
Drainage : Bon
Utilisation actuelle : Agro-sylvicole

Données d'analyses physico-chimiques :

N° Horizon	Ko- 2-1 0-20 cm	Ko-2-2 20 – 50 cm	Ko-2-3 50-100cm
% C	0.15	0.34	0.25
Sable % > 0.05 mm	63	51	36
Limon fin % 0.05-0.002mm	25	27	33
Argile % < 0.002 mm	12	22	31
Classe texturale	LS	LAS	LA

LAS : Limon argilo-sableux /Silty clay loam
LA : Limon argileux /Clay loam

Ko-3 : longitude 5° 21' 363 N, latitude 12° 19'208 W ; 1 km de Kanico vers Namposséla.

Géomorphologie : Plaine d'inondation
Type de sol : Typic haplaquepts
Sols peu évolués d'apport alluvial gleyifiés
Drainage : mauvais drainage
Utilisation actuelle : Agricole

Données d'analyses physico-chimiques :

N° Horizon	Ko- 3-1 0-20 cm	Ko-3-2 20 – 50 cm	Ko-3-3 50-100cm
% C	0.11	0.15	0.14
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	62 36 2 LS	63 28 9 LS	52 28 20 LAS

Try II

Ti-1 : longitude 5° 23' 648 N, latitude 12° 16'832 W

Géomorphologie : Bas glacis
Type de sol : Lithic haplustalfs
Sols peu évolués d'apport colluvial
Drainage : Bon
Utilisation actuelle : Sylvo-pastorale

Données d'analyses physico-chimiques :

N° Horizon	Ti- 1-1 0-20 cm	Ti-1-2 20 – 43 cm
% C	0.08	0.22
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	74 20 6 LS	62 25 12 LS

Ti-2 : longitude 5° 24' 232 N, latitude 12° 17'615 W

Géomorphologie : Plateau cuirasse
Type de sol : Typic cuirustalfs
Sols peu évolués d'érosion sur cuirasse, régosoliques
Drainage : Bon
Utilisation actuelle : Sylvo-pastorale

Données d'analyses physico-chimiques :

N° Horizon	Ti- 2-1 0-20 cm	Ti-1-2 20 – 38 cm
% C	0.76	0.54
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale*	43 45 12 L	44 36 20 L

Texture limon gravillonnaire

Ti-3 : longitude 5° 24' 676 N, latitude 12° 18'408 W

Géomorphologie : Plaine d'épandage
Type de sol : Plinthic haplustalfs
Sols ferrugineux lessivés à pseudoley ou tâches et concrétions
Drainage : Imparfait
Utilisation actuelle : Agricole

Données d'analyses physico-chimiques :

N° Horizon	Ti- 3-1 0-20 cm	Ti-3-2 20 – 50 cm	Ti-3-3 50-95cm
% C	0.38	0.20	0.11
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	48 48 4 L	44 40 15 L	32 38 30 LA

Tindiè

Te-1 : longitude : 007° 09' 204 W, latitude : 15° 03' 633 N

Géomorphologie : Dune aplanie à pente modérée (2 à 3 % de pente)
Type de sol : Ustalfic haplargids
Sols brun-rouges sub-arides
Drainage : Excessif
Utilisation actuelle : Agro-pastorale à pastoralisme dominant

Données d'analyses physico-chimiques :

N° Horizon	Té- 1-1 0-20 cm	Té-1-2 20 – 50 cm	Té-1-3 50 - 100
% C	0.28	0.15	0.07
Texture Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	 89 8 3 SL	 85 8 7 SL	 77 10 12 LS

SL : Sable limoneux / Loamy sand

Te-2 : longitude: 007° 07' 424 W, latitude: 15° 03' 355 N

Géomorphologie: Dune morte à pente modérée à forte (4 à 8 % de pente)
Type de sol : Psammentic haplargids
Sols brun-rouges sub-arides sur sable
Drainage : Excessif
Utilisation actuelle : Pastorale

Données d'analyses physico-chimiques :
Texture :

N° Horizon	Té- 2-1 0-20 cm	Té-2-2 (20 – 50 cm)	Té-2-3
% C	0.08	0.16	-
Texture Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	 92 5 3 S	 84 7 8 SL	 75 8 17 LS

S : Sableux

Alasso

Aso 1 : 14° 53’ 993 N, 008° 01’ 185 W ; 2,5 km du village vers le village de Sampaka (direction sud-est)

Géomorphologie : Dépression interdunaire à pente faible (1 à 3%)
Type de sol : Ustalfic haplargids
Sols brun-rouges sub-arides
Drainage : Excessif
Utilisation actuelle : Agro-pastorale

Données d’analyses physico-chimiques :

N° Horizon	Aso-1-1 (0-20 cm)	Aso-1-2 (20 – 50 cm)	Aso-1-3 (70-100)
% C	0.20	0.11	0.28
Sable % > 0.05 mm	27	86	63
Limon fin % 0.05-0.002mm	72	9	18
Argile % < 0.002 mm	1	5	19
Classe texturale	LfA	SL	LS

LfA : Limon fin argileux / Silt loam

Aso 2 : 14° 52’ 479 N, 008° 00’ 646 W ; 5,5 km vers Sampaka

Géomorphologie : Plaine sableuse à pente quasi nulle
Type de sol : Ustalfic haplargids
Sols brun-rouges sub-arides
Drainage : Bon
Utilisation actuelle : Pastorale

Données d’analyses physico-chimiques :

N° Horizon	Aso-2-1 (0-20 cm)	Aso-2-2 (20 – 50 cm)	Aso-2-3 (50-100)
% C	0.01	0.05	0.10
Sable % > 0.05 mm	91	89	87
Limon fin % 0.05-0.002mm	6	5	5
Argile % < 0.002 mm	3	6	8
Classe texturale	S	SL	SL

Aso 3 : 14° 55’ 099 N, 008° 00’ 642 W ; 1,3 km vers Sambabougou (direction Est)

Géomorphologie : Sommet de Dune Aplanie
Type de sol : Ustalfic haplargids
Sols brun-rouges sub-arides
Drainage : Excessif
Utilisation actuelle : Agro-pastorale à pastoralisme dominant

Données d’analyses physico-chimiques :

N° Horizon	Aso-3-1 (0-20 cm)	Aso-3-2 (20 – 50 cm)	Aso-3-3 (50-100)
% C	-	0.26	-
Sable % > 0.05 mm	93	90	88
Limon fin % 0.05-0.002mm	5	5	5
Argile % < 0.002 mm	2	5	7
Classe texturale	S	S	SL

Aso 4 : 14° 50’ 520 N, 008° 01’ 278 W; Alasso vers Samé (direction Nord)

Géomorphologie : Sommet de Dune morte
Type de sol : Psammentic haplargids
Sols brun-rouges sub-arides sur sable
Drainage : Excessif
Utilisation actuelle : Agro-pastorale à pastoralisme dominant

Données d’analyses physico-chimiques :

N° Horizon	Aso-4-1 0 - 20 cm	Aso-4-2 20 – 50 cm	Aso-4-3 50 -100
% C	0.39	0.03	0.23
Sable % > 0.05 mm	96	95	93
Limon fin % 0.05-0.002mm	3	3	4
Argile % < 0.002 mm	1	2	3
Classe texturale	S	S	S

N'Dotan

Dot 1 : 12° 52' 053 N, 008° 10' 330 W ; 1,2 km au Sud-Est du village vers Wayambougou

Géomorphologie : Bas-glacis hydromorphe
Type de sol : Plinthic haplustalfs
Sols ferrugineux lessivés à pseudoley ou tâches et concrétions
Drainage : Imparfait
Utilisation actuelle : Agricole ; Culture : Sorgho

Données d'analyses physico-chimiques :

N° Horizon	Dot-1-1 (0-20 cm)	Dot-1-2 (20 – 50 cm)	Dot-1-3 (50-100)
% C	0.40	0.24	0.14
Sable % > 0.05 mm	52	54	51
Limon fin % 0.05-0.002mm	39	30	31
Argile % < 0.002 mm	8	16	18
Classe texturale	LS	LS	L

Dot 2 : 13° 51' 904 N, 008° 11' 066 W ; 2,8 km au Sud-Est du village vers Wayambougou

Géomorphologie : Sommet tabulaire de plateau rocheux gréseux
Type de sol : Lithic torriorthents
Sols minéraux bruts sur argillites ou sur grès
Drainage : Excessif
Utilisation actuelle : Sylvo-pastorale

Données d'analyses physico-chimiques :

N° Horizon	Dot-2-1 0-20 cm
% C	0.40
Sable % > 0.05 mm	52
Limon fin % 0.05-0.002mm	39
Argile % < 0.002 mm	8
Classe texturale*	LS

* Limon sableux graveleux

Dot 3 : 13° 51’ 485 N, 008° 10’ 797 W ; 4 km au Sud-Est

Géomorphologie : Glacis colluvial
Type de sol : Lithic haplustalfs
Sols peu évolués d’apport colluvial sur grès
Drainage : Excessif
Utilisation actuelle : Sylvo-pastorale

Données d’analyses physico-chimiques :

N° Horizon	Dot-3-1 0-20 cm	Dot-3-2 20 – 50 cm
% C	0.24	0.25
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	61 32 7 LS	54 37 9 LS

Dot 4 : 13° 51’ 343 N, 008° 09’ 942 W ; 900 m au Sud

Géomorphologie : Bas-glacis
Type de sol : Oxic haplustults
Drainage : Bon
Utilisation actuelle : Agricole

Données d’analyses physico-chimiques :

N° Horizon	Dot-4-1 0-20 cm	Dot-4-2 20 – 50 cm	Dot-4-3
% C	0.45	0.246	0.14
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	80 16 4 LS	61 27 12 LS	46 39 15 L

Missira

Mra 1 : 13° 43’ 079 N, 008° 27’ 403 W

Géomorphologie : Bas-glacis
Type de sol : Oxic haplustults
Drainage : Bon
Utilisation actuelle : Agricole

Données d’analyses physico-chimiques :

N° Horizon	Mra-3-1 0-20 cm	Mra-3-2 20 – 50 cm	Mra-3-3 50-100
% C	0.50	0.54	0.33
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	62 31 7 LS	60 24 16 LS	57 25 18 LAS

Mra 2 : 13° 44’ 046 N, 008° 28’ 288 W

Géomorphologie : Bas-glacis hydromorphe
Type de sol : Plinthic haplustalfs
Sols ferrugineux lessivés à pseudoley ou tâches et concrétions
Drainage : Imparfait
Utilisation actuelle : Agro-pastorale

Données d’analyses physico-chimiques :

N° Horizon	Mra-2-1 0-20 cm	Mra-2-2 20 – 50 cm	Mra-2-3 50-100
% C	0.50	0.54	0.33
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	65 25 6 LS	62 22 16 LS	53 27 20 LAS

Mra 3 : 13° 42' 086 N, 008° 27' 324 W, 1,5 km vers Sirakorola (direction Sud-Ouest)

Géomorphologie : Versant glacis
Type de sol : Lithic torriorthents
Sols minéraux bruts sur argillites ou sur grès
Drainage : Excessif
Utilisation actuelle : Sylvo-pastorale

Données d'analyses physico-chimiques :

N° Horizon	Mra-3-1 0-20 cm
% C	0.55
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale*	72 23 5 SL

* Sable limono-graveleux

Mra 4 : 13° 41' 451 N, 008° 28' 154 W ; 3,5 km du village vers Sirakorola

Géomorphologie : Bas-glacis hydromorphe
Type de sol : Plinthic haplustalfs
Sols ferrugineux lessivés à pseudoley ou tâches et concrétions
Drainage : Imparfait
Utilisation actuelle : Agro-pastorale

Données d'analyses physico-chimiques :

N° Horizon	Mra-2-1 0-20 cm	Mra-2-2 20 – 50 cm	Mra-2-3 50-100
% C	0.28	0.28	0.18
Sable % > 0.05 mm Limon fin % 0.05-0.002mm Argile % < 0.002 mm Classe texturale	42 51 7 LfA	31 50 19 L	30 45 25 L

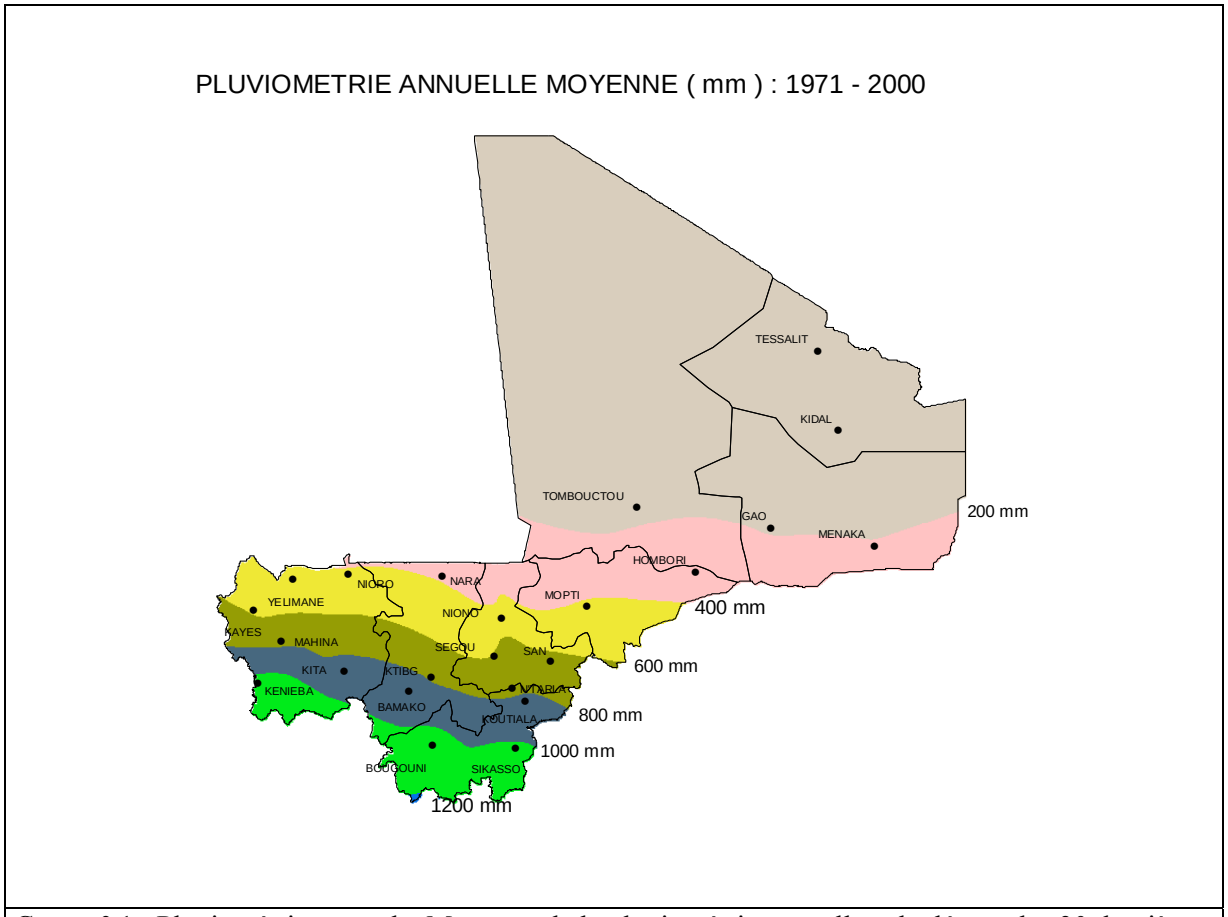
V. Données climatiques

Dans le cadre de la mise en œuvre des activités du programme relatif au SEMSOC l'évolution du climat de 1975 à 2004 a été analysée dans les localités de Koutiala, Kolokani et Nara afin de voir l'impact du climat sur ces zones. Compte tenu du manque des données de température à Kolokani, l'étude a concerné la localité de Bamako-ville la station la plus proche.

L'étude fait ressortir les caractéristiques climatiques du pays, l'analyse des paramètres climatiques pour les localités citées, fiat ressortir les dates de début et de fin de la saison des pluies ainsi que le calendrier prévisionnel de semis.

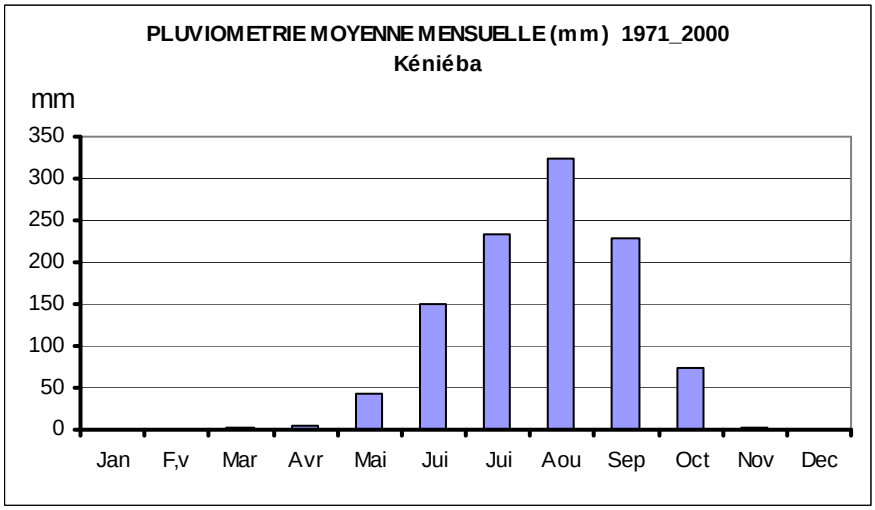
5.1 Caractéristiques Climatiques

Le climat se caractérise par une pluviométrie annuelle décroissante du Sud au Nord (de plus de 1300 mm à moins de 100 mm) pour la période 1971 - 2000 (voir carte n° 1). Le climat est saharien au Nord (pluviométrie annuelle < 200 mm), sahélien au centre (pluviométrie annuelle comprise entre 200 mm et 600 mm), soudanien (pluviométrie annuelle comprise entre 600 mm et 1200 mm) et pré-guinéen (pluviométrie > 1200 mm). Selon la classification climatique basée sur le zonage bioclimatique de C.O. Justice (International Journal of remote Sensing, Vol 7 N° 11 novembre 1986), les zones sahélienne et soudanienne se subdivisent respectivement en trois zones (nord sahélien de 150 mm à 300mm, sahélien de 300 mm à 450 mm, sud sahélien de 450mm à 600mm) et en deux zones (nord soudanien de 600 mm à 800 mm, sud soudanien > 800 mm).



Carte n° 1 : Pluviométrie normale. Moyenne de la pluviométrie annuelle calculée sur les 30 dernières années (1971 – 2000)

Le découpage de l'année en saisons se caractérise par l'alternance d'une saison sèche dont la longueur varie de neuf mois au Nord à cinq ou six mois au Sud et d'une saison humide ou hivernage, d'avril à octobre au Sud, de juillet à septembre au Nord avec des intersaisons plus ou moins marquées correspondant à des mois «ni pluvieux, ni secs». Les pluies liées aux lignes de grains sont particulièrement importantes aux latitudes sahéliennes. Le régime de mousson est le facteur dominant de la saison des pluies.



Les totaux pluviométriques mensuels et annuels traduisent une diminution des précipitations en latitude. Cette distribution sensiblement identique à celle de l'humidité relative, est l'inverse de celle de l'évapotranspiration potentielle. Dans tous les cas, la distribution des pluies dans le temps, que ce soit par mois ou par décade est unimodale ce qui veut dire qu'il n'y a qu'une seule saison des pluies et le mois d'août représente dans la plupart des saisons, le pic pluviométrique mensuel.

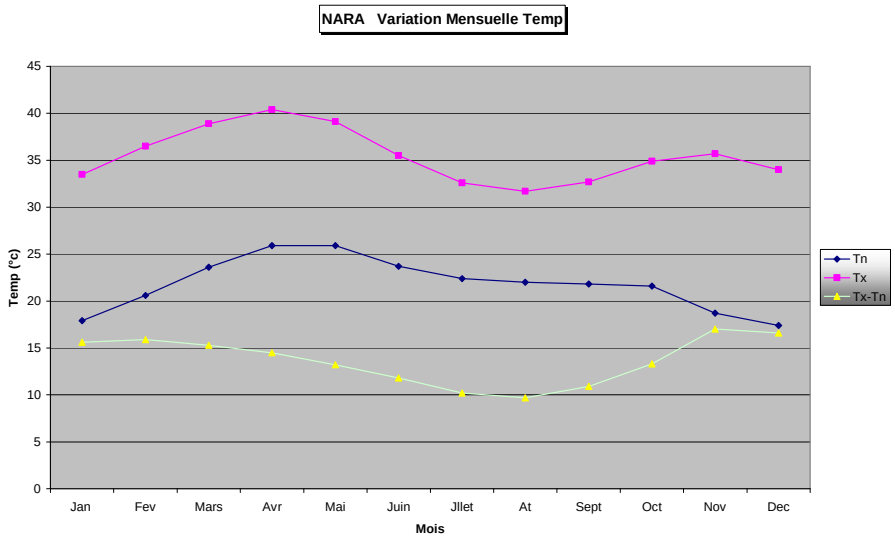
Le Mali est fondamentalement un pays agricole. Son économie est soutenue par les activités des secteurs primaires à 49.5% dont l'agriculture seule occupe plus de 75%, secondaire à 16% et tertiaire à 34.5%.

Toutes les zones situées au sud du parallèle de Mopti (14°30' nord) reçoivent en moyenne plus de 400 mm de pluie par an et disposent de bonnes terres qui se prêtent bien à l'agriculture. Dans cette partie du sud du pays, la culture de rente qu'est le coton ne s'y est pas développée au détriment des cultures vivrières qui occupent les deux-tiers des surfaces cultivées.

5.2 Températures: variations mensuelles et annuelles

1. NARA

Graphique N°1 : Variations mensuelles



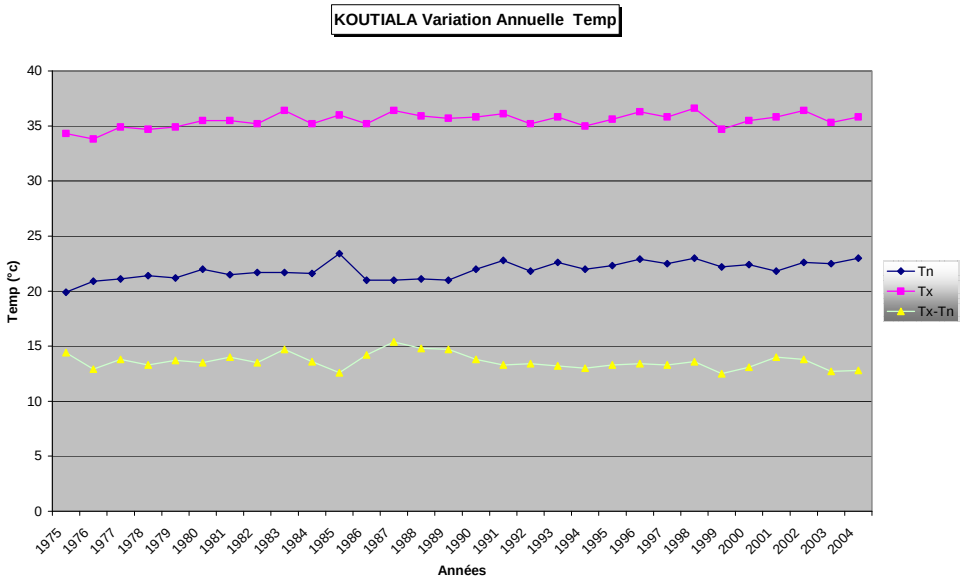
Les températures maximales moyennes mensuelles (TxMM) ont varié entre 41.6°c en mai et 31.2°c en janvier. Quant aux minimales moyennes mensuelles (TnMM) , elles ont oscillé entre 15.1°c en janvier et 27.6°c en mai.
Les moyennes mensuelles ont été de 36.2°c et 21.9°c respectivement pour les températures maximales et les minimales.

Les amplitudes thermiques moyennes mensuelles (ATMM) ont varié entre 9.8°c (août) et 17.0°c (novembre).

L'amplitude thermique moyenne (ATMM = TxMM - TnMM) la plus forte a été observée au mois de novembre et la plus faible au mois d'août et la moyenne mensuelle a été de 14.3°c.

Pendant les mois de janvier et décembre, les amplitudes thermiques ont été supérieures aux valeurs des températures minimales moyennes observées.

Graphique N°2 : Variations annuelles



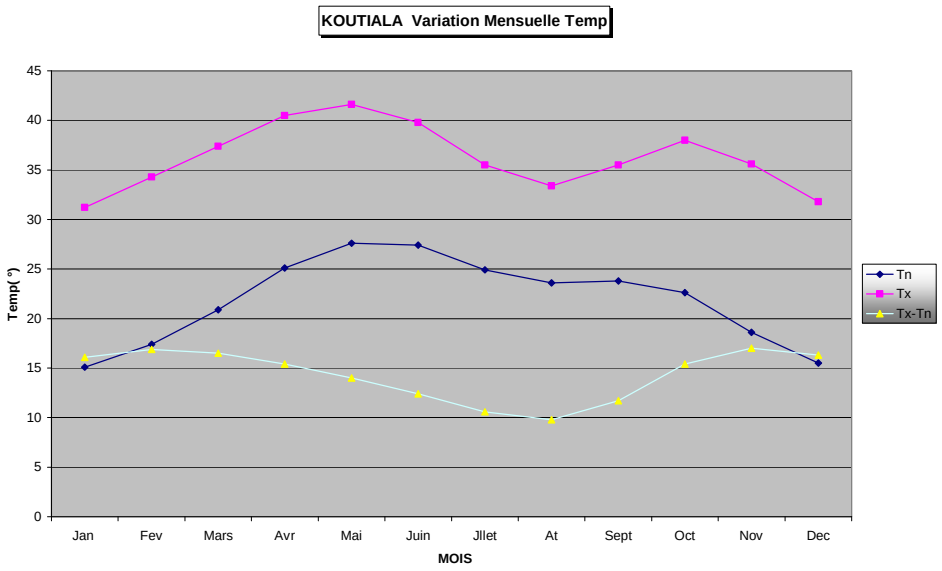
Les températures maximales moyennes annuelles ont varié entre 37.7°c (2004) et 34.2°c (1976) et les minimales moyennes annuelles entre 21.1°c (1975,1976 et 1978) et 23.5°c (2004).

La température maximale moyenne annuelle la plus forte (37.7°c) a été observée en 2004 et la minimale la plus faible (21.1°c) en 1975, 1976 et 1978.

Les amplitudes thermiques moyennes annuelles (ATMA = TxMA – TnMA) ont varié entre 13.1°c et 15.6°c. Ces amplitudes sont restées inférieures aux valeurs des températures minimales moyennes annuelles.
L'amplitude thermique moyenne annuelle a été de 14.3°c.

2. KOUTIALA

Graphique N°3 : Variations mensuelles (Fig n°3)



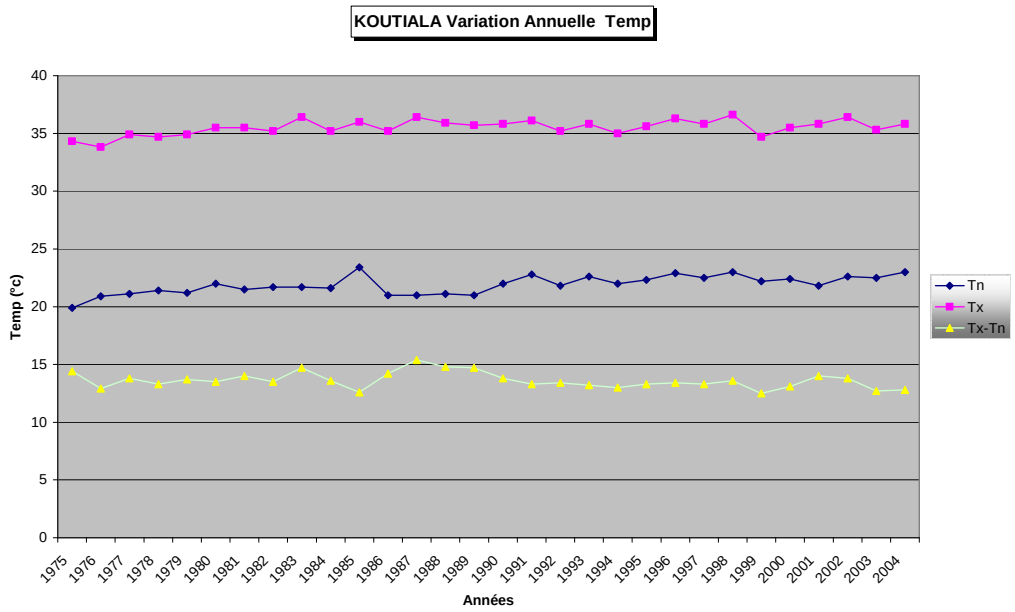
Les températures maximales moyennes mensuelles ont oscillé entre 38.6°c (avril) et 30.2°c (août), les valeurs des minimales moyennes mensuelles ont varié entre 25.9°c (avril) et 15.9°c en décembre.
Les températures maximales et minimales moyennes mensuelles ont été respectivement de : 34.1°c et 21.3°c.

Les amplitudes thermiques moyennes mensuelles (ATMM) ont varié entre 8.2°c (août) et 16.9°c (février).

L'amplitude thermique moyenne mensuelle la plus forte s'est produite au mois de février et la plus faible au mois d'août, avec une moyenne mensuelle de 12.8°c.

Au cours des mois de janvier et décembre, les amplitudes thermiques moyennes mensuelles ont atteint et même dépassé les valeurs des températures minimales moyennes mensuelles.

Graphique N°4 : Variations annuelles



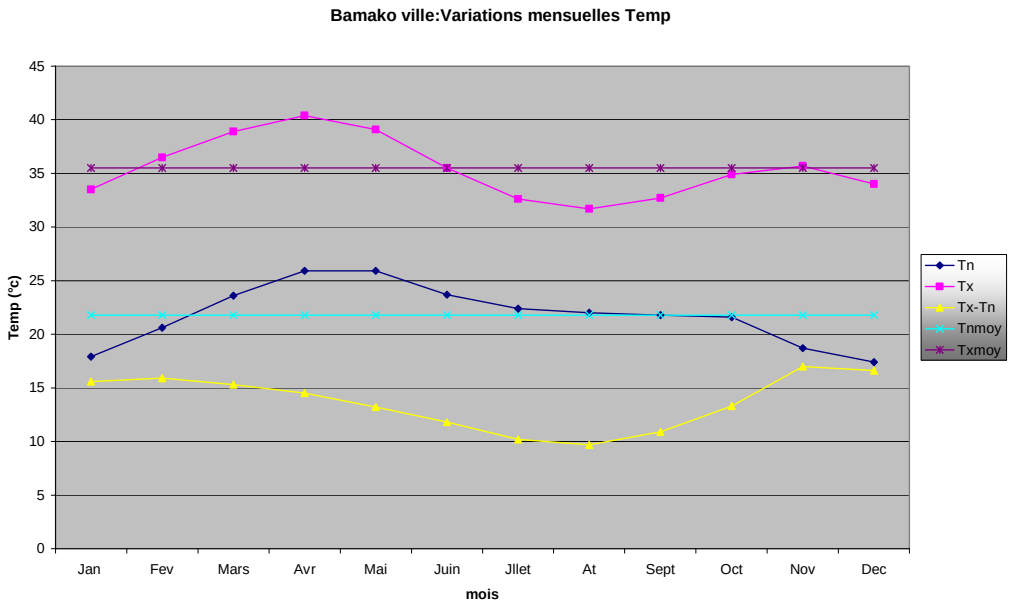
Les températures maximales moyennes annuelles ont fluctué entre 35.0°c (1987) et 33.0°c (1976) et les valeurs des minimales moyennes annuelles ont varié entre 23.0°c (2004) et 19.7°c (1975).

La température maximale moyenne annuelle la plus forte a été réalisé en 1987 et la plus faible température minimale moyenne annuelle a été observé en 1975.

Les amplitudes thermiques moyennes annuelles ont varié entre 14.0°c et 11.6°c.
Ces amplitudes sont restées inférieures aux valeurs des températures minimales moyennes annuelles observées.

3. BAMAKO-VILLE

Graphique N°5 : Variations mensuelles



Les températures maximales moyennes mensuelles ont oscillé entre 40.4°c (avril) et 31.7°c (août), les valeurs des minimales moyennes mensuelles ont varié entre 25.9°c (avril/mai) et 17.4°c en décembre.

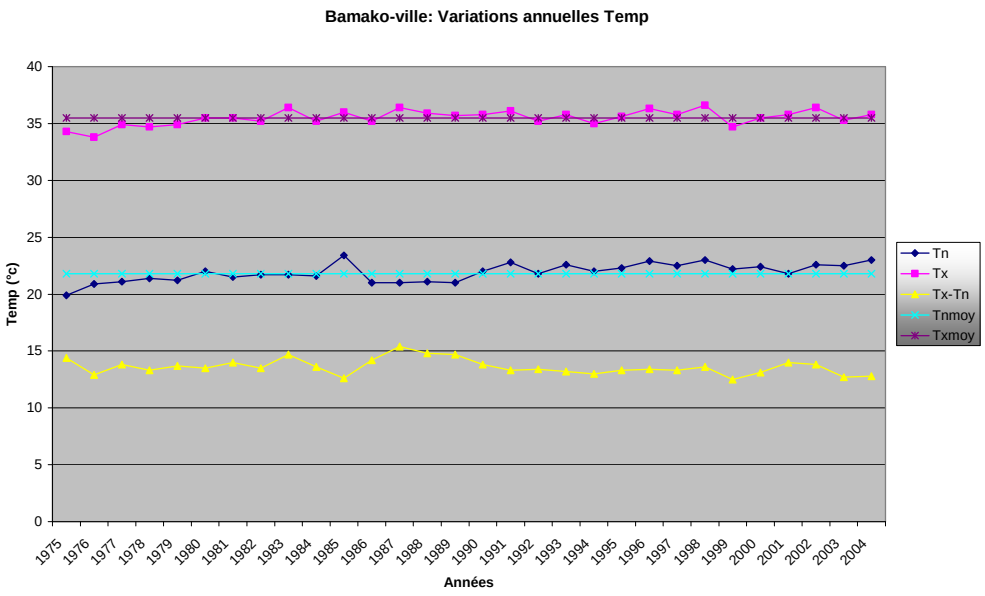
Les températures maximales et minimales moyennes mensuelles ont été respectivement de : 35.5°c et 21.8°c.

Les amplitudes thermiques moyennes mensuelles (ATMM) ont varié entre 9.7°c (août) et 17.0°c (novembre).

L'amplitude thermique moyenne mensuelle la plus forte s'est produite au mois de novembre et la plus faible au mois d'août, avec une moyenne mensuelle de 13.7°c.

Ces amplitudes sont demeurées inférieures aux valeurs des températures minimales moyennes enregistrées.

Graphique N°6 : Variations annuelles



Les températures maximales moyennes annuelles ont oscillé entre 36.6°c (1998) et 33.8°c (1976) et les valeurs des minimales moyennes annuelles quant à elles ont varié entre 23.4°c (1985) et 19.9°c (1975).

La température maximale moyenne annuelle la plus forte a été réalisée en 1998 et la plus faible température minimale moyenne annuelle a été observé en 1975.
Les amplitudes thermiques moyennes annuelles ont varié entre 14.8°c (la plus forte) et 12.5°c (la plus faible).

Ces amplitudes sont restées inférieures aux valeurs des températures minimales moyennes annuelles observées.

4. Records des températures (maxi et mini) ET AT (ampli thermique) observées au cours des 30 dernières années (1975 – 2004)

Tableau n° 1 :

STATIONS	T maxi plus fortes obs		T min plus faible obs		AT plus forte	
	mois	an	mois	an	mois	an
NARA	41.6	37.7	15.1	21.1	17.0	15.6
BKO-VILE	40.4	36.6	17.4	19.7	17.0	14.8
KOUTIALA	38.6	35.0	15.9	19.7	16.9	14.0

Les trois stations sont situées sur le transect Nord-sud : Nara au Nord, Bamako ville au Centre Sud et Koutiala au Sud.

L'analyse du tableau ci-dessus révèle :

- La température la plus chaude du mois et de l'année ont été observées à Nara (mois de mai et l'année 2004) ;
- La température la plus froide du mois a été observée à Nara (mois de janvier) et la plus froide de l'année a été enregistrée à Bko-ville et à Koutiala (année 1975) ;
- Les amplitudes thermiques mensuelles les plus fortes enregistrées sont sensiblement les mêmes pour les trois stations : Nara (novembre), Bamako ville (novembre), Koutiala (février);
- La plus forte amplitude thermique a été observée à Nara (année 2001)

5.4 Pluviométrie annuelle

L'analyse porte sur les pluviométries annuelles enregistrées au niveau de chacune des stations, situées du Nord au Sud, pour la période 1975 – 2004.
La plus grande et la petite quantité annuelle enregistrée est comparée à la quantité moyenne (normale) pour chaque station.

Normale annuelle des trois stations :

- Nara : 391.8 mm ;
- Koutiala : 835.9 mm ;
- Bamako ville : 932.0 mm.

Les figures n°7 à 9 montre que :

- la plus grande précipitation annuelle enregistrée sur les 30 ans à :
  - Nara : 631.7 mm (en 1989) soit 161 % de la normale ;
  - Koutiala : 1358.4 mm (en1994) soit163 % de la normale ;
  - Bamako ville : 1253.9 mm (1988) soit 135 % de la normale ;

- la plus faible précipitation annuelle enregistrée :
  - Nara : 198.7 mm (1984) soit 51 % de la normale ;
  - Koutiala : 516.3 mm (1984) soit 62 % de la normale ;
  - Bamako ville : 722.6 mm (1983) soit 75 %de la normale.

De l'analyse de la série des pluviométries annuelles enregistrées au niveau des trois stations, il ressort :

- Nara : l'année 1989 a été la plus pluvieuse et 1984 l'année la plus sèche ;

- Koutiala : l'année 1994 a été la plus pluvieuse et l'année 1984 la plus sèche ;

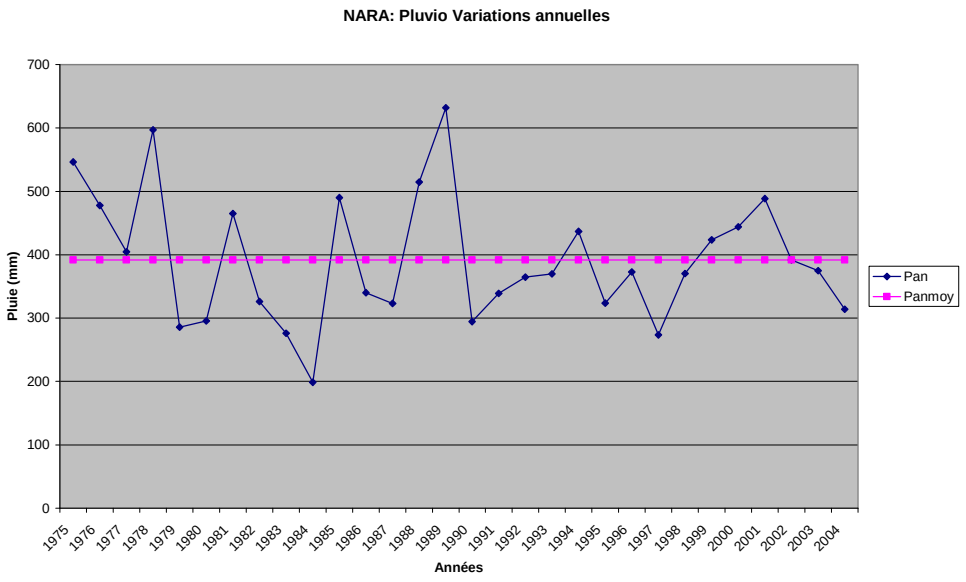
- Bamako ville : l'année 1988 a été la plus pluvieuse et 1983 la plus sèche.

On remarquera aisément que le déficit pluviométrique a été très marqué en 1984 aussi bien au Nord (Nara) qu'au Sud (Koutiala), par contre , il a été modéré au Centre (Bko ville) en 1983.

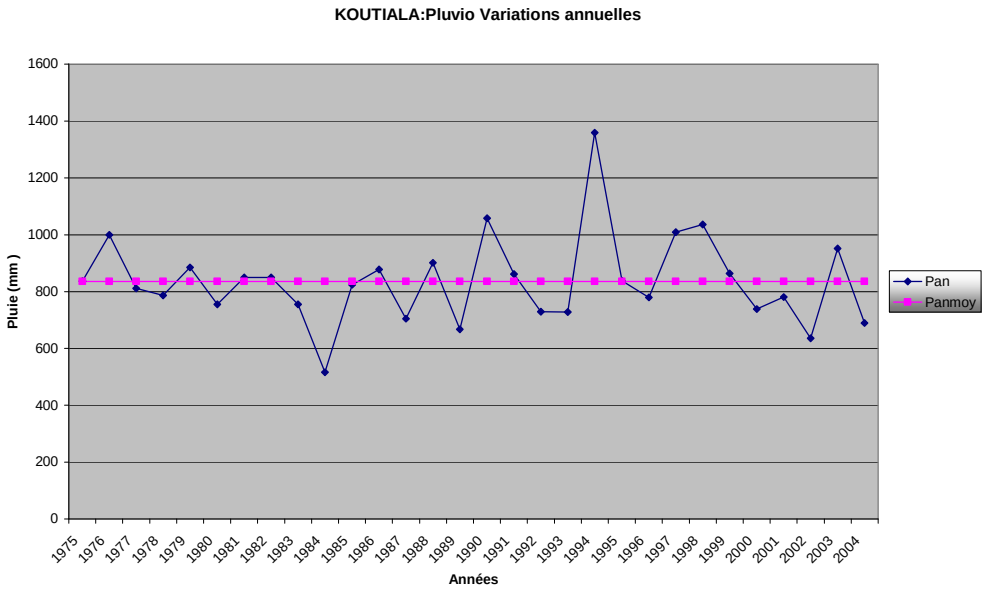
La pluviométrie annuelle va de 631.7 mm à Nara dans la bande Sahélienne au Nord à 1358.4 mm à Koutiala dans le Sud.

Ceci montre que les possibilités de cultures sont très diverses du Nord au Sud.

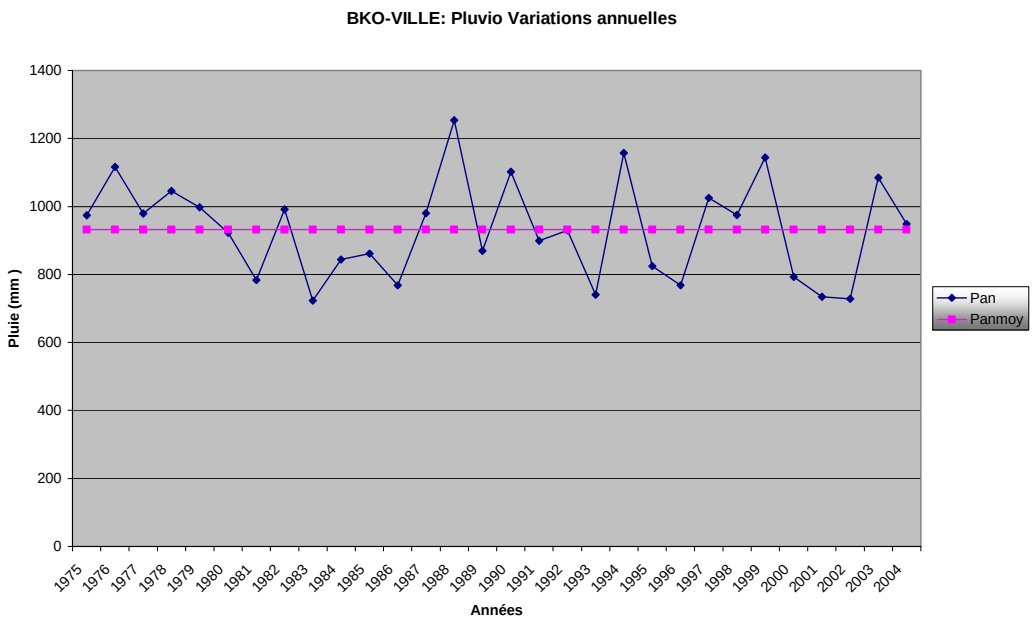
Graphique N° 7 : Variations annuelles de la pluviométrie à Nara



Graphique N°8 : Variations annuelles de la pluviométrie à Koutiala



Graphique N°9 : Variations annuelles de la pluviométrie à Bamako-ville



5.5 Date moyenne de début et de fin des pluies
(A.TEKETE ET M V K SILVAKUMAR)

Les dates approximatives de début et de fin des pluies sont représentées en tableau n°2 et la figure n°10 représente les iso lignes de dates de début des pluies.

Il ressort de ces résultats que la date moyenne de début des pluies varie avec la latitude. Elle commence tôt dans le Sud du pays et tard au fur et à mesure qu'on monte vers le Nord. C'est ainsi que dans la zone Sahélienne, cette date se situe aux environs du 10 juillet, vers début juin dans la zone Soudano sahélienne et vers début mai dans la zone Soudanienne.

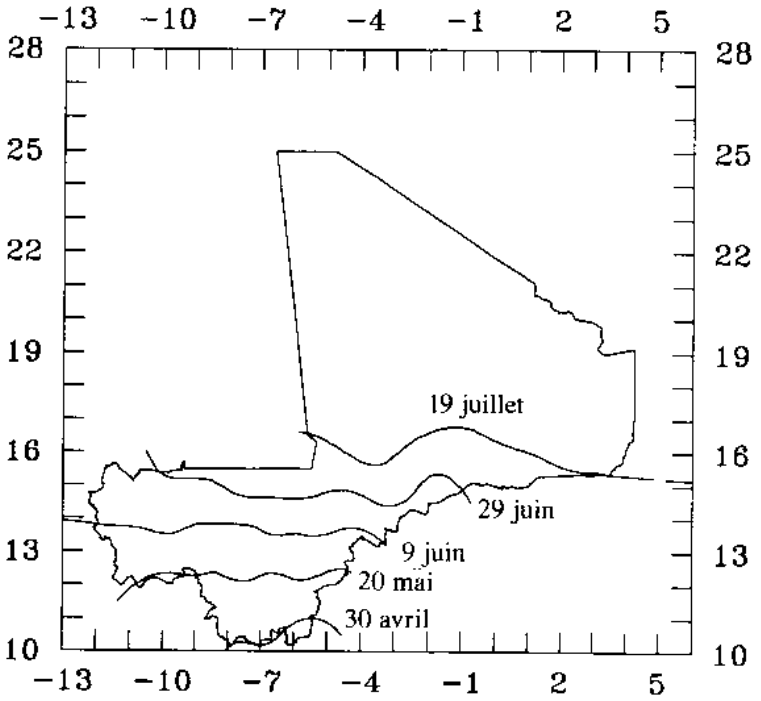


FIG n° 10

Tableau n° : 2

STATIONS	DEBUT PLUIE		FIN PLUIE		LONGUEUR SAISON		PLUIE ANNUELLE
	DATE	ECART-TYPE	DATE	ECART-TYPE	JOUR	ECART-TYPE	
NARA	09 jllet	19.49	23 sept	15.85	77	25.71	391.8
BKO VILLE	25 mai	22.32	19 oct	15.47	147	29.20	932.0
KOUTIALA	18 mai	21.70	13 oct	13.17	149	26.83	835.9

On note à partir du tableau qu'à :

- Nara, la date approximative de début de la saison des pluies se situe dans la première décade de Juillet avec une durée moyenne de la saison de 77 jours ;
- Bko ville, elle se situe dans la troisième décade de mai avec une durée moyenne de la saison de 147 jours ;
- Koutiala, c'est dans la deuxième décade de mai avec une durée moyenne de 149 jours.

5.6 Guide pratique aux semis

Le développement socio-économique notamment l'agriculture dans les régions semi-arides de l'Afrique de l'Ouest comme le Mali évolue dans un contexte d'extrême variabilité des facteurs environnementaux. Parmi ces risques, la variabilité des facteurs climatiques est considérée comme l'une des causes des fléaux qui menacent les sources de revenus dans ces régions. Pour y faire face ; les chercheurs ainsi que les producteurs comptent sur différentes stratégies pour venir à bout de ces risques en essayant de satisfaire leurs besoins de consommation à travers un aménagement adéquat de leurs ressources naturelles et humaines.

Ainsi la fourniture d'informations agrométéorologiques et agroclimatiques fiables sur des séries aussi longues que possibles par les services météorologiques peut aider efficacement à la réduction de la vulnérabilité face aux aléas climatiques surtout au moment de la mise en place des cultures (semis). Ceci, à travers l'élaboration et la mise à la disposition des producteurs ruraux d'outils comme le guide de semis (calendrier prévisionnel) par la Direction Nationale de la Météorologie.

1. Méthodologie d'élaboration du guide pratique de semis

A. Concept

Le rendement d'une culture dépend de plusieurs facteurs à savoir :

- la disponibilité de l'eau,
- le niveau de fertilisation,
- l'état structural du sol,
- l'état sanitaire du couvert végétal,
- les techniques et pratiques culturales etc.

Cependant, lorsque les facteurs non hydriques ne sont pas limitant (c'est à dire restent dans des normes tolérables), le rendement de la culture dépendra essentiellement de la manière de caler le cycle avec le régime hydrique, c'est à dire de l'état de satisfaction de ses besoins en eau pendant ses différentes phases phénologiques.

Or, l'irrégularité de la pluviométrie étant une constante du climat sahélien, de nombreuses incertitudes angoissent les paysans, livrés à eux-mêmes quant à la programmation de leurs opérations agricoles :

Faut –il procéder au semis précoce pour faire bénéficier les plants des premières pluies et avoir à ressemer si le premier semis ne réussit pas ; ou choisir le semis tardif en espérant sur une certaine fin normale ou prolongée de la saison des pluies ? ce qui est incertain.

Cela constitue un dilemme très pertinent que les agro météorologues tentent d'élucider en proposant des calendriers prévisionnels de semis pour mieux caler le cycle de croissance des cultures dans le régime hydrique, et cela dans le but de minimiser les effets des déficits pluviométriques éventuels et d'optimiser la production agricole.

Il s'agit là d'assister efficacement l'agriculture en donnant aux paysans un outil de travail dont l'utilisation judicieuse pourrait leur permettre de minimiser le risque climatique et d'accroître certainement la production. Ce processus permettrait au secteur rural de jouer pleinement son rôle véritable de moteur et d'impulsion des autres secteurs de la vie économique.

Des études et recherches ont été menées à ce sujet dans le domaine de l'Agrométérologie et diverses méthodes ont été proposées parmi lesquelles :

- des valeurs seuils de pluie à partir desquelles le semis peut être déclenché. Par exemple la FAO propose comme seuil une pluviométrie décadaire d'au moins 30 mm.

  Certes, cette méthode est simple et facilement applicable car ne nécessitant que des appareils de mesure de la pluie ; mais en cas de pluies précoces suivies d'une période sèche assez prolongée, les plants souffriraient et un ressemis pourrait être nécessaire.

- Le semis en sec : on sème et on attend les pluies qui comme nous le savons ne répondent pas toujours aux aspirations de l'homme. Là, il y a des risques que les semences brûlent dans le sol et que des ressemis soient également nécessaires.

- La méthode proposée par Pierre Franquin consiste à déclencher le semis lorsque la pluviométrie devient et reste supérieure ou égale à la moitié de l'évapotranspiration potentielle (ETP).

  Cette méthode basée essentiellement sur l'ETP et la pluviométrie ne tient malheureusement pas compte de la réserve en eau du sol et donc pourrait retarder inutilement le semis.

- Une autre méthode consisterait à faire des études statistiques sur les relations entre date de semis et rendement des cultures, mais malheureusement les séries de données agronomiques disponibles ne sont pas suffisamment longues pour de tels traitements.

  L'institut de Recherche en Agronomie Tropicale (IRAT) a alors proposé une solution qui consiste à traiter statistiquement les résultats des simulations du bilan hydrique en relation avec des indicateurs agro climatiques de rendement bâtis à partir des taux de satisfaction des besoins en eau de la culture à des stades spécifiques de son développement.

  Il s'agit là de substituer au processus réel de croissance de la plante, un processus artificiel utilisant les données climatiques du passé en choisissant plusieurs dates de semis pour chacune de ces dates. Cela permet de déterminer des dates et conditions de semis qui conduisent le plus fréquemment à des indices de rendement

acceptables, ainsi l'on peut caler au mieux le cycle de développement des cultures dans le régime hydrique pour éviter le plus souvent un déficit de rendement dû à la pluviométrie.

B - Méthodologie

Il s'agit de simuler le bilan des échanges hydriques entre la plante, le sol et l'atmosphère à partir des données pluviométriques réelles, mais en choisissant plusieurs dates de semis et de calculer l'indice de réussite pour chacune de ces dates.

Cela permet de déterminer les dates et conditions de semis qui conduisent le plus fréquemment à des indices de rendement acceptables. Ainsi l'on peut caler au mieux le cycle de développement des cultures dans le régime hydrique pour éviter le plus souvent un déficit de rendement dû à la pluviométrie.

A cet effet, nous allons dans ce qui suit présenter les outils et les méthodes que nous avons utilisés pour obtenir et traiter les données collectées.

- Matériel
- micro-ordinateur ;
- logiciel BIP184.

B1. Les données utilisées

B1.1 Pluviométrie journalière

Le modèle exige pour fonctionner des données de pluviométries journalières sur plusieurs années (au moins 30 ans pour l'analyse statistique des résultats).

Pour chacune des stations, nous avons utilisé une série de 30 ans de données disponibles.

B1.2 Données climatiques et agronomiques : fichier ETP et coefficients culturaux.

Les données décadaires d'ETP utilisées pour l'étude sont celles calculées par la formule de Penman.
Les coefficients culturaux utilisés sont ceux recommandés par le Centre Régional Agrhymet.

B1.3. Données pédoclimatiques et agronomiques

Selon la structure de nos sols, des réserves hydriques maximales ont pu être déterminées à partir de l'approche méthodologique du zonage au Mali (B. DIARRA, Février 1984, Montpellier).

B1. 4 Coefficient de ruissellement

Le ruissellement étant un facteur pédoclimatique très important dans la caractérisation du bilan hydrique, le modèle prend en compte des coefficients de ruissellement relatifs au type de sol et au seuil pluviométrique.

Par exemple sur sol ferrugineux dégradé, d'après les travaux réalisés par le PIRT ;

Si P > 20 mn alors kruiss = 20%
P = pluie
Kruiss = coefficient de ruissellement.

B2 - Bilan hydrique

B2.1 définition : Apports – Pertes

On définit le bilan hydrique à un instant donné par la quantité des apports d'eau, des pertes d'eau et des stocks d'eau dans le sol, et la manière dont ces apports et ces pertes se manifestent.

Quatre éléments principaux agissent sur les pertes et les apports en eau du sol : le climat, le sol, la plante et l'action humaine.

B2.2 Principes du bilan hydrique

Le modèle d bilan hydrique utilisé ici est celui proposé par FOREST (1974) et réactualisé par l'IRAT-CIRAD. Il est basé sur le principe suivant :

$Pi + Resi_{-1} - Rui = ETRi + Resi + Dri$
où
Pi = pluviométrie de la décade i considérée,
$Resi_{-1}$ = réserve hydrique du sol à la fin de la décade i-1 (décade précédente),
Resi = Réserve hydrique du sol à la fin de la décade i,
Rui = Ruissellement pendant la décade i,
ETRi = Evapotranspiration réelle au cours de la décade i,
Dri = Drainage pour la décade i.

La profondeur de sol considéré est équivalente à celle de l'enracinement maximum (150 cm). La tranche de sol utilisable comme réservoir d'eau est celle colonisée par 90% des racines.

Toutefois, le modèle est formulé de façon que la profondeur de sol à considérer à chaque instant soit la profondeur d'enracinement est supposée elle même croître linéairement après la levée (cf.IRAT – CIRAD).

Le drainage est pris égal à zéro tant que l'offre efficace en eau ($Pi + Resi_{-1} - Ru$) est inférieur à la réserve maximale utile de la zone racinaire, sinon on l'estimera par la différence entre cette offre efficace et la réserve maximale utile (RMUi) à savoir :

$Dri = Pi + Resi_{-1} - Ru - RMUi$

L'évapotranspiration réelle est estimée à partir de la formule de l'Eagleman (1971).

En effet, Eagleman a proposé à partir de différentes expérimentations sur les besoins en eau une relation empirique entre l'évapotranspiration réelle, les besoins en eau d'une culture et l'humidité relative du sol :

$ETRi = 0{,}732 - 0{,}056\ ETMi + (4{,}93\ ETMi - 0{,}661\ ETMi^2)\ HRi - (8{,}57\ ETMi - 1{,}56\ ETMi^2) + HR^2i + (4{,}35\ ETMi - 0{,}88\ ETMi^2)\ HRi^3$

ETMi = Ki.ETPi (évapotranspiration maximale d'un couvert végétal dans les conditions hydriques favorables).

ETMi est égale au produit du coefficient cultural Ki par l'évapotranspiration potentielle ETPi calculée à partir de la formule de Penman.

HRi est l'humidité relative, c'est à dire le rapport de la réserve réelle utilisable de la zone racinaire à la réserve maximale utilisable. Elle s'écrit :

$HRi = Pi + RESi_{-1} / RMi$

Ainsi, toutes les décades, le modèle permet d'avoir une estimation de l'évapotranspiration réelle (ETR) de la réserve hydrique du sol (Res) et du taux de satisfaction des besoins en eau de la culture (ETR/ETM).

C. Traitement des données

L'élaboration du bilan hydrique se fait par le biais d'un logiciel conversationnel, qui par une série de questions nous a permis d'introduire nos paramètres collectés.

Le bilan a été calculé pour :
- les mil, sorgho, mais, coton, arachide et niébé.
- cinq seuils de pluies (0, 10, 20, 30 et 40 mm) par décade,
- trois décades par mois ;
- trois à quatre mois (mai, juin, juillet et août) pour chaque longueur de cycle.
- trois cycles (court, moyen, long) pour chaque spéculation et pour chaque station d'étude. Chacun de ces cycles comprend 4 phases (IDV, FL1, FL2, MATU) et la longueur de chacune de ces phases est fixe.

D- Dépouillement

Les résultats obtenus à partir du traitement informatique sont attentivement analysés seuil après seuil, décade après décade, mois après mois et année après année pour chacune des cultures considérées.
Les produits issus de ces dépouillements sont assignés dans des tableaux prévus à cet effet.

E – Analyse statistique

Une plante passe au cours de la période de végétation par des stades de développement différents, correspondant à des évènements physiologiques caractéristiques (initiation paniculaire, floraison, épiaison, etc.) et sa sensibilité au stress hydrique varie selon les phases :

Levée croissance (IDV) : faible sensibilité au déficit hydrique mais grande sensibilité à l'excès d'eau ;
Début floraison (FL1) : moyenne sensibilité au déficit hydrique ;
Fin floraison (FL2) : grande sensibilité au déficit hydrique ;
Maturation (Matu) : faible sensibilité au déficit hydrique.

Par cette décomposition, le critère ETR/ETM apparaît être explicatif du comportement de la plante vis à vis du déficit hydrique.

Pour chacune de ces phases, le taux de satisfaction des besoins en eau ETR / ETM est calculé.

L'indice de réussite est aussi calculé.

L'indice de réussite

L'analyse repose sur le principe suivant :
En combien d'années sur 30, un semis effectué après P mm de pluie à la décade D du mois M a-t-il pu satisfaire ses besoins pendant ses phases phénologiques.

P = quantité de pluie ; elle varie de 0 à 40 mm.
D = décade, peut être la 1ère, 2ème ou 3ème décade du mois.
M = mois (de mai à août, période considérée comme favorable au semis d'après l'analyse statistique de la pluviométrie qui a été effectuée sur la période 1975-2004).

Pour caractériser la réussite de la culture, on définit un indice de réussite (IR) qui est égal au produit des indices de satisfaction ETR/ETM des différentes phases de la culture.

Cet indice théorique prend à priori en compte toutes les phases de la culture. Mais pour être réaliste on ne va pas exiger qu'une plante ait ses besoins en eau satisfaits pendant chacune des phases de son développement, cela n'étant ni nécessaire, ni possible. Aussi l'on ciblera trois phases supposées les plus cruciales car il y a un postulat à faire lié à un risque à prendre à condition que le résultat soit satisfaisant dans la pratique.

Phase I : semis – croissance,

Phase II : début épiaison/floraison,
Phase III : pleine épiaison/floraison.

Donc, IR = (ETR) / (ETM) Phase I x (ETR) /(ETM) Phase II x (ETR) / (ETM) Phase III

L'idée est que, lorsque les autres conditions agronomiques sont acceptables, si les besoins en eau de la culture sont satisfaits au moins assez bien pendant la levée- croissance, la floraison, l'on devrait s'attendre à un rendement assez bon.

Ainsi, pour une station donnée, en faisant des simulations de bilans hydriques à partir de différentes dates de semis correspondant à différentes conditions d'humidité du sol, l'on obtient un ensemble d'indices de réussite que l'on peut analyser statistiquement afin de trouver les périodes optimales de semis.

Pour que cet indice soit acceptable, nous avons posé comme hypothèse :
ETR/ETM > 0,8 ; ce qui implique que IR > $(0,8)^3 = 0,51$
Interprétation des données

Pour une décade et un seuil pluviométrique quelconque, on compte le nombre de fois où IR ≥ 0,51 (cas favorables) que l'on divise par le nombre de cas possibles (le nombre total d'années de simulation).

En outre, pour donner une base agronomique acceptable à nos résultats nous avons subdivisé les plantes en trois groupes : les mils/sorghos, les maïs arachide et le coton, compte tenu du fait que les premiers sont en général à 90% photopériodiques donc fleurissent à une période fixe quelle que soit la date de semis.

5.7 Résultats

Guide Pratique aux semis avec probabilité de réussite de 80 %

Localité : Nara.

Cultures : Mil /Sorgho/ /Maïs/Arachide.

Cycles : 90-70 jours.

1- Eviter de semer avant le 10 juin, mais procéder à la préparation des champs.

2- Du 11 juin au 10 juillet, semer dès que le cumul des pluies recueillies au cours d'une décade atteint ou dépasse 20 mm.

3- Du 11 au 20 juillet, semer dès que le cumul des pluies recueillies au cours de la décade atteint ou dépasse 10 mm.

4- Au delà du 20 juillet, semer des cycles plus courts.

Localité : Bamako.

Cultures : Mil/Sorgho.

Cycle : 120 - 90 jours.

1- Eviter de semer avant le 20 mai, mais procéder à la préparation des champs.

2- Du 21 au 31 mai, semer dès que le cumul des pluies recueillies au cours de la décade atteint ou dépasse 30 mm.

3- Du 1er au 30 juin, semer dès que le cumul des pluies recueillies au cours d'une décade atteint ou dépasse 20 mm.

4- Du 1er au 10 juillet, semer dès que le cumul des pluies recueillies au de la décade atteint ou dépasse 10 mm.

5- Après le 10 juillet, semer des cycles de 90 jours au plus.

Cultures : Maïs / Arachide / Niébé.
Cycles : 120 – 90 jours.

1- Eviter de semer avant le 20 mai, mais procéder à la préparation des champs.

2- Du 21 au 31 mai, semer dès que le cumul des pluies recueillies au cours de la décade atteint ou dépasse 30 mm.

3- Du 1er au 10 juin, semer dès que le cumul des pluies recueillies au cours de la décade atteint ou dépasse 20 mm.

4- Du 11 juin au 10 juillet, semer dès que le cumul des pluies recueillies au cours d'une décade atteint ou dépasse 10 mm.

5- Au delà du 10 juillet, semer des cycles de 90 jours au plus.

Localité : Koutiala.

Cultures : Mil / Sorgho.

Cycles: 150- 120 - 90 jours.

1- Eviter de semer avant le 31 mai, mais procéder à la préparation des champs.

2- Du 1er au 30 juin, semer les cycles de 150-120 jours dès que le cumul des pluies recueillies au cours d'une décade atteint ou dépasse 10 mm.

3- Du 1er au 31 juillet, éviter de semer les cycles de plus de 90 jours, de préférence choisir des cycles plus courts.

Cultures : Maïs/Arachide/Niébé.

Cycles : 130 - 120 – 110 – 90 jours.

1- Du 1er au 10 mai, semer les cycles d'au moins 120 jours dès que le cumul des pluies recueillies au cours de la décade atteint 40 mm.

2- Du 11 mai au 30 juin, semer les cycles d'au moins 110 jours dès que le cumul des pluies recueillies au cours d'une décade atteint ou dépasse 10 mm.

3- Du 1er au 10 juillet, éviter de semer les cycles de plus de 120 jours.

4- Du 11 au 20 juillet, éviter de semer les cycles de plus de 90 jours, de préférence choisir des cycles plus courts.

EN RESUME

En zone soudano sahélienne, le problème majeur que connaît l'agriculteur est celui que lui crée la pluviométrie.
En effet, vu l'énorme variabilité du régime pluviométrique, l'agriculteur se trouve très souvent face à des problèmes qu'il ne sait pas résoudre car en général il se réfère à une connaissance empirique de son milieu pour l'exécution de ses travaux culturaux. S'agissant de la préparation du sol ou du semis par exemple qui nécessitent une appréhension de la situation hydrique, cette connaissance est souvent prise en défaut par des variations importantes du régime hydrique au début de la saison pluvieuse.

La simulation du bilan hydrique décadaire permet d'élaborer une stratégie rationnelle de prise de décision.

Le calendrier prévisionnel ainsi élaboré ne permet certes pas de décider le semis avec la certitude totale de le réussir, mais il donne une méthode de décision qui, appliquée régulièrement permet assez fréquemment d'éviter des échecs de campagne.

La méthode n'est certainement pas parfaite, mais elle constitue une solution simple à un problème complexe : le choix de la période de semis.

Le calendrier cultural une fois disponible, il suffit simplement que le paysan (ou l'encadrement) dispose d'un pluviomètre et qu'il sache mesurer les quantités de pluies recueillies.

Notre étude basée sur quelques stations (3) du pays n'est que modeste étant entendu que des études supplémentaires sont à faire. Toutefois, elle propose une méthodologie de décision utilisable pour les localités ayant le même climat et le même type de sol que les stations que nous avons considérées.

Il serait utile de faire le même travail pour chaque localité pour aboutir à un calendrier prévisionnel utilisable.

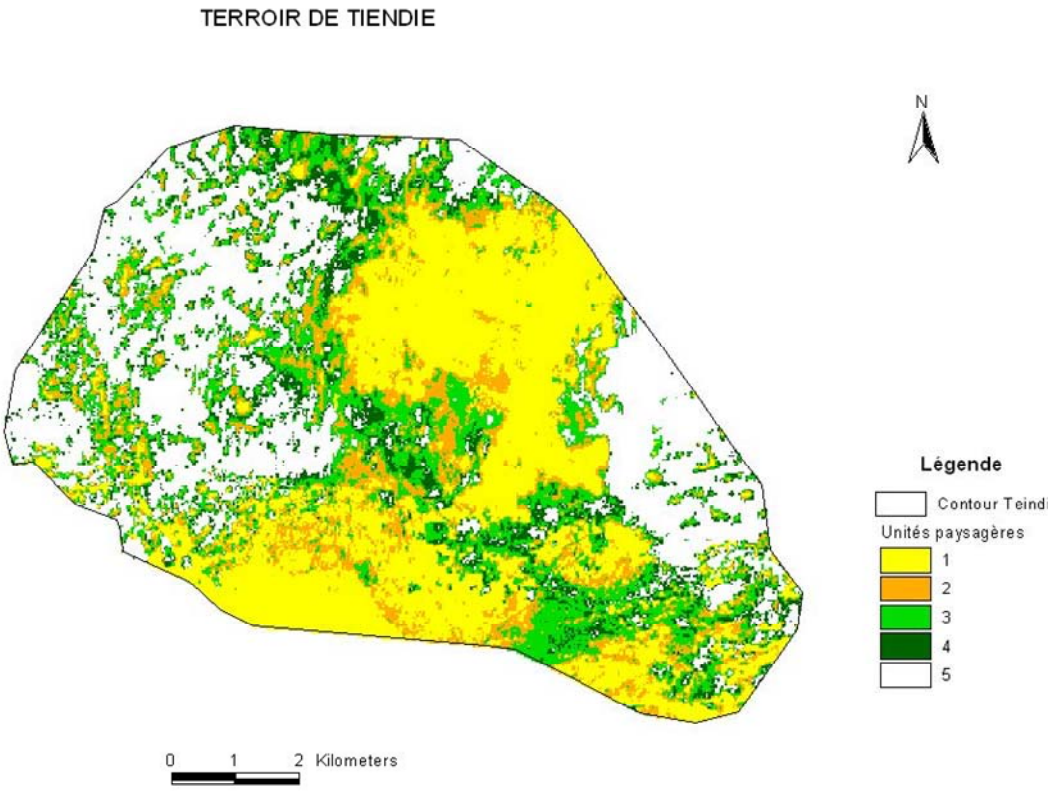
5.8 Conclusion:

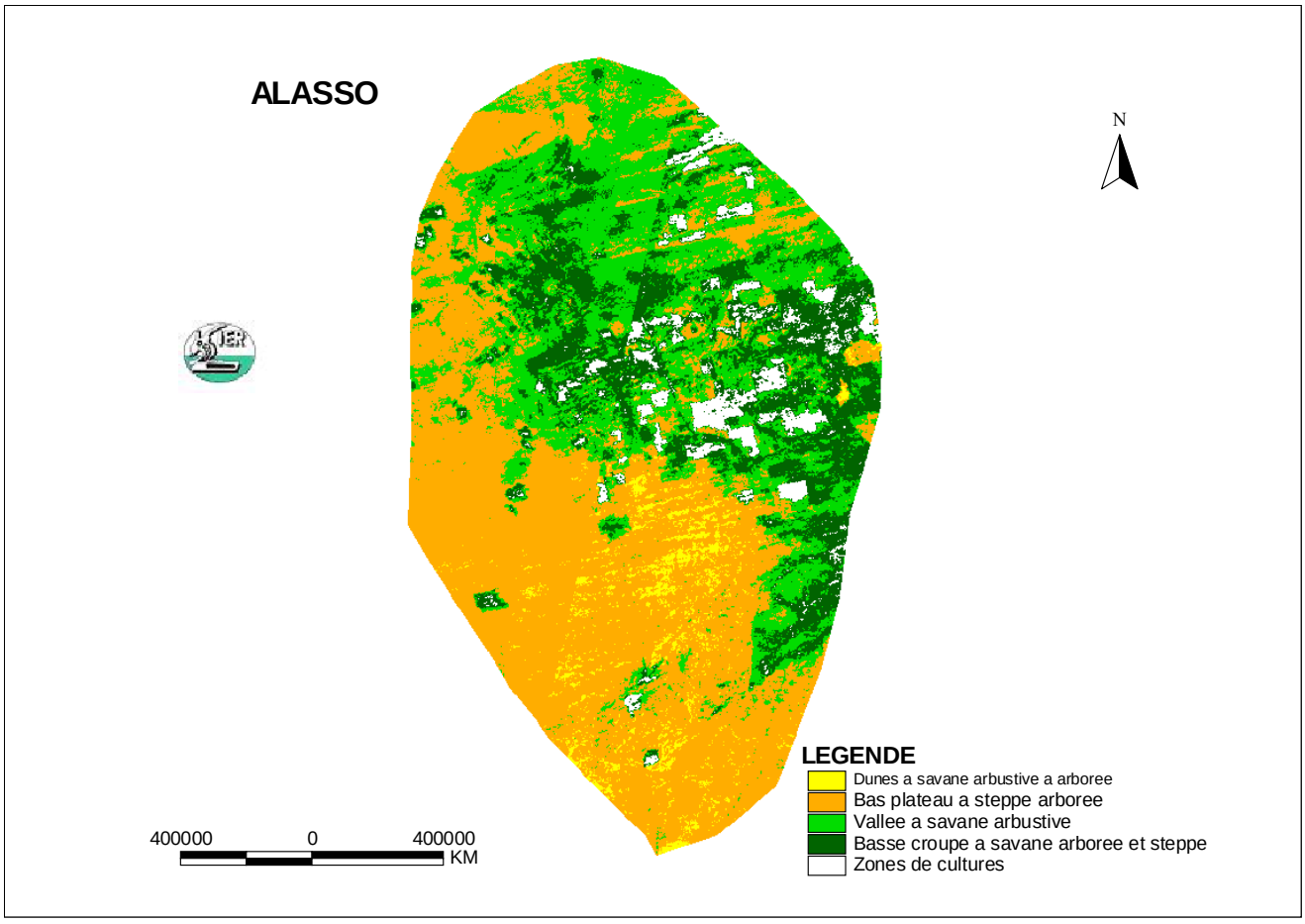
Malgré des principes simples, la mesure de la température de l'air et des précipitations reste délicate et souvent entachée d'erreurs, en particulier celle des quantités de précipitations.

Aux difficultés de mesures instrumentales s'ajoute l'effet de l'environnement proche qui peut engendrer des erreurs supérieures aux erreurs instrumentales.
Par exemple, un pluviomètre placé contre un mur ou au voisinage d'un arbre sous estimera (ou sur estimera) fortement les précipitations quand le mur ou l'arbre l'abritera du vent.

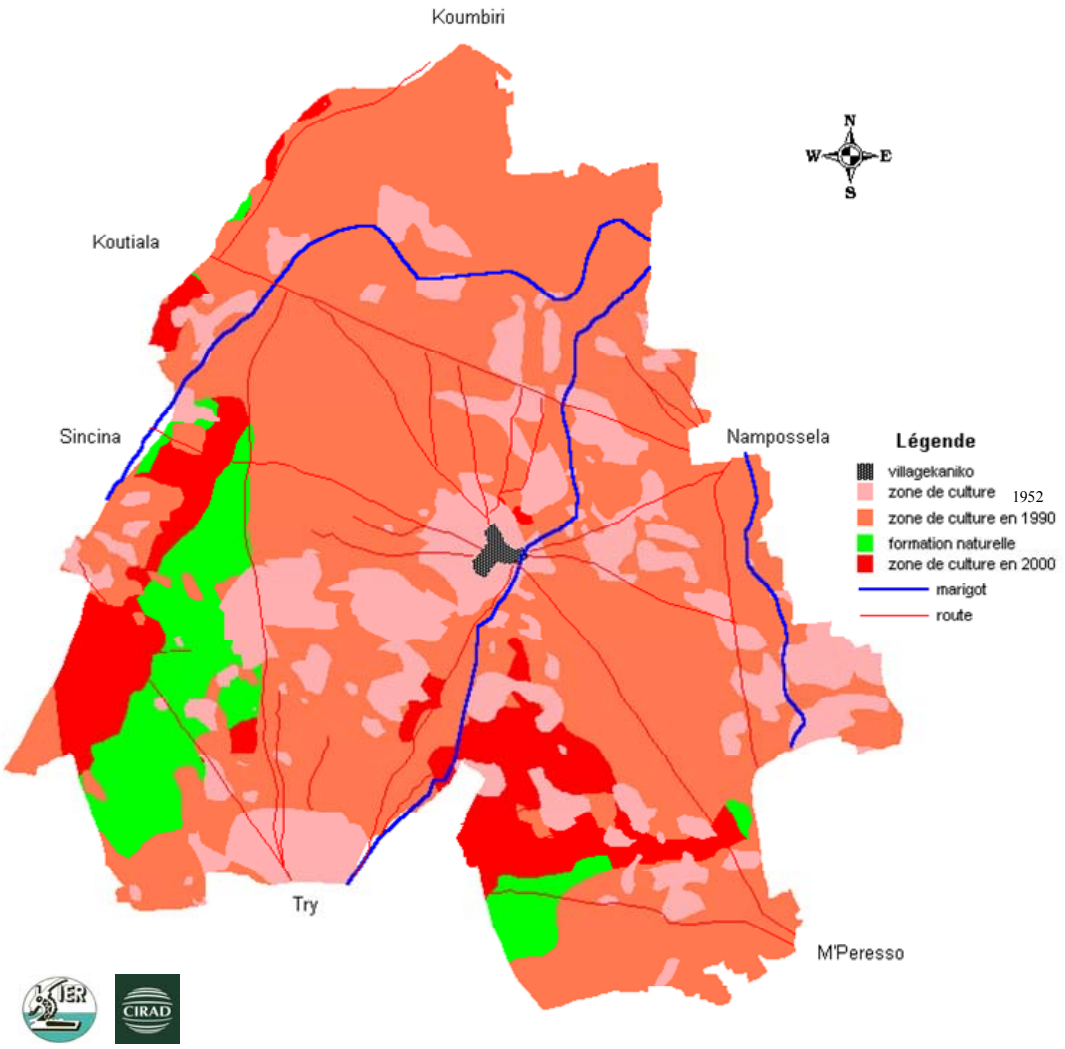
Aussi, ces analyses montrent que les stratégies culturales reposent en grande partie sur la date de début des pluies et peuvent permettre de déterminer la culture et la variété selon le type de saison.

Mais pour prendre des décisions stratégiques en vue d'une planification à long terme des systèmes agricoles, il est fort utile de connaît


TERROIR DE TIENDIE
N
Légende
Contour Teindi
Unités paysagères
1
2
3
4
5
0 1 2 Kilometers

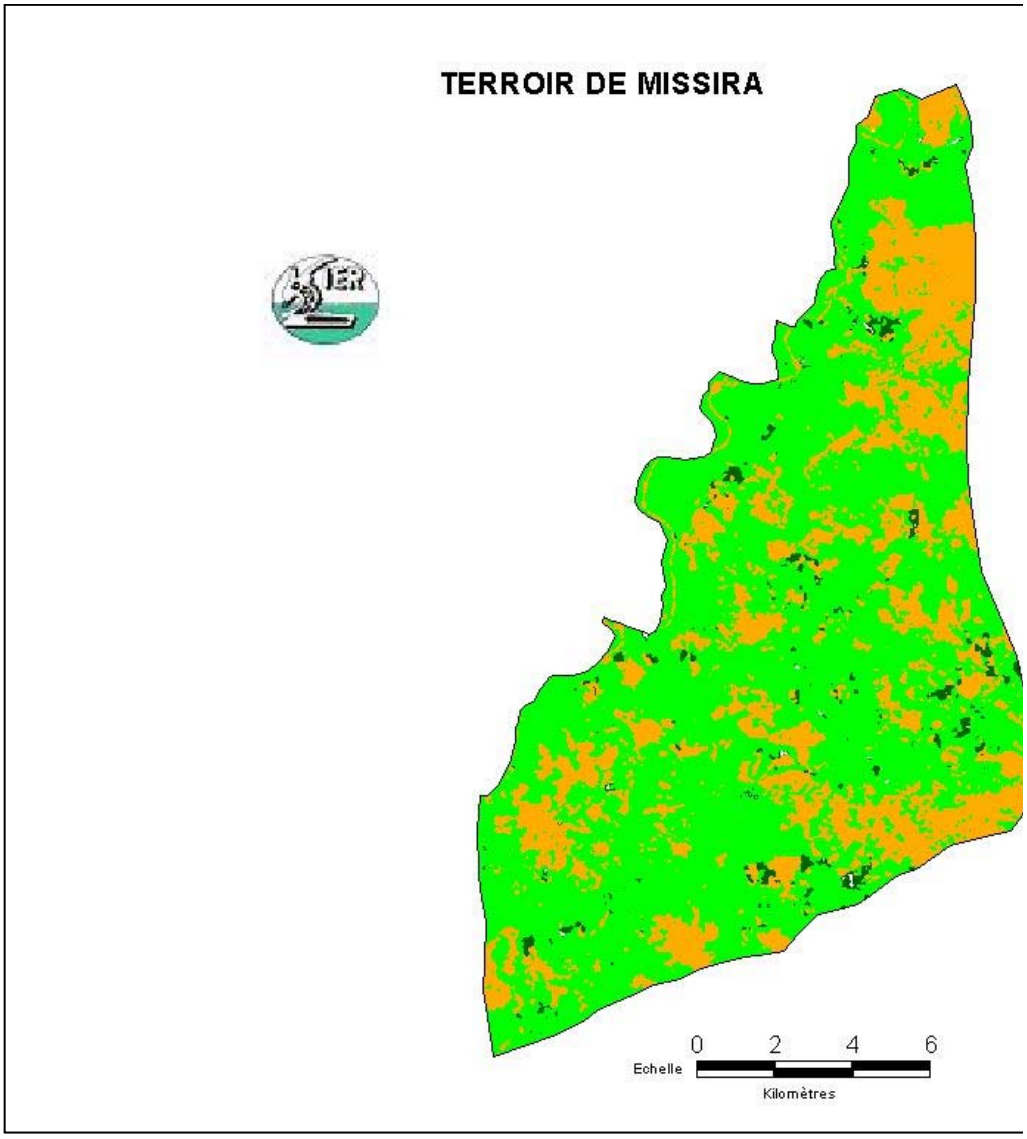

ALASSO
N
LEGENDE
Dunes a savane arbustive a arboree
Bas plateau a steppe arboree
Vallee a savane arbustive
Basse croupe a savane arboree et steppe
Zones de cultures
400000 0 400000
KM

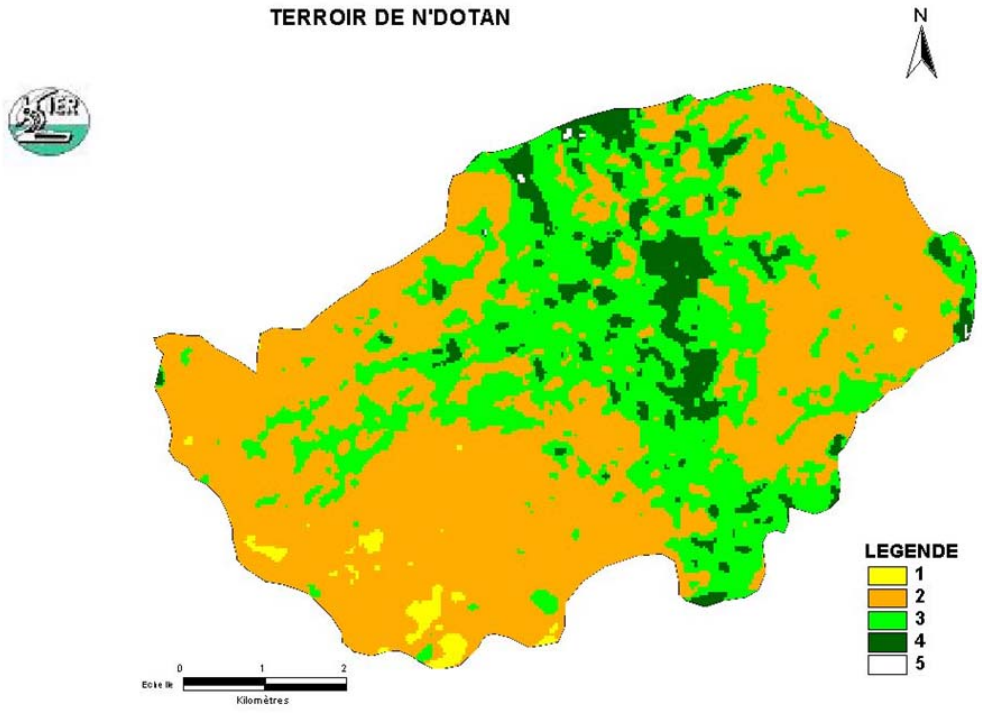
CARTE DE SYNTHESE: EVOLUTION DES ZONES DE CULTURES DE 1952 A 2000

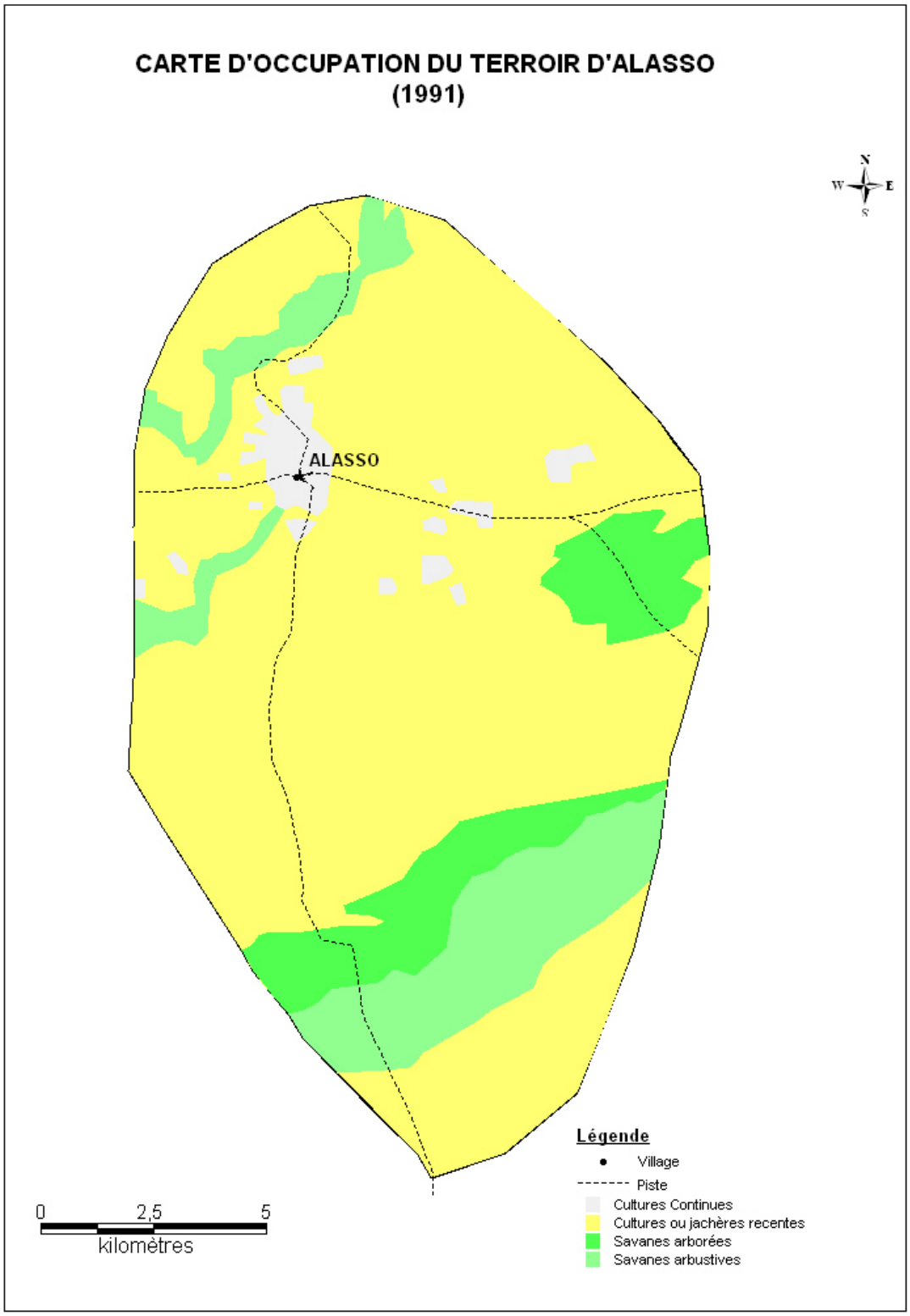


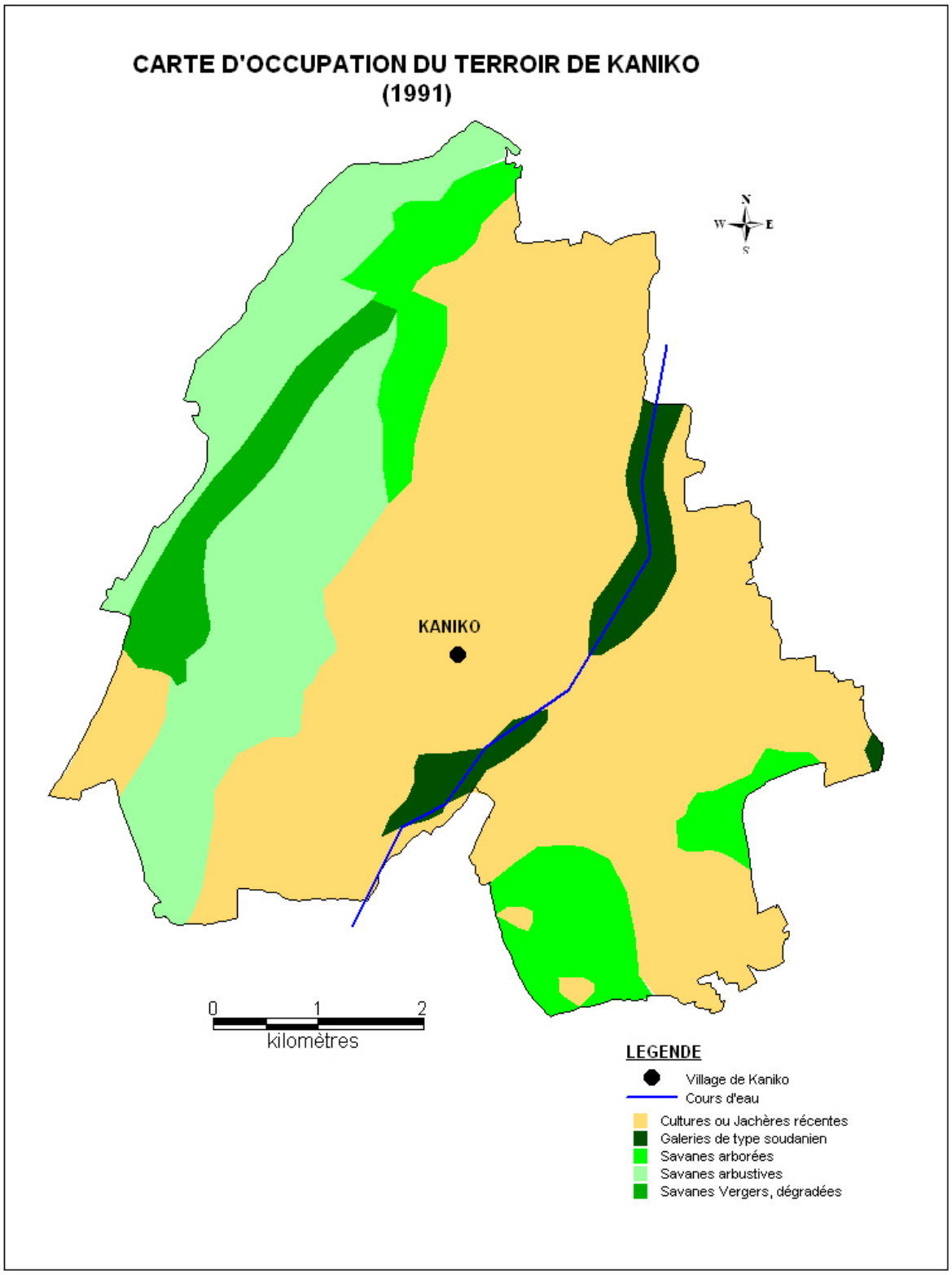
Echelle: 0 1 2 kilomètres

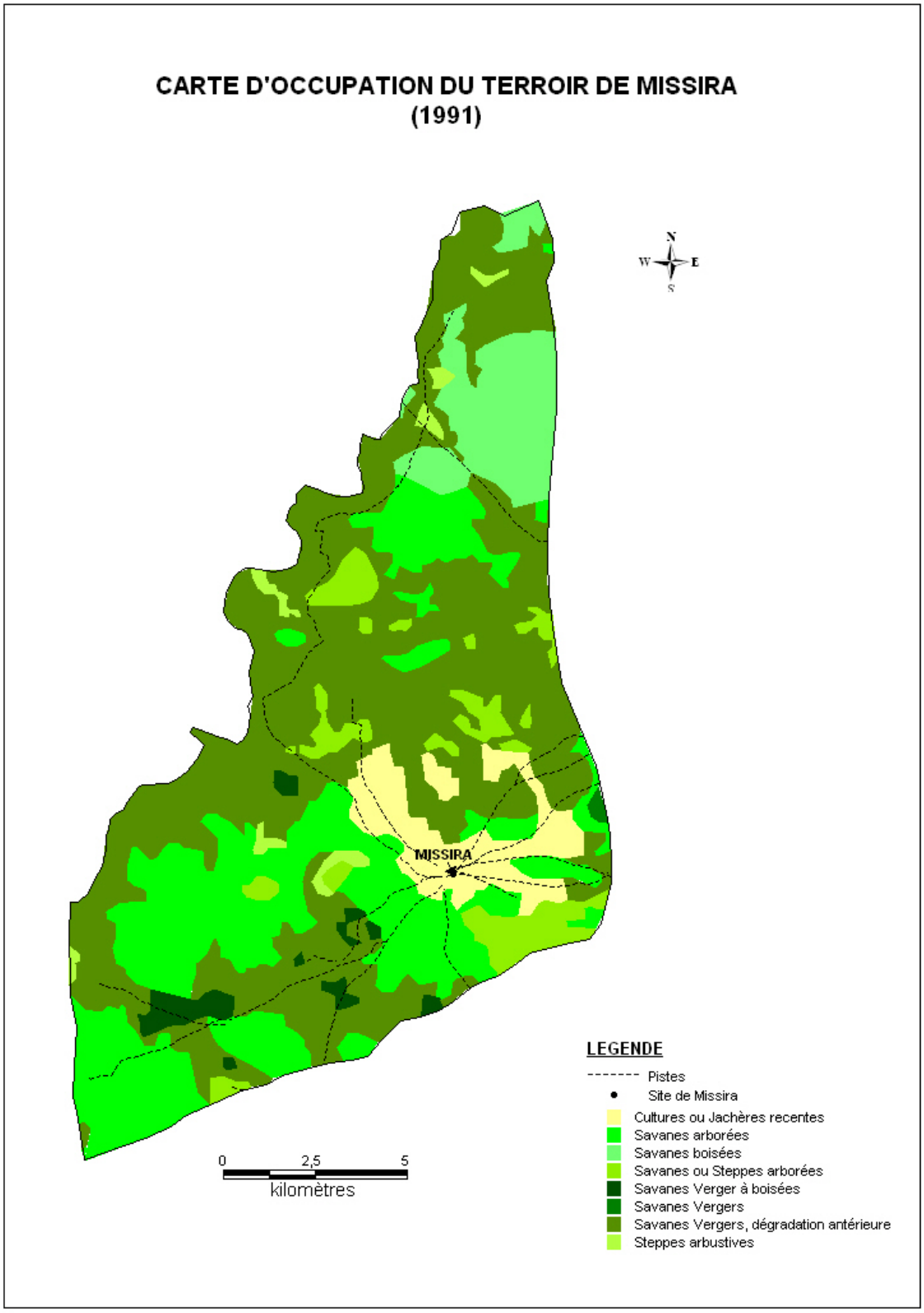
Source: Données photo 1952 1990 et image 2000 Landsat TM
Preparée par J.DEMBELE, K.KONE

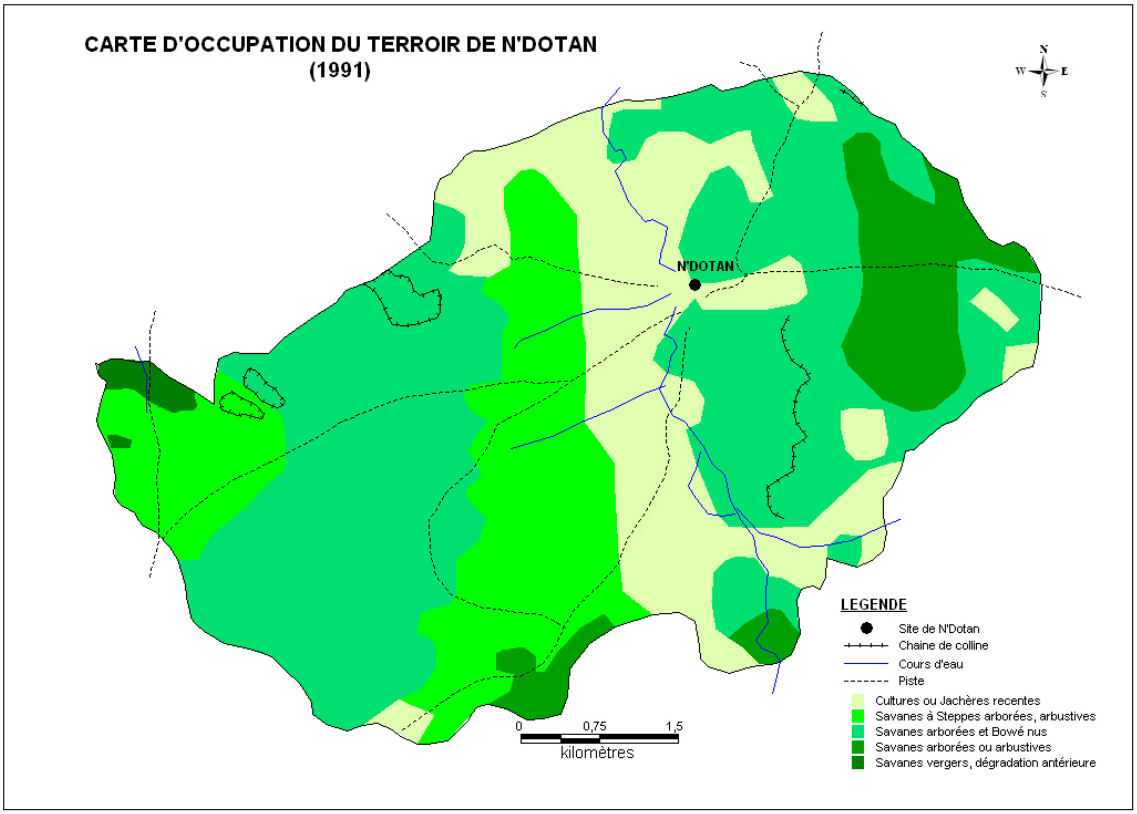

TERROIR DE MISSIRA
0 2 4 6
Echelle
Kilomètres

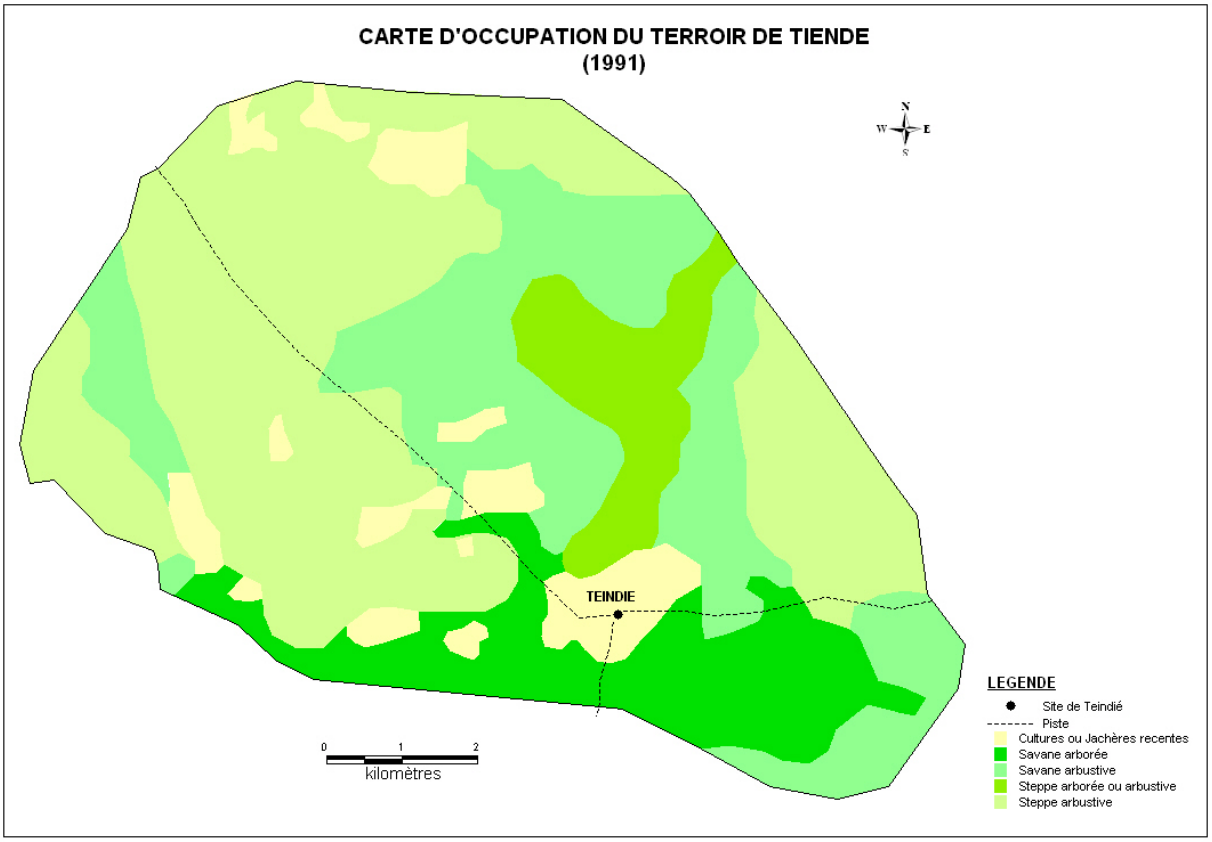

TERROIR DE N'DOTAN
N
LEGENDE
1
2
3
4
5
0
1
2
Kilomètres

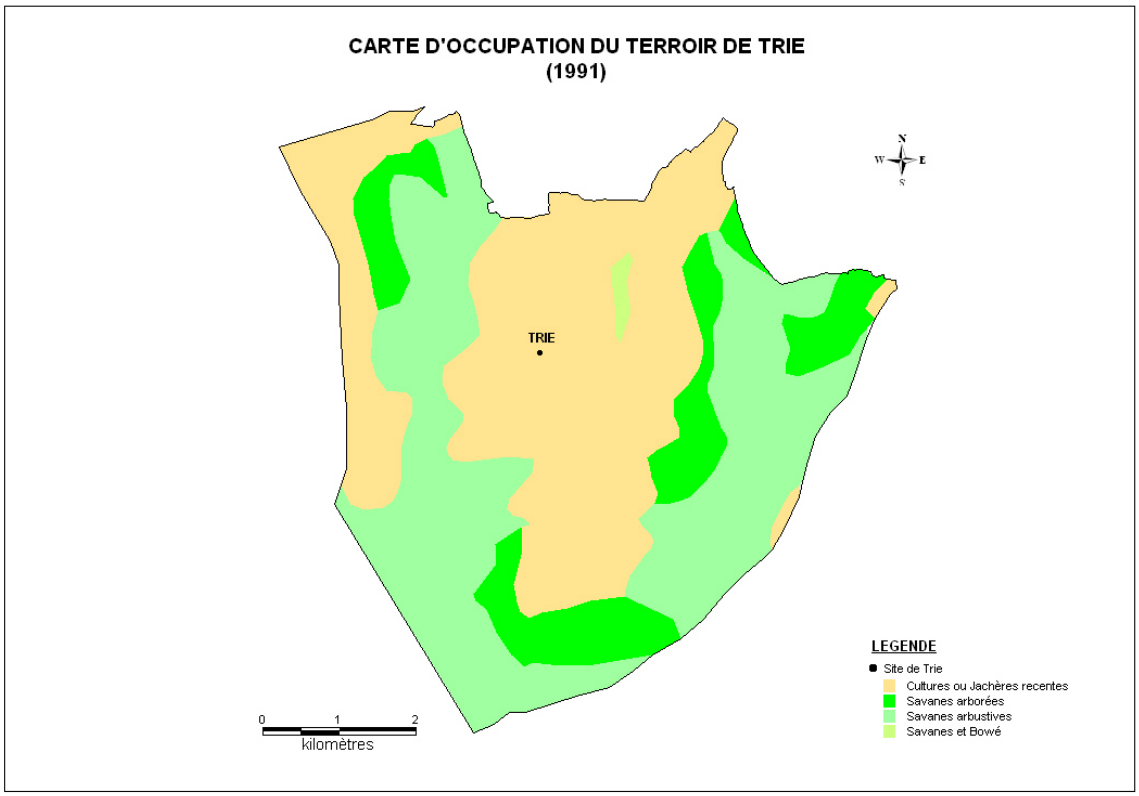

CARTE D'OCCUPATION DU TERROIR D'ALASSO
(1991)
N
W
E
S
ALASSO
Légende
Village
Piste
Cultures Continues
Cultures ou jachères recentes
Savanes arborées
Savanes arbustives
0
2,5
5
kilomètres


CARTE D'OCCUPATION DU TERROIR DE KANIKO
(1991)
N
W
E
S
KANIKO
0
1
2
kilomètres
LEGENDE
Village de Kaniko
Cours d'eau
Cultures ou Jachères récentes
Galeries de type soudanien
Savanes arborées
Savanes arbustives
Savanes Vergers, dégradées


CARTE D'OCCUPATION DU TERROIR DE MISSIRA
(1991)
N
W
E
S
MISSIRA
0
2,5
5
kilomètres
LEGENDE
Pistes
Site de Missira
Cultures ou Jachères recentes
Savanes arborées
Savanes boisées
Savanes ou Steppes arborées
Savanes Verger à boisées
Savanes Vergers
Savanes Vergers, dégradation antérieure
Steppes arbustives


CARTE D'OCCUPATION DU TERROIR DE N'DOTAN
(1991)
N
W
E
S
N'DOTAN
LEGENDE
Site de N'Dotan
Chaine de colline
Cours d'eau
Piste
Cultures ou Jachères recentes
Savanes à Steppes arborées, arbustives
Savanes arborées et Bowé nus
Savanes arborées ou arbustives
Savanes vergers, dégradation antérieure
0
0,75
1,5
kilomètres


CARTE D'OCCUPATION DU TERROIR DE TIENDE
(1991)
N
W
E
S
TEINDIE
LEGENDE
Site de Teindié
Piste
Cultures ou Jachères recentes
Savane arborée
Savane arbustive
Steppe arborée ou arbustive
Steppe arbustive
0
1
2
kilomètres



RAPPORT DE MISSION EFFECTUEE A KOUTIALA, NARA ET KOLOKANI DU 13 AU 26 OCTOBRE 2005

Suivant ordres de mission N°178, N° 0179 et N°180/IER/DS du 6 Octobre 2005 une équipe pluridisciplinaire du projet SEMSOC s'est rendue dans les villages de Kaniko et Try dans le cercle de Koutiala, dans les villages de Tindié et Alasso dans le cercle de Nara et les villages de Dotan et Missira dans le cercle de Kolokani du 13 au 26 Octobre 2005.

I. OBJECTIFS DE LA MISSION:

- Collecter les données relatives à la population, au cheptel et aux techniques culturales d'après une enquête village,
- Collecter les données pédologiques avec prélèvements d'échantillons pour les analyses au labo,
- Caractériser les différentes classes pour les besoins de la cartographie ;
- Matérialiser les limites des différents terroirs villageois au GPS.

II. DEROULEMENT DE LA MISSION :

La mission s'est déroulée de la manière suivante :

- 13 Octobre départ pour Koutiala ;
- 14 Octobre Visite du village de Kaniko ;
- 15 Octobre visite du village de Try ;
- 16 –17 Octobre voyage sur Nara ;
- 18-19 Octobre visite du village de Tindié dans la commune de Nara ;

- 19-20 Octobre visite du village de Alasso dans la commune de Dilly;
- 21 Octobre départ pour Kolokani ;
- 22-23 Octobre visite du village de Dotan dans la commune rurale de Djidiéni ;
- 24-25 Octobre visite du village de Missira ;
- 26 retour à Bamako.

Dans tous les villages visités, la démarche a consisté en une réunion avec les populations pour expliquer les objectifs de la mission. Pendant la réunion des représentants des villages sont désignés pour participer ensuite à l'enquête village avec les socio-économistes de l'équipe, et pour accompagner les pédologues, les environnementalistes et les cartographes pour la visite de terrain.

2.1 Socio-économie :

La fiche administrée lors de l'enquête village pour l'ensemble des villages retenus porte sur la population, le cheptel, les jachères, les forêts, les pâturages, la composition et la rotation des cultures, les variétés cultivées et les rendements et ceci pendant trois périodes précises (avant le 26 mars 2001 ;après le 26 mars ; 2ème mandat de Konaré). Trois cercles sont choisis : Koutiala, Nara et Kolokani. Pour chaque cercle deux terroirs villageois sont concernés par l'étude :

Cercle de Koutiala :

Kaniko :

Il ressort de ce premier survol que le village de Kaniko avec ses 7 Km2 comme superficie a vu l'arrivée des bambaras après le 26 Mars 2001 de même qu'il a connu un éclatement des exploitations plus prononcé. Au niveau du cheptel, il y a eu un accroissement des effectifs toutes espèces confondues pendant le 2ème mandat de Alpha

Comme structures d'encadrement, on peut citer la CMDT, Le DRSPR, l'AMEDD et Le SLACAER.

Les organisations locales sont les AV, la Kafo, le Ton « Nako séné », le ton des femmes, la banque de céréales, les brigades de surveillance des feux de brousse etc.

Comme infrastructures socio-économiques, on trouve une école, une structure sanitaire.
Les autres aspects seront traités dans le rapport technique qui découlera de l'exploitation des fiches d'enquête.

Try :

Les informations recueillies se rapportent à la démographie, aux ethnies, à l'évolution des effectifs du cheptel et aussi aux structures d'intervention. La situation de l'évolution des effectifs du cheptel en liaison avec les trois périodes proposées n'est pas maîtrisée par les populations de ce village. La population est constituée surtout de minianka. La superficie de 135 Km2 n'a pas connu de changement.

On trouve à Try une école, un marché. Au niveau des structures d'encadrement, on peut citer la CMDT, l'ESPGRN et la Kafo.

Cercle de Nara :

Tindié :

Les Sarakolé constituent l'ethnie principale du village. Ils s'adonnent à l'agriculture et à l'élevage. On trouve quelques maures surtout pasteurs. Le village connaît le phénomène de migration de populations surtout

pendant l'hivernage. Certaines familles venant de Nara et de Goumbou y séjournent pour la campagne agricole.
Dans le village, on trouve deux magasins de stockage, trois fontaines et deux puits à grand diamètre.

Alasso :

Les questions posées se rapportant à la démographie, aux ethnies, à l'évolution des effectifs du cheptel et aussi aux structures d'intervention ont été bien comprises par les populations qu se sont montrées très intéressées par les objectifs visés par la mission. Les problèmes des changements climatiques sont bien perçus dans le village qui a décidé volontaire de réserver une bonne partie de son terroir à la forêt et au pâturage. La population entière est mobilisée pour éteindre les feux qui se déclarent. Celui qui est empêché ou qui ne peut participer physiquement paie 5000 FCFA comme contribution à l'effort.

L'intégration agriculture-élevage est bien perçue dans ce village et mérite d'être signalée avec force. Chaque famille a son enclos pour parquer ses animaux sur ses parcelles. Le fumier produit est utilisé pour fertiliser les parcelles familiales appauvries. L'emplacement de tous les enclos privés du village toujours dans la zone agricole autour du village est décidé par le conseil du village en fonction de la pauvreté des terres. Cette année par exemple tous les enclos sont à l'est du village.

Il y aussi, une école, un marché

Cercle de Kolokani :

Dotan :

Petit village de 745 habitants, dotan compte 33 exploitations. Les déficits pluviométriques enregistrés ont entraîné une baisse de la production et même un éclatement au niveau des grandes exploitations. Le village compte trois tons de jeunes pour la culture de l'arachide, un ton de femmes pour la culture de l'arachide et l'épargne crédit.

Comme infrastructures, on note la présence d'une école, de deux magasins de vente de céréales.
Le village dispose d'une convention locale se rapportant au lieu de pâture.

Missira :

La population actuelle du village est de 1500 sur une superficie de 660 km². La principale ethnie est le « ***Kakolo***.

Comme infrastructures le village dispose :
- d'une école avec 6 classes depuis le année 1995 ;
- d'un dispensaire en 2004 ;
- de deux puits à grand diamètre en 2005 ;
- d'un barrage en 1995 qui n'a jamais fonctionné.

Plusieurs structures ont travaillé dans le village. Il s'agit de :

- projet de lutte contre le paludisme en 2004 ;
- service des Eaux et Forêts OPNBB depuis la 1ère République ;
- PGRN dans le cadre des forages et barrages ;
- SLACAER au temps de la 27me République ;
- l'IER avant le 26 mars.

Comme organisations locales il y a :

- l'Association des jeunes ;

- l'Association des femmes;
- le ton des chasseurs.

2.2 Caractérisation des sols :

- Koutiala :

Les observations des sols ont été faites par sondages à la tarière le long de 3 transects :

- KANIKa-N'KONTINA ; 2 sondages ont été effectués le long de ce trajet au niveau des points suivants :

1er Point (Ko-1) : Coordonnées : longitude 5° 22' 433 N,
latitude 12° 19' 185 W, 600 m du village de Kanico ;
2éme Point(Ko-2): Coordonnées: longitude 5° 22 ' 932 N,
latitude 12° 279 W, 1,4 km de Kanico.

Ces sols représentent les unités PL9 et PL11 de la légende sol/végétation du PIRT, classés respectivement (Classification USDA) : Plinthic haplustalfs et Ultic haplustalfs. Ils sont formés sur la plaine d'épandage et sur le bas-glacis en piedmont du plateau latéritique se trouvant dans la zone nord-ouest du terroir de Kaniko.

Sur ces sites 4 échantillons de terre ont été prélevés pour l'analyse de la granulométrie et pour la détermination de la capacité de rétention du sol en eau conformément aux indications du Manuel GEMS-CENTURY. Ces prélèvements ont été faits aux profondeurs 0 – 20 cm et 20 – 50 cm. Pour les mêmes profondeurs 6 prélèvements au cylindre ont eu lieu pour la détermination de la densité apparente.

Le site Ko-1 se trouve dans la zone des sols sous culture contrairement au site Ko-2 ou on ne rencontre que d »es cultures éparses. Les cultures identifiées sont : sorgho, mil et coton.

Le sol Ko-1 est un bon drainage ; c'est seulement à 70 cm de profondeur que les signes d'hydromorphie et la présence de taches d'oxydation (plinthites) sont perceptibles.

- KANIKO-SINCINA : ce transet a permis de vérifier les mêmes toposéquences reconnues sur le transet Kanico-vers N'Kantina.

- KANICO-NAMPOSSELA : 1 sondage sur terrain hydromorphe a été réalisé au point ci-dessous :

3éme Point(Ko-3) : Coordonnées : longitude 5° 21' 363 N,
latitude 12° 19'208 W ; 1 km de Kanico vers Namposséla.

Deux échantillons pour la texture et la capacité de rétention en eau , et 6 cylindres ont été prélevés pour la détermination de la densité. Ce sol a un mauvais drainage ; les signes de gley sont visibles depuis l'horizon de surface avec apparition de taches d'oxydation rougeâtres à 70 cm de profondeur.

Terroir du village de Tindiè Cercle de Nara

Le terroir de Tindiè est situé au sud-est, à une vingtaine de kilomètres de Nara, sur la route reliant cette dernière localité à la ville de Nioro. Il se caractérise par une relative homogénéité de sa couverture pédologique. En effet, ce terroir est dominé par l'unité sol/végétation des Dunes Aplanies (DA-4) et dans sa partie sud-est par les Dunes mortes (D-5). Trois transects ont été parcourus, le long desquels les points suivants ont été observés :

Te-1 longitude : 007° 09' 204 W, latitude : 15° 03' 633 N ; 800 m du village vers le village Madina (direction nord-est) :

Géomorphologie : Dune aplanie à pente modérée (2 à 3 % de pente)
Type de sol : Ustalfic haplargids
Drainage : Excessif
Utilisation actuelle : Agro-pastorale à pastoralisme dominant
: Te1-1 (0 – 20 cm) Sable limoneux; Te1-2 (20 –50 cm) Limon sableux; Te1-3 (70 –100 cm) Limon Argileux fin

Te-2 longitude: 007° 07' 424 W, latitude: 15° 03' 355 N

Géomorphologie : Dune morte à pente modérée à forte (4 à 8 % de pente)
Type de sol : Psammentic haplargids
Drainage : Excessif
Utilisation actuelle : Pastorale
: Te 2-1(0 – 20 cm) Sable limoneux; Te 2-2(20 –50 cm) Limon Argilo- sableux; Te 2-2 Limon Argilo-sbleux

Terroir du village de Alasso Cercle de Nara

Le terroir de Alasso est situé à environ 100 km au sud-ouest de la ville de Nara en passant par le village de Dilly. Les sondages à la tarière ont été effectués en direction des 4 points cardinaux. Le terroir est dominé par les unités DA-4 au centre, D-5 au nord et partout ailleurs par l'unité PS-1.

Aso 1 : 14° 53' 993 N, 008° 01' 185 W ; 2,5 km du village vers le village de Sampaka (direction sud-est)

Géomorphologie : Dépression interdunaire à pente faible (1 à 3%)
Type de sol : Ustalfic haplargids
Drainage : Excessif
Utilisation actuelle : Agro-pastorale
: Aso 1-1 (0 – 20 cm) Sable limoneux; Aso1-2 (20 –50 cm) Limon argilo-sableux; Aso1-3 (70 –100 cm) Limon argileux;

Aso 2 : 14° 52' 479 N, 008° 00' 646 W ; 5,5 km vers Sampaka

Géomorphologie : Plaine sableuse à pente quasi nulle
Type de sol : PS-1
Drainage : Bon
Utilisation actuelle : Pastorale
Texture : Aso 2-1 (0 – 20 cm) Sable limoneux; Aso 2-2 (20 –50 cm) Limon Sableux; Aso 2-3 (70 –100 cm) Limon Sableux;

Aso 3 : 14° 55' 099 N, 008° 00' 642 W ; 1,3 km vers Sambabougou (direction Est)

Géomorphologie : Sommet de Dune Aplanie
Type de sol : Ustalfic haplargids
Drainage : Excessif
Utilisation actuelle : Agro-pastorale à pastoralisme dominant
Texture : Aso 3-1 (0 – 20 cm) Sable limoneux; Aso 3-2 (20 –50 cm) Limon Sableux; Aso 3-3 (70 –100 cm) Limon argilo-sableux;

Aso 4 : 14° 50' 520 N, 008° 01' 278 W; Alasso vers Samé (direction Nord)

Géomorphologie : Sommet de Dune morte
Type de sol : Psammentic haplargids
Drainage : Excessif
Utilisation actuelle : Agro-pastorale à pastoralisme dominant

Aso 4-1 (0 – 20 cm) Sable limoneux; Aso 4-2 (20 –50 cm) Limon Sableux; Aso 4-3 (70 –100 cm) Limon Sableux

Terroir du village de N'Dotan cercle de Kolokani

Le terroir de N'Dotan s'étend sur une vallée encaissée limitée à l'Est par un plateau latéritique et à l'Ouest par un plateau rocheux gréseux. Ces plateaux culminent à une hauteur d'environ 400 à 500 m. La vallée est drainée par un cours d'eau à régime temporaire. De part et d'autre de ce ruisseau on observe une toposéquence composée du bas-glacis, du glacis colluvial et du plateau. Les observations ont été effectuées le long de 2 transects, aux points suivants :

Dot 1 : 12° 52' 053 N, 008° 10' 330 W ; 1,2 km au Sud-Est du village vers Wayambougou

Géomorphologie : Bas-glacis hydromorphe
Type de sol : PL-9 : Plinthic haplustalfs
Drainage : Imparfait
Utilisation actuelle : Agricole ; Culture : Sorgho
Texture : Dot 1-1 (0 – 20 cm) Limon; Dot 1-2 (20 –50 cm) Limon Argileux fin;
Dot 1-3 (50 –100 cm) Limon Argileux fin

Dot 2 : 13° 51' 904 N, 008° 11' 066 W ; 2,8 km au Sud-Est du village vers Wayambougou
Géomorphologie : Sommet tabulaire de plateau rocheux gréseux
Type de sol : TR-
Drainage : Excessif
Utilisation actuelle : Sylvo-pastorale
Texture : Dot 2-1 (0 – 20 cm) Limon graveleux
Dot 3 : 13° 51' 485 N, 008° 10' 797 W ; 4 km au Sud-Est

Géomorphologie : Glacis colluvial
Type de sol : TR-
Drainage : Excessif
Utilisation actuelle : Sylvo-pastorale
Dot 3-1 (0 – 20 cm) Limon Sableux; Dot 3-2 (20 –50 cm) Limon argilo-sableux;
Cuirasse à 53 cm

Dot 4 : 13° 51' 343 N, 008° 09' 942 W ; 900 m au Sud

Géomorphologie : Bas-glacis
Type de sol : PL11
Drainage : Bon
Utilisation actuelle : Agricole
Dot 4-1 (0 – 20 cm) Limon; Dot 4-2 (20 –50 cm) Limon Argilo-Sableux; Dot 4-3 (50 –100 cm) Limon Argileux

Terroir du village de Missira cercle de Kolokani

Le terroir de Missira est aussi dominé par des Terrains Rocheux à pente moins plus émoussée comparativement au terroir de N'Dotan. Les sondages ont été effectués dans 2 directions : 1) de Missira vers le fleuve Baoulé (direction Ouest) et 2) de Missira vers Sirakorola (direction Sud-Ouest).

Mra 1 : 13° 43' 079 N, 008° 27' 403 W ; 1,5 km du village

Géomorphologie : Bas-glacis
Type de sol : PL11
Drainage : Bon

Utilisation actuelle : Agricole
Mra 1-1 (0 – 20 cm) Limon Sableux; Mra 1-2 (20 –50 cm) Limon argilo-sableux; Mra 1-3 (50 –100 cm) Limon Argileux

Mra 2 : 13° 44' 046 N, 008° 28' 288 W ; 3,5 km du village

Géomorphologie : Bas-glacis hydromorphe
Type de sol : PL9
Drainage : Imparfait
Utilisation actuelle : Agro-pastorale
Mra 2-1 (0 – 20 cm) Limon Sableux; Mra 2-2 (20 –50 cm) Limon Argilo-sableux; Mra 2-3 (50 –100 cm) Limon argilo-sableux

Mra 3 : 13° 42' 086 N, 008° 27' 324 W, 1,5 km vers Sirakorola (direction Sud-Ouest)
Géomorphologie : Versant glacis
Type de sol : TR-
Drainage : Excessif
Utilisation actuelle : Sylvo-pastorale
Texture : Mra 3-1 (0 – 20 cm) Limon très graveleux; Cuirasse à 20 cm
Mra 4 : 13° 41' 451 N, 008° 28' 154 W ; 3,5 km du village vers Sirakorola

Géomorphologie : Bas-glacis hydromorphe
Type de sol : PL9
Drainage : Imparfait
Utilisation actuelle : Agro-pastorale
Mra 4-1 (0 – 20 cm) Limon fin argileux; Mra 4-2 (20 –50 cm) Limon Argileux fin; Mra 4-3 (50 –100 cm) Argile Limoneuse

2.3 Matérialisation des limites des terroirs :

Zone Koutiala

L'Unité à cartographier retenue est le terroir villageaois. Ainsi pour la zone de Koutiala se sont les terroirs de Kaniko et celui de Tri. L'opération de terrain a commencé à Kaniko. La méthodologie adoptée est la suivante : accompagné des partenaires de recherche dans les villages, on doit sillonner le terroir en suivant toutes les pistes au départ du village jusqu'aux limites avec les voisins. Les différents points limites seront géo-référencés au GPS. Pour le village de Kaniko, cette opération a été déjà faite dans le cadre d'un projet en cours au LaboSEP. L'équipe en charge de la cartographie du terroir a ainsi appuyé les pédologues pour le géoréférencement des différentes unités pédologiques. Ainsi trois points ont été référencés ; le premier dans une parcelle de mil (sol sableux limoneux), le second dans une formation de savane arbustive (limoneux sableux en surface) et la troisième dans une parcelle de Dah (limoneux sableux à limoneux argileux).

Pour le village de Tri, onze points ont été collectés. Le terroir étant circonscrit, la totalité des points référencés corresponds au prélèvement d'échantillons des sols et de la description des unités d'occupation sol (champs de culture, savane arbustive, etc.)

Zone de Nara.
Les terroirs retenus sont Teindié dans la commune de Nara et Alasso dans la commune de Dilly.

Tindié. Au total huit points été géoréférencés ; quatre pour les limites avec les terroirs voisins, un pour le village et les trois autres sur les formations naturelles ou points de prélèvement d'échantillon de sols bien caractéristiques. Les unités de paysage les plus fréquentes sont : la steppe arbustive, la steppe herbeuse avec plage de sol-nu et les zones de cultures (jachère et parcelles de cultures).

Alasso. Cinq points sont référencés : le village et les limites avec les terroirs voisins. Les formations (unités de paysage) les plus fréquentes sont : les zones de cultures principalement à l'Ouest et Est du village, les jachère et les savanes arbustives.
NB. La zone Sud du terroir est protégée depuis plus d'une dixaine d'année contre toute exploitation.

Zone de Kolokani.
Les villages retenus sont N'Dotan dans la commune de Djidiéni et Missira dans la commune de Sébékoro I. Les deux terroirs étant référencés, on a procédé à la matérialisation de quelques unités pédologiques et paysagiques bien caractéristiques.

Pour chacun des deux villages les points référencés sont au nombre de quatre qui sont :
A N'Dotan

- deux parcelles de cultures (sorgho et arachide) dans la vallée du cours d'eau,
- une formation de savane arbustive,
- une ancienne jachère (savane arbustive).

Et à Missira

- une parcelle de sorgho sur la piste allant à Dioumara,
- une jachère sur la même direction,
- un plateau versant sur la piste allant à Sirakoroba,
- la vallée du cours d'eau se situant entre Missira et Sirakoroba (Jachère).

2.4 Caractérisation des différentes classes :

Au niveau des deux terroirs choisis à Koutiala, le paysage comporte trois classes distinctes : les plaines alluviales des rivières où se rencontrent les vergers, les glacis versants d'épandage domaine des cultures séches(mil, sorgho et coton) et les plateaux latérites couverts d'une savane arbustive dominée par les combretacées. (Combretum micranthum,Combretum glutinosum, Terminalia avicennioïdes).

Dans chacune de ces classes un inventaire floristique a été effectué avec une estimation du recouvrement à la fois de la strate ligneuse que de la strate herbacée. Le domaine agricole correspond au système parc à Karité et Néré. Les points de relevé de la flore sont les mêmes que ceux où les prélèvements de sol ont lieu.

Au niveau de Nara, une rencontre avec la direction du projet arbres autochtones a permis le choix des villages de Tindié dans la commune de Nara et de Alasso dans la commune de Dilly en présence du président de la chambre d'agriculture de Nara.

Au niveau du village de Tindié, le paysage présente des dunes aplanies alternant avec des dépressions interdunaires.

Les dunes aplanies sont fixées par une végétation ligneuse dominée par *Combretum glutinosum* à faible recouvrement (10-20%) et une herbacée comportant *Schoenefeldia gracilis*, *Eragrostis tremula* et *Cenchrus biflorus*. C'est la zone pastorale.

Les dépressions sont le domaine des cultures (mil et surtout sorgho). On y trouve des parcelles cultivées en *Hibiscus sabdarifa*. Dans les endroits les plus bas où se concentrent les eaux de ruissellement pour former des petites mares, on trouve dans le lit mineur, *Mitragyna inermis* , *Anogeissus leiocarpus*, *Ziziphus mauritiana*. Dans le lit majeur, on trouve, un peuplement comprenant essentiellement *Balanites aegyptiaca* et *Acacia seyal* faisant l'objet d'émondage par les pasteurs.

A Alasso, on retrouve a peu près les mêmes unités avec cependant des dépressions plus marquées sur au Nord du village. La végétation est plus dense (70 à 80%) aussi bien dans sa strate ligneuse comportant principalement *Combretum glutinosum*. Dans la strate herbacée, on trouve une dominance de *Andropogon*

pseudapricus associé à *Schoenefeldia gracilis* et *Cenchrus biflorus* sur les parties sableuses et Cacia tora dans les endroits limono-sableux. Des pieds isolés de *Balanites aegyptiaca* sont observés ça et là.

Dans les champs cultivés et les jeunes jachères, on trouve un système parc à *Sclerocarya birrea*. On y rencontre en sous-étage Combretum glutinosum. Des pieds isolés de *Commiphora africana* et de *Sterculia setigera* sont observés par endroit.

Dans le cercle de Kolokani, le village de Dotan situé dans la commune de Djidiéni et celui de Missira dans la commune de Sébékoro1 sont tous de la grande région naturelle du plateau mandingue. Si à Dotan, le village et la zone de culture sont coincés dans l'étroite vallée alluviale de la rivière Kalo du nom de la grotte où elle prend sa source, le village de Missira dispose de plus d'espace pour les cultures en raison de sa situation sur les terres alluviales du Baoulé. C'est le domaine de la savane arbustive à *Pterocarpus lucens*. On trouve aussi *Combretum glutinosum*, *Acacia macrostachya* et *Sclerocarya birrea*. Le recouvrement est de 50 à 60%. Des plages de sols gravillonnaires nus sont observées par endroit d'où la discontinuité de la couverture végétale. Le tapis herbacé comporte *Andropogon pseudapricus*. On trouve également Schyzachirium exilé et *Pennisetum pedicellatum* sous *Acacia seyal* dans les zones de concentration des eaux de ruissellement sur plateau cuirassé.

III.CONCLUSION :

Dans l'ensemble la mission s'est bien passée. Il est important de faire remarquer le changement intervenu dans les sites initialement proposés. Il s'agit en fait du remplacer du village de Kebane par celui de Tindié dans le cercle de Nara. La raison est toute simple. Sur le terroir nous nous sommes rendus compte qu'il y a deux Kebane : Kebane Sarakolé et Kebane Maure. On ne pouvait pas le traiter comme un seul village bien qu'évoluant sur le même terroir, chacun se considérant comme village à part entière. La mission a donc décider sur place de remplacer Kebane par Tindié pour éviter tout problème.

RAPPORT DE MISSION EFFECTUEE SUR LA MODELISATION : Projet SEMSOC OUAGADOUGOU 26 juin au 1er juillet 2006

Suivant ordre de mission n^0 001810 SB-RM du 19 juin 2006 une équipe du projet SEMSOC Mali composée de Dr Abdou Yehiya Maiga coordinateur national du projet, M Abdou Ballo du laboratoire sol-eau-plante de Sotuba et de M Mahamane Maiga de l'ISFRA s'est rendue à Ouagadougou pour participer à l'atelier de modélisation portant sur GEMS-CENTRY. Le modèle est alimenté par les données récoltées sur le terrain dans le cadre du projet dans les trois sites retenus : plateau de Koutiala (Kanika et Try), le plateau mandingue (Missira, N'Dotan) et le hodh (Tendie et Alasso). Ces données concernent l'occupation des sols, la socio-economie, la pluviométrie et les sols.
L'atelier a regroupe les participants du Burkina Faso, du Mali et du Niger.

Objet de l'atelier :

- Intégrer les différentes couches de données collectées (occupation du sol, pratiques culturales, pédologie…) dans un modèle qui simule la dynamique de l'utilisation des sols et les flux de carbone ;
- Interpréter les résultats obtenus ;
- Préparer le plan de rédaction du rapport final du projet.

Programme de la mission :

La mission s'est déroulée selon le programme si dessous :
24 juin 2006 Départ : Bamako – Ouagadougou par Air Sénégal International Vol N° V7 730
Du 25 au 30/6/06 préparation des paramètres d'entrée pour le modèle SEMSOC et préparation du plan de rédaction du rapport final du projet.

1 juillet 2006 Retour : Ouagadougou – Bamako par Air Sénégal International Vol N° V7 731

Déroulement de l'atelier :

Le programme a été adopté par les participants après l'ouverture de l'atelier. Les travaux de l'atelier étaient animés par Amadou Moctar DIEYE co-principal investigator of the SEMSOC project. Les travaux ont porte sur les points ci-dessous :

- préparation des paramètres d'entrée du modèle :

Ces paramètres sont les données de base indispensables pour faire tourner le modèle. Parmi les données de base nous pouvons citer entre autres : l'occupation du sol, les types de sol (la classe texturale, le drainage, le pouvoir de rétention), les éléments du climat (températures mensuelles et minimales, températures mensuelles maximales et la pluviométrie mensuelle), la pratique culturale et le système d'assolement rotation des parcelles. Les paramètres cités ci haut ont été fournis par les représentants des trois pays du projet. L'image des paramètres climatiques a été fournie par Amadou Moctar DIEYE.

Après nous avons procédé au contrôle de qualité des données fournies par les représentants des trois pays (Mali, Burkina Faso et le Niger). Ainsi, nous avons converti les données de base des coordonnées géographiques en projection Universel Tranversel Mector. Les données de base furent rastérisées. La rasterisation consiste transformer les fichiers vecteurs (shape file) en fichiers image au format grid. La transformation des différentes couches de données collectées (occupation du sol, pratiques culturales, pédologie…) en fichier grid a été élaborée á partir du logiciel ARCMAP. La méthodologie de conversion et de rastérisation sont les suivantes :

✓ **Des coordonnées géographiques en projection UTM**.
*Pour operer ce changement, aller dans le menu **Window** /Data management tools / projections and transformations / feature/project choisir la projection et le Datum correspondant.*

✓ **La conversion des fichiers shp en fichier grid**
Dans le menu *Window* *choisir Data conversion tools / feature to raster et définir Output cell size (optinal).*Cette étape est identique pour l'ensemble des couches de données de base.

Les couches d'occupation de sol et les types de sol ont été classifiés. Les classes font de 1 á 5 selon nombre de classes pouvant être trouvé sur un terroir donné. Quant aux données climatiques elles ont été extraites des données générales du climat en Afrique. Il s'agit de 12 fichiers (représentant les 12 mois de l'année).
Une fois les extractions finies nous avions procédé au *Ré-écchantillonnage des fichiers grid de 5000 à 250 mètres.*

- Modélisation :

Les données climatiques ont été combinées en un seul fichier. Le fichier de format *JFD* est crée par la combinaison des autres fichiers grid formés á partir des données de base. Le fichier JFD et le control.in constituent les programmes de base pour faire tourner le modèle ***GEMS-CENTURY.*** Le control.in enferme l'ensemble des fichiers de format txt des données de base.
Pour l'évaluation du taux du carbone de référence (1900), le fichier jfd a été joint au fichier de scmot du model00 1900. Le fichier scmot est le programme du modèle qui permet d'estimer le taux de du carbone avant l'an 2000. Le fichier scmot fut à son tour joint au fichier jfd de nos zones d'étude. Le résultat de cette jointure nous a permis d'estimer le taux du carbone par an et de faire des scénarises pour les années futures. Une carte a été produite par année. Une figure fut également produite pour constater l'évolution du carbone à partir logiciel EXCEL.

Conclusion :
Dans l'ensemble, on peut dire que l'atelier s'est bien déroule. Il a permis de mieux appréhender certaines difficultés liées au modèle et de finaliser la modélisation pour le terroir de Tendie. Les échéances à venir prévoient la poursuite des activités de modélisation avec les données des sites restant et un atelier en août 2006 à Accra au Ghana.

8. Appendices

- Appendix 1: National work plans, as established in January 2005
- Appendix 2: List of country experts identified at the beginning of the project, January 2005
- Appendix 3: Individual country reports (Ghana, Niger, Burkina Faso, and Mali); Fall 2006

National Work Plans, January 2005 (Appendix 1)

GHANA: OUTLINE OF ACTIVITIES FOR SEMSOC TASKS

Task 1:

Activities:

1) collect + collate all available info (sat. images; historical data), time series, ETM, TM (maybe Corona)
2) study sites/sample frames – national coverage
3) identify extremes: neg: Wassa West (surface mining), Bawku East (livestock, farming, devastated); Pos: Twifo-Hemang-Lower Denkyira (forest reserve); Mole National Park Damango District (savanna woodland, national park) and 1 well-managed area to be identified
4) prepare raster map for entire country
5) from there, identify "hotspots" (+ and – anomalies)
6) interpretation of maps
7) ground-thruthing/validation also to get NPP/biomass estimates
8) organize in database
9) prepare data for modeling

Key people:
- Prof Yakubu
- Emmanuel Tachie-Obeng
- Albert Allotey
- Roger Leh

Existing data:
- land use/land cover trends Ghana (EPA); scale = 1:250.000 (ongoing)
- LULC map; 2000, scale= same
- Soil survey data/map (date?; scale ?)
- Crop suitability map (date?, scale?), EPA, numerical
- State of forest reserves, map,
- Min. Ag., map, Date?
- Land suitability map
- Historical LULC, profile land use, legalities, Land Policy
- Images ETM 2000, 01, TM 85, 86, MSS 72, 73, Corona 66 (Accra only), NOOA daily

Data gaps:
- Corona for focal areas (scanned at AGRHYMET)

Training:
Yes, more needed: land cover interpretation (NPP/biomass/C)
2 to March workshop Niamey
1 workshop in Ghana to train other people at national level

Software: Erdas Imagine

Task 2:

Activities:

1) collect existing data
2) update + complement soil + biomass C measurements
3) land use/management history (questionnaire)
4) soil analysis SOC locally (C:N ratio, texture, moisture)
5) estimate C in biomass (different eco zones), allometric equations
6) analysis of land use/management history
7) correlation soil C trends + climate trends

Key people:
- Mark (soil)
- C Yamoah (soil)
- Mensah Bonsu (soil)
- Sam (soil)
- Morgan (biomass)
- Emma (biomass)

Existing data:
- for 5 ecological zones 0-10cm, 10-20cm, mean and range
- some complete soil profiles
- biomass: LULUCF (details?)
- climate data: series 61-present entire country (precip, t max min, daily, monthly, estimates evapotr., sunshine hours)
- more soil data? Soil Research Inst., soil FAO 1999 equivalents, typical profiles; ask for times series
- Forestry Research Inst. of Ghana (biomass data)? Now on strike
- Forestry Commission:

Data gaps:
Update where necessary

Equipment: Soil kit

<u>Task 3:</u>

Activities:

1) get data (land use, soils) from other group members
2) get data on crop yields (+ groundtruthing during biomass measurements and farmer interviews)
3) get data on management practices (task 4)
4) get data on plant C:N ratios from literature + some lab analysis for key plants
5) climate data: historical data (since 61), present, climate change scenarios (⇨ 2100)

Capacity building:
- 1-2 days introduction to Century/GEMS to entire group members (by Emma + Charles)
- More detailed training for experts as part of 4-country modeling workshop, with all real data (beginning 2006?); outputs = real model runs for each country
- Explore training possibilities on climate models (check with other countries)
- Explore possibilities to bring students to modeling workshop

Key people:

Minia – Emmanuel – Charles – Mensah – Adiku - Boateng

Task 4

Activities

Identify:

1) livelihoods strategies
2) policy drivers (Land tenure, pricing policies, non-traditional export promotion,
3) demographic drivers (population, migration, displacement,
4) economic drivers (economy, market….)
5) livelihoods assets
6) cultural drivers
7) crop calendar
8) land/community transect, village resources mapping
9) management history for individual fields
10) stratified households/fields survey
11) livelihood risks assessment (types of risks, responses and types of responses, success/failure responses
12) all cost and benefit categories and actual/projected values
13) benefit from carbon trading projects
14) discuss investment/sponsorship priorities
15) identify appropriate methods for each activity

Training

1) livelihoods/risks assessment
2) cost-benefit
3) participatory methods

- Introductory training for the entire group
- Detail training for field people (students + EPA staff)
- More specific training on C/B for identified experts

Key people:

Ramatu – Regina — Buabeng – Yakubu - Charles - Angelina

Data

Existing: Census data (from Statistical services),
GPRS (Ghana Poverty Reduction Strategy)
District profiles (districts assemblies)
Regional profiles (EPA)
Crop yields/areas estimates (Min. of Agric.)
National Initial Communication on CC
NCSA (National capacity self assessment; Min of Env. Sces , on-going)
Reports, studies, archives….
Population projections (last census 2000)
Land & Water management unit report in progress (MOFA: min. of Food Agric.)
Gaps: To be identified

Task 5

Activities:

1) Identify audiences/stakeholders (policy makers, researchers, farmers…)
2) Assess/create awareness and carbon literacy (stakeholders meetings, brochures, booklets….)
3) Create a medium of communication (network emails forum, discussion page…)
4) Create a website + metadata
5) Organize mid-term and final workshops
6) Working groups meetings (up to 4)
7) Communicate with other 3 countries + Senegal
8) Final regional workshop
9) Language issue ???

Key people:

EPA (Roger Leh?) (for metadata, website);
EPA national project coordinator (Emmanuel + Angelina)

For all tasks:

- think in terms of publishing (relevant journals, literature, co-authors)
- explore possibilities for students training/ Msc, PhD
- identify task leader

MALI : ACTIVITES PREVUES POUR LES 5 TACHES SEMSOC

TACHE 1 (Occupation/Utilisation des Sols):

Activités :
- état de lieu
  format : cartes, images, zonages, etc.
  paramètres (couvert végétal, sols, données climatiques)
- harmonisation de stratification (éco-région *versus* agro-écologique)
- évaluer les résultats existants de PIRL pour le calcul de biomasse dans les fenêtres (biomasse ligneuse)
- biomasse herbacée (NDVI AGRHYMET) prendre des mesures dans chaque fenêtre
- validation sur le terrain et actualisation (dans quelques fenêtres)
- critères de sélection des sites (diversité agro-écologiques + socio-économiques
- choix des sites (avec les autres groupes)

Personnes clef :
- Abdou Maiga
- Cheick Hamala Diakite
- Amadou Diallo
- Mahamane Maiga
- Khassoum Dieye
- Oumar Doumbia (sols)
- Mahamadou S. Keita
- Amidou Traoré

Données existantes :
- occupation des sols dans les fenêtres (1965, TM Landsat 5 98/99, LS 7 2000/01) occupation des sols, pourcentage
- zonage agro-écologique (PIRT)
- cartes NDVI (AGRHYMET)
- cartes PIRL

Données absentes :

?

TACHE 2 (Mesures de C):

Activités :
- quantification des stocks de carbone dans la biomasse à partir des résultats des images satellites (venant du groupe 1)
- vérité terrain biomasse/mesures (ground-truthing)
- demander types des sols
- reports historiques
- évaluer les résultats CRSP pour l'estimation du C dans les sols à partir des images Quickbird
- mesures de terrain C dans les sols
- analyse (discussion + harmonisation des méthodes avec les 3 autres pays)
- extrapolation
- calcul du budget national
- calcul des changements dans le temps

Personnes clef :
- Sibiri Traoré (C dans la végétation)
- Mamadou Doumbia
- Cheick Hamala
- Abdou Maiga
- Hamidou Konaré
- Modibo Cissé

Données existantes :
- base de données Labo des Sols
- cartes PIRT (échelle nationale ; 33 études de cas) et PIRL
- cartes des sols (pas pour tous les territoires)
- carte FAO
- études de cas

Données absentes :
- dériver une carte de C de la carte PIRT
- images satellite Quickbird pour des sites précis (éventuellement)

TACHE 3 (étude socio-économique)

Activités :
- concertations sur les méthodes
- revue documentaire (PANA, …)
- identifier les perceptions des populations sur les CC (observations faites par les pop. + stratégies développées par les populations)
- mener une analyse politico-institutionnelle (impacts des politiques sur la GRN ; impacts des institutions sur les GRN ; adéquation des instit/politiques par rapport aux capacités d'adaptation ;
- Comment faciliter un programme de marché de carbone
- Analyses de vulnérabilité aux différents risques
- Analyses des stratégies de modes de vie/survie (par rapport aux risques, périodes, contextes, et l'efficacité de ces stratégies et leurs impacts/feedback loops…)
- Inventaire et analyse des pratiques de GRN (parcelles, terroirs, CR, DevDurable ; efficacité et impacts…)
- Evaluer les coûts/bénéfices des pratiques (y compris marché de carbone) - en relation avec la typologie de la communauté (différents modes de vie) ;

- identifier les déterminants des changements de comportements (culturales, culturelles, sociales, politiques, économiques,…)

Personnes clef :
Abou Berthe
Mohamed Koite
Birama Diarra
Khassoum Dieye
Zana Jean Luc Sanogo
O. Sanogo
Amidou Traore
Modibu Sacko
Youssouf Siaka Kone
Mahamane Maiga
Aly Kouriba

Données existantes :
Documents, rapports, thèses et mémoires (CSLP, Mali prospective 2025, Schéma Direction Développement Rurale, PNAE, Plan Stratégies Recherche Agricole, Projet Adaptation to Impacts of CC (17 villages avec IER), Rapports CCD, CDB, CCCC …) ; recensements de population 1998 …)

Données absentes : (collecte au niveau des villages)

Formation :
- former l'équipe de chercheurs (méthodes participatives, CC, Carbone…)
- analyse de vulnérabilité, capacité d'adaptation
- former aux méthodes d'analyse coûts/bénéfices

TACHE 4 (Modélisation)

Activités :
- préparer des protocoles sur les données nécessaires dans les formats appropriés (pour les autres groupes)
- collecte des données (météo)
- compilation des données des autres tâches
- tourner le modèle/simuler
- analyse/interprétation des résultats

Personnes clef:
- Sibiri Traoré
- Cheikh Hamala Diakite
- Khassoum Dieye
- Mohamed Koité
- Abdou Maiga
- Birama Diarra
- Mamadou Doumbia
- Amadi Djouara
- Mme Awa Makalou
- Abdou Berthé
- Mahamadou S. Keita

Données existantes :
- données météo : des zones agro-écologiques : précipitation mensuelle, température
- Scénarios CC pour le Mali (à voir avec la Méteo) basés sur les modèles globaux
- données RGA (recensement général de l'agriculture)

- données pratiques – à demander au groupe 3
- données sols – à demander au groupe 2 (important : bulk density et variation)

Formation :
- en modélisation : en cascade (général pour l'ensemble et plus avancé pour les experts modélisation)
- à partir des données existantes (modélisation test) formation de base
- avec toutes les données réelles, modélisation majeur

TACHE 5 (réseaux d'échange):

Activités :
- créer le site web
- identifier web master (à plein temps)
- brochures
- réseau email (pour l'équipe)
- réseau pour les 4 pays (AGRHYMET)
- petits ateliers d'échange et de restitution : interne (2/an) et externe avec les 4 pays (1 rencontre annuelle)
- ateliers de restitution au niveau des communautés et peut-être autres
- base de données/meta-données
- publications scientifiques

au niveau régional : bulletin de liaison (à discuter, peut-être électronique)

Personnes clef :
- Mohamed Koité
- Amidou Traoré (base de données)
- Abdou Maiga
- Cheikh Hamala Diakité (site web)

NIGER : ACTIVITES et DATES PREVUES POUR LES 5 TACHES SEMSOC

Tâche 1: Evaluation de l'utilisation/occupation du sol (UOSOL)

Activités :
1) état des lieux (images, cartes, études, base de données, etc) ; inventaire, analyse
2) harmonisation des classifications (éco-régions, zones agro-écologiques, etc)
3) démarche méthodologique - choix des années
4) élaboration des cartes des changements UOSOL pour les autres fenêtres
5) calcul de biomasse pour les fenêtres pour les 3 années de référence
6) vérification UOSOL sur le terrain

Personnes clef :
AGRHYMET : André Nonguierma, Alfari, Job
INRAN : Ide Maiga, Garba Mallan Annou, Idrissa,
Direction de l'Env : Habibou Mamadou, Issa Ada, Abdou Nouhou, Hamani Saley, Amadou Seydou
UAM, IGN

Données existantes :
1) photos 56/75/84/96 (partie sud agricole), images Corona 64, Landsat 84/86, SPOT 96 , Landsat ETM+ 99/2000, MODIS 03/04

2) partie sud agricole : cartes occupation du sol 1975 (1 :100.000), Occupation du sol 1996 (1 : 200.000) ; Occupation du sol 2000 (Global Land Cover /GLC-FAO 2000, 1 :1.000.000) ;
3) carte de changements UOSOL pour une fenêtre (années 1965, 1986, 2000), plus le Département de Maradi (1956, 1975, 1986)

Données absentes :
A revoir après l'état des lieux

Formation :
Logiciel ERDAS : avec Agrhymet si néessaire

Tâche 2 : Mesures de carbone dans les sols et la biomasse

Activités :
1) Défintion de la méthodologie (y compris fiches terrain)
2) état des lieux : études réalisées
3) choix sites concernés, cartes des sols, cartes des projets terrain (différentes zones)
4) mesures/prélèvements de biomasse (racinaire, litière, aérienne) prélèvements de sols (0-20, 20-40cm)
5) analyse labo
6) extrapolation
7) chercher les explicatifs, dates et quantités de biomasse après récoltes
8) (en tenant compte du calendrier agricole) en relation avec le groupe 3
9) faire déjà les premières observations;

Personnes clef :
INRAN : Salou Moussa, Mahaman Issaka, Ichaou, Moussa Hassane, Maiyaki, Amadou Moustapha
Université : Guero Yadji, Nomao
AGRHYMET : Bakary Djaby, Traoré

Données existantes :
1) cartes des sols : ORSTOM (1 :500.000) couvrant le sud ; FAO 94 mise à jour en 2003 (1 :5,000.000) pour le pays entier,
2) différentes cartes des projets
3) cartes de biomasse AGRHYMET (mai – octobre)
4) avec le Ministère des Ressources Animales : sites biomasse (données numériques + spatialisées)

Données absentes :

Tâche 3 : Activités socio-économiques

Activités :
1) Recherche documentaire
2) y inclus choix des sites (avec les autres groupes, à voir à la fin du document)
3) Préparation de la méthodologie, des questionnaires, etc)
4) Enquêtes de terrain (pratiques d'UOSOL ; les logiques ; les perceptions des populations rurales aux changements climatiques, les politiques ; typologie des stresses et inventaire des stratégies d'adaptation (par mode de vie et système de production) + évaluation des stratégies dans le temps et l'espace; facteurs déterminants ; le sens donné à la séquestration du Carbone
5) Saisie, traitement et analyse des données
6) Evaluer les politiques et les aspects institutionnels (cohérence entre les différentes institutions et les politiques) ;

Les autres activités suivantes seront réalisées après le mois d'aout 2005:

Etudes économiques (prix au producteur, du marché, nouvelle valeur économique de certains produits (ex. biomasse, herbe) ;
Effets et impacts de l'OMC ;
Analyse coûts/bénéfices des pratiques actuelles par rapport aux options séquestration du Carbone; (revoir les modèles économiques tels que Stella)

Personnes clef :
INRAN : Mme Ibro Germaine ; Abdoulaye Tahirou, Moussa Hassane ; Idrissa Oumarou ; Moussa Boureima ;
Université : Abdoulaye Mohamadou ; Kore Harouna ;
AGRHYMET: Hubert Ndjaffa; Sacko ; Laouali ;
CNEDD : Gousmane Moussa, Mme Manou Ai ;

Données existantes :
Document Stratégique de Réduction de la Pauvreté DSRP (2002) ; SDR (Stratégie de Développement Rural, 2003) ; Sécurité Alimentaire et Vulnérabilité (Care International 99, travail effectué sur sept (7) régions) ; Communication Nationale sur les Changements Climatiques ; Stratégie Opérationnelle de Sécurite Alimentaire (SOSA, 99) ; PANA (Programme d'Action National pour l'Adaptation au Changememts Climatiques, en cours) ; Documente sur la Stratégie Nationale pour la Biodiversite et Stratégie pour les Changements Climatiques ; Les Zones Agro-écologiques du Niger (FAO, 1989) ; les thèses et mémoires ; Monographies et diagnostics villageois (INRAN/Département Economie) ; Systèmes de Production au Niger ; Etat de l'Environnement au Niger (2003, CNEDD) ; RGPH (Recensement Général de la Population et de l'Habitat, 2001) ; PNEDD (Plan National de l'Environnement por le Déeveloppement Durable, 2000) ; Enquêtes ménages (CNEDD, Pripan 2004, Sur l'improtance de la biomasse foliaire dans l'alimentation des ménages) ; Plan d'Action National pour la Lutte Contre la Desertification et pour la Gestion des Ressources Naturelles (PANLCD/GRN, CNEDD, 2001) ; Pratiques d'utilisation des Ressources Naturelles (CILSS) ; SIM (Système d'Information sur les Marchés)

Données manquantes :
A revoir en fonction des sites

Formation :
1) Echanges et mise à niveau et harmonisation entre techniciens et chercheurs sur le sens à donner à la séquestration du Carbone et choix des termes/concepts à utiliser durant les enquêtes de terrain
2) Formation aux méthodes participatives axées sur la vulnérabilité et la capacité d'adaptation; (Agrhymet parmi les formateurs ; voir aussi les outils et méthodes de CARE)
3) L'équipe s'attachera les compétences complémentaires pour mener à bien le travail;

Tâche 4 : Modélisation

Activités :
2) Préparer une liste des données nécessaires (+ le format) pour chaque groupe
3) Etat des lieux des données disponibles
4) Collecter les données sur le climat
5) Collecter les données de scénarios climatiques IPCC

A partir de janvier 2006 :
6) Assimiler/caller les données des autres groupes pour le modèle
7) Tourner le modèle
8) Analyser les sorties/résultats
9) échange avec les autres groupes pour l'interprétation

Experts :
INRAN : Amadou Moustapha, Mamadou Gandah, Salou Moussa, M. Issaka, Abdoulaye Tahirou
AGRHYMET : Abou Hamani, Traoré Seydou, Benoit Sarr, André Nonguierma, Hubert Ndjeffa,

Direction de l'Environnement : Amadou Seydou
CNEDD : Adamou Issaka, Attari Boukar
Direction de la Météorologie Nationale : Daouda Mamadou
IRD : Luc, Jean-Louis Rajot
ICRISAT : Bruno Gérard
Direction de l'Agriculture : Bassirou Amadou
Université (Faculté Agronomie) : à identifier

Données existantes : collecte de données à travers les autres groupes

Formation :
1) Formation générale pour toute l'équipe + recyclage (formation plus poussée pour les experts chargés de la modélisation)
2) Appui technique à l'équipe modélisation

Tache 5 : Information, communication, échange

Activités :
1) connection sur internet pour INRAN ;
2) créer/héberger site web INRAN à lier avec d'autres sites existants ;
3) constitution des bases de données ;
3) réseautage (réunions inter/intra groupes, forum d'échange sur internet) ;
4) bulletin de liaison ;
5) notes aux décideurs
6) fiches techniques, mass media (conférences, télé débats, JPO (journée porte ouverte),
7) création d'un comité carbone national ;
8) publications scientifiques ;
9) recherche/revue des publications existantes en pdf et mise à la disposition des équipes (*mars05 – juillet06, travail à partir de Penn State University/Petra)*
10) atelier sous-régional (avec les 4 pays) ;
11) faciliter la participation aux conférences internationales ;

Personnes clef :
INRAN : Moustapha Soumailou, Mahamadou Gandah, Mme H. Adamou (création site web, base de données, navigation internet) ;
B. Kanfideni, Farmo Amadou (fiches techniques, bulletins), Amadou Moustapha (publications scientifiques)
CNEDD : Gousmane Moussa (échanges, base de données, ateliers….)
AGRHYMET : Ali Kaba (base de données, site web)
Université : Campus numérique

Nota Bene :

1) Choix des sites à faire en concertation avec tous les groupes *(février)*
2) Privilégier l'implication des étudiants dans les différentes activités.
A coordonner avec Amadou Moustapha (INRAN) et Guero Yadji (Université) ; (*février)*

BURKINA : ACTIVITES POUR LES 5 TACHES SEMSOC

Tâche 1: Evaluation de l'utilisation/occupation du sol (UOSOL)

Activités :
- l'état des lieux sur les données (cartes, rapports, études, images, photos aériennes, etc.)
- évaluation de l'état des lieux
- choix des sites (à voir avec les autres groupes)
- travaux complémentaires : validation/interprétation d'étude UOSOL, extrapolation
- augmenter l'échantillonnage des sites existants pour prendre en compte la réalité complexe des zones agro-écologiques (déjà 50 sites suivis par l'INERA)
- vérification des résultats des études des images/cartes sur le terrain (dont la biomasse)
- déduction/calcul de la biomasse

Institutions/Personnes clef :
- INERA : Georges Yameogo
- CONEDD : Jean Abdias Compaoré
- Univ/Dept de Géographie : H.P. Somé
- SIGET : Serge Assim Da, Patrice Sanou
- BUNASOLS : Roger Kissou
- BUMIGEB : Alexis Soulama
- Direc National des Forets : Coulibaly Sia

Données existantes :
- base de données Occupation de terres, 1992, 2002, 1 :200.000 ; (PNGT/IGB)
- base de données topographiques, 1 :200.000 ; 100% du territoire (PNGT/IGB)
- base de données pédologiques, 1 :100.000 ; 60% du territoire (BUNASOLS) et plus cartes partielles
- fichiers Excel sur l'évaluation d'O/US sur toutes les fenêtres (65, 85, 99) (INERA + ex DSA) ; 14 zones avec des fenêtres ; % d'occupation ; harmonisation à niveau USGS ;
- base de données sur les feux de brousse, 2001-03 (PNGT) ; 1 :1,000.000
- estimation de la biomasse ligneuse et herbacée, 2003 mesures de terrain (PNGT, INERA) ;
- base de données sur les bas-fonds ; (PNGT, PAFR (plan d'action filière riz), INERA, SIGET)
- carte fertilité/dégradation des sols
- cartes topo, 1 :50.000 (numériques), IGB
- base de données sue des ressources en eau (DGIRH)
- cartes démographiques humaines et du cheptel (Services de l'Elevage, Inst. National Statistiques et Démographique)
- base de données sur les localités du BF (les villages), PNGT, INSD
- données climatiques (Dir Météo)
- Inventaire Forestier des Ressources Ligneuses, 78, 87 (PNGIM)
- Base de données sur les ressources animales (M des Ressources Animales)
- Données sur ressources minérales (BUMIGEB)

Formation :
- formation interne/partage des connaissances sur les outils/méthodes
- formation sur l'utilisation des images NOAA, SPOT/Végétation…

<u>Tâche 2</u> : Mesures de carbone dans les sols et la biomasse

Activités :
- l'état des lieux sur les données (rapports, études etc.)
- évaluation de l'état des lieux
- choix des sites (à voir avec les autres groupes)
- mesures de biomasse (espèces clef pour les relations allométriques) et analyse + estimation C
- collecte des équations allométriques existantes
- prélèvement des sols (y inclut teneur + densité apparente) et analyse + estimation C
- paramétrage des données (comparabilité des méthodes d'analyse)
- extrapolation

- évaluation dans le temps – analyse tendancielle
- estimation des résidus de récoltes (utilisations des residus)
- correspondance avec les résultats des études des images/cartes
- écrire le rapport (bilan C et composante économique) ; contribution potentielle du marché de C dans la Comptabilité Nationale ;

Institutions/Personnes clef :
- INERA : Edmond Hien, Victor Hien
- Univ/Dept de Géographie : Emmanuel Bandré
- SIGET : Léopold Somé (INERA), Jean-Baptiste Taonda (INERA)
- BUNASOLS : Roger Kissou
- BUMIGEB : Alexis Soulama
- Direc National des Forets : Coulibaly Sia, Rouamba Tenga, Kaboré Cyrille
- Inst Développement Rural/Bobo :
- Centre National des Semences Forestières :
- Ressources animales
- Point Focal CC

Données existantes :
- base de données pédologiques, 1 :100.000 ; 60% du territoire (BUNASOLS) et plusieurs cartes partielles
- Inventaire Forestier des Ressources Ligneuses, 78, 87 (PNGIM)
- 1ière Communication Nationale CC
- estimation de la biomasse ligneuse et herbacée, 2003 mesures de terrain (PNGT, INERA) ;
- étude sur la biomasse (Institut du Sahel) ;
- document sur les relations allometriques (voir avec Jean Abdias Compaoré) ;
- faune/cheptel (pour la pression sur la biomasse)?

Formation :
- formation interne/partage des connaissances sur les outils/méthodes
- formation des nationaux sur l'évaluation de l'état de référence en Carbone ; (Panel IPCC (International Panel sur les Changements Climatiques) sur les méthodologies)

<u>Tâche 3</u> : Activités socio-économiques

Activités :
- l'état des lieux/**recherche documentaire** (évolution des systèmes de production/conservation, marchés et commercialisation des produits, connaissances, gestion foncière) ; **évaluation** de l'état des lieux ;
- **enquêtes** : connaissances locales, savoir-faire, typologie des exploitations/modes de vie (via enquêtes ménages), source d'énergie domestique/utilisation du bois de service/œuvre/ chauffe; **étude des marchés**,
- analyse des **pratiques de GRN** / aménagement des formations végétales (acquis et contraintes, niveau politique et communautaire, foncier,
- identifier les **types de stress** (actuel/passe/futur)
- identifier les **stratégies d'adaptation** et évaluer leurs efficacités / par rapport aux moyens d'existence,
- mener une **analyse politico-institutionnelle** (impacts des politiques + mesures d'atténuation,
- Analyse **coûts/bénéfices**, viabilité économique et écologique des actions de GRN; les bénéfices potentiels dans l'engagement des populations dans des activités de séquestration de Carbone ;

Institutions/Personnes clef :
- INERA : Alfred Ouedraogo, Daniel Kaboré (économiste), Georges Yameogo (foresterie, énergie)
- CONEDD : Louis Blanc Traoré,
- Université : Pr. Honore Somé,
- INSD :

- Statistiques agricoles : Bila
- SIGET : Patrice Sanou, Idani Fulgence
- PNGT : Dominique Zongo, Pamoussa Zongo
- Comite National des Secours d'Urgence (CONASUR):

Données existantes :
- Documents, rapports : Diversité Biologique, Savoir faire traditionnel, PANA (en cours, CONEDD), BDLB (base de données sur les localités, Zones vulnérables (CONASUR) ; 1ere Communication Nationale (CONEDD, 2002) ; Enquêtes prioritaires (INSD) ; Rapports des Projets ; PAN/LCD ; RAF (reforme agraire et foncière, 1996), etc.
- RGPH (1985, 1996, 2004) ; recensement de l'administration générale

Formation :

- Atelier sur la problématique du Carbone et autres Gaz à effet de Serre (avec CONEDD, Banque Mondiale, INERA): CC, PK, aspects économiques, MDP, Atténuation, Adaptation, Partenariat Public Privé),

Tâche 4 : Modélisation

Activités :
- Documentation sur les expériences d'application du modèle
- Elaborer le format de collecte des variables d'entrée du modèle (à l'intention des autres groupes)
- Collecte des données climatiques + scenarii climatiques ;
- Valider et intégrer les données ;
- Faire tourner le modèle ;
- Analyser les résultats, valider et documenter ;
- Rédiger, valider et publier les rapports.

Experts :
- SIGET-A : Patrice Sanou, Leopold Some, Jean Baptiste Taonda
- CONEDD : Louis Blanc Traoré, Jean Abdias Compaoré, Adama Diallo, Cyrille Kaboré, Lambert Ouedraogo
- INERA : Moussa Bonzi, Edmond Hien, Ouattara Korodjouma, Moussa Sanou
- Meteo : Ali Garane, Frederic Ouattara, Pascal Yaka

Données existantes :
- données provenant des autres tâches
- Données météo

Formation :
- formation initiale pour tous les experts
- formation approfondie pour les experts en charge de la modélisation

Tache 5 : Information, communication, échange

Activités :
- Créer un site web sous-régional + un site/portail national dédié au carbone (SP/CONEDD) ;
- un réseau email interne/national et sous-régional ;
- bulletins papier pour le public + numérique sur le site ;
- dépliants + poster ;
- CD-ROM multimédia, + autres supports a la fin du projet ;
- Atelier sous-régional annuel avec les 4 pays ; au début ? au milieu du projet ou à la fin ?;
- Ateliers nationaux de restitution ;
- Créer une Base de données + méta-données pour capitaliser les données disponibles ;
- Accéder aux publications scientifiques dans les revues (exemple abonnement à Elsevier, INIST/CNRS)
- Faciliter la participation et présentations dans des manifestations ;
- Faciliter l'accès aux publications disponibles dans le domaine ;

- Compilation périodique des docs publiés dans le domaine (sur CD ou sur un site web) ;
- Traduction en anglais ;

Institutions/Personnes clef :
BUMIGEB : Souleymane Mihin (conception BD, page web, doc…)
SP/CONEDD : Paul Tapsoba, Janvier Bazoun (conception BD, page web, doc, Internet, métadonnée…)
SIGET : Boris Yameogo (journaliste), Patrice Sanou (conception; géo-information, SDI) ;

Existant :
- Réseau du CONEDD
- Base de données documentaires du CONEDD (+30,000 références, ISIS, MSAccess) ;
- BD sur les fonctions allométriques (avec J. Abdias)

<u>Pour toutes les 5 tâches, tous les 5 groupes :</u>

Choix des sites :
Critères :

I. Typologie des exploitations/modes de vie/systèmes économiques ;
II. Plateau Central : plusieurs publications (+14) ; 12 sites ont été étudies ;
III. Prendre en compte les grands groupes de sols

APPENDIX 2 :

Experts/Personnes Clef et Organisations Nationales et Régionales pour le Projet SEMSOC

Expertise	Noms	Institution	Téléphone	Adresse e-mail	Présence SEMSOC Janvier 2005
GHANA					
Land Use/Land Cover change GIS and image interpretation	Emmanuel Tachie-Obeng	Environmental Protection Agency, P.O. Box M 326 Accra,	021-662465, 020-8196879	etachieobeng@yahoo.com eobeng@epaghana.org	+
	Albert Allotey	Department of Geography and Development studies, University of Ghana, Legon	021-500394	allotey@ug.edu.gh	+
	Enoch Boateng	Soil Research Institute, Accra Centre	021- 778226	soils@africaonline.com.gh	+
	Dela Dedzoe	Soil Research Institute		soils@africaonline.com.gh	-
	Prof. Yakubu	University of Cape Coast	0244-378726	yakubuh@hotmail.com yakubuh@ncc.edu.gh	+
	Roger Leh	EPA	021-662465, 0244-382900	rojolensleh@epaghaa.org	+
Carbon measurements (soil, biomass)	Charles Yamoah	SM – CRSP Sahel P.O. Box AH 1254, Achimota College, Accra,	0244 - 791226	yamoahcf@yahoo.com	+
	Emmanuel Tachie-Obeng	Environmental Protection Agency, P.O. Box M 326 Accra,	021-662465, 020-8196879	etachieobeng@yahoo.com eobeng@epaghana.org	+
	Edward Yeboah	Soil Research Institute, Academy Post Office, Kwadaso Kumasi		Eyeboah5@hotmail.com	-
	Rev. Prof. Mensah Bonsu	Dept of Soil Science, University of Cape coast	042-30851, 0244-704512	mensbons@yahoo.com	+
	Abekoe Mark	Soil Science Department, University of Ghana, P.O. Box 245, Fac. Of Agric. Legon	021-500180	k-abekoe@ng.edu.gh	+
	Adiku Sam G. K	Soil Science Dept, University of	0277-734060	sadiku@ug.edu.gh	+

		Ghana			
	Morgan	?	?	?	-
Biogeochemical modeling	Adiku Sam G. K	Soil Science Dept, University of Ghana	0277-734060	sadiku@ug.edu.gh	+
	Emmanuel Tachie-Obeng	Environmental Protection Agency, P.O. Box M 326 Accra,	021-662465, 020-8196879	etachieobeng@yahoo.com eobeng@epaghana.org	+
	Z. Minia	Metrological Services of Ghana, P.O. Box 87 Legon, Accra	021-7012520	metro@africaonline.com.gh	+
	Naab, J.B	Savanna Agricultural Research Institute		jbnaab@sfricaonline.com.gh	-
	Charles Yamoah	SM – CRSP Sahel P.O. Box AH 1254, Achimota College, Accra,	0244 - 791226	yamoahcf@yahoo.com	+
	Enoch Boateng	Soil Research Institute, Accra Centre	021- 778226	soils@africaonline.com.gh	+
Socio-economic assessments and/or Adaptation AND Farming systems and extension (management practices)	Prof. Ramatu Alhasan	Dept of Agro. Economic & Faarm Mgt Faculty of Agriculture, University of Ghana	021- 512902	aramatu@ug.edu.gh	+
	Dr. Regina Sagoe	Agricultural Science Dept, KNUST, Kumasi	0244-441984	r.sagoe@cropresearch.org	+
	Prof. Yakubu	University of Cape coast	0244-378726	yakubuh@hotmail.com yakubuh@ncc.edu.gh	+
	Stephen Nkasna-Buabeng	BIRD, KNUST, Kumasi	020-8168541	snbuabeng@yahoo.com	+
	Angelina Tutua Mensah	Environmental Protection Agency	0244-379159		+
	Charles Yamoah	SM – CRSP Sahel P.O. Box AH 1254, Achimota College, Accra,	0244 - 791226	yamoahcf@yahoo.com	+
	Vincent Anchirinah	Crops Research Institute		anchirinah@yahoo.com	-
	Harison Dapaah	Crops Research Institute		HDapaah@hotmail.com	-
Project	William Agueman-Bonsu	EPA, P.O. Box M326 Accra		wbonsu@epaghana.org	-

implementation – national requirements					
	Asiamah, R.D.	Soil Research Institute, Academy Post Office, Kwadaso, Kumasi		soils@africaonline.com.gh	-
Information & communication	Emmanuel Tachie-Obeng	Environmental Protection Agency, P.O. Box M 326 Accra,	021-662465, 020-8196879	etachieobeng@yahoo.com eobeng@epaghana.org	+
	Roger Leh	EPA	021-662465, 0244-382900	rojolensleh@epaghaa.org	+
	Edward Yeboah	Soil Research Institute, Academy Post Office, Kwadaso Kumasi		Eyeboah5@hotmail.com	-
MALI					
Utilisation/occupation des sols - SIG et interprétation des images	Dr Cheick Hamala Diakité	LABOSEP/IER	224.61.66	hamala.diakite@ier.ml	+
	Dr Abdou Maiga	IER	222.26.06 223.19.05 644.95.83	abdou.maiga@ier.ml	+
	Sibiri Traoré	ICRISAT		p.s.traore@cgiar.org	-
	Amadou Diallo	Institut Géographique du Mali (IGM)	220.28.40 676.08.13	diallopoulo61@yahoo.fr	+
	Mahamane Maiga	ISFRA Université de Bamako		mahamane_alido@yahoo.fr	+
	Khassoum Dieye	Institut du Sahel	223.40.67	dieye@agrosoc.insah.org	+
	Mahamadou S. Keita				**?**
	Amidou Traoré	STP/CIGQE	223.10.74 678.44.07 618.62.25	amtraore22@yahoo.fr amidoutraore222@hotmail.com stp@timbagga.com.ml	+
Mesure de carbone (sol, biomasse)	Dr Mamadou Doumbia	LABOSEP/IER	224.61.66 673.96.28	madu.doumbia@ier.ml	+
	Dr Abdou Maiga	IER	222.26.06 223.19.05	abdou.maiga@ier.ml	+

			644.95.83		
	Oumar Doumbia	IER		Oumar.doumbia@ier.ml	-
	Dr Abdoulaye Bayoko	CNRST		projetgef@afribone.net.ml	-
	Modibu Cissé	Direction Nationale de la Conservation de la Nature	223.36.95/97	conservationature@datatech.net.ml	+
	Sibiri Traoré	IER			-
	Amadou Mallé Kouyaté	IER		Amadou.kouyate@ier.ml	-
	Dr Abdoulaye Bayoko	CNRST		projetgef@afribone.net.ml	-
	Dr Cheick Hamala Diakité	LABOSEP	224.61.66	hamala.diakite@ier.ml	+
Modélisation biochimique	Dr Cheick Hamala Diakité	IER/LOBOSEP	224.61.66	hamala.diakite@ier.ml	+
	Sibiri Traoré	ICRISAT		p.s.traore@cgiar.org	-
	Khassoum Dieye	Institut du Sahel	223.40.67	dieye@agrosoc.insah.org	+
	Mohamed Koité	Direction Nationale de la météorologie	229.62.03	Koite_mohamed@caramail.com mohamedkoite@yahoo.fr	+
	Dr Abdou Maiga	IER	222.26.06 223.19.05 644.95.83	abdou.maiga@ier.ml	+
	Birama Diarra	Direction Nationale de la météorologie. Chef division recherche et développement	610.34.28	biramadia@yahoo.fr	+
	Dr Mamadou Doumbia	LABOSEP/IER	224.61.66 673.96.28	madu.doumbia@ier.ml	+
	Amadi Djouara				-
	Mme Awa Makalou				-

Recherche socio-économique et/ou adaptation ET Systèmes agraires et de vulgarisation agricole/forestière (pratiques de gestion des ressources)	Abou Berthé	IER	224.78.53 646.35.74	abou.berthe@ier.ml	+
	Ousmane Sanogo	IER		Ousmane.sanogo@ier.ml	-
	Zana Jean Luc Sanogo	ESPGRN Sikasso	2620.028 672.80.74	zjlsanogo@yahoo.fr	+
	Boubacar S. Berthé	STP		stp@timbagga.com.ml	-
	Khassoum Dieye	Institut du Sahel	223.40.67	dieye@agrosoc.insah.org	+
	Mohamed Koité	Direction Nationale de la météorologie	229.62.03	Koite_mohamed@caramail.com mohamedkoite@yahoo.fr	+
	Birama Diarra	Direction Nationale de la météorologie. Chef division recherche et développement	610.34.28	biramadia@yahoo.fr	+
	Moussa Dembelé	STP		stp@timbagga.com.ml	-
	Amidou Traoré	STP/CIGQE	223.10.74 678.44.07 618.62.25	amtraore22@yahoo.fr amidoutraore222@hotmail.com stp@timbagga.com.ml	+
	Modibo Dr.Sacko	Direction Nationale de l'assainissement et du contrôle des pollutions et des nuisances	229.38.04 229.24.10 671.49.83	dnacpn@experco.net dnacpn@datatech.toolnet.org	+
	Mahamane Halidou Maiga	ISFRA Université de Bamako		mahamane_alido@yahoo.fr	+
	Aly Kouriba	Institut d'Economie Rurale	222.26.06 223.19.05	aly.kouriba@ier.ml	+
	Youssouf Siaka Koné	Programme Economie des Filières Institut d'Economie Rurale	221.59.04 618.66.83	youssouf.koné@ier.ml	+
Mise en œuvre de projets-formalités et contenu	Dr Abdou Maiga	IER	222.26.06 223.19.05 644.95.83	abdou.maiga@ier.ml	+
	Dr Ibrahima N'Diaye	IER		Ibrahima.ndiaye@ier.ml	-
	Mama Konaté	Direction Nationale de la météorologie	229.62.03 229.51.49	dnm@afribone.net.ml ou ma_konate@yahoo.com	+

Information et communication	Dr Ibrahima N'Diaye	IER		Ibrahima.ndiaye@ier.ml	-
	Amidou Traoré	STP/CIGQE	223.10.74 678.44.07 618.62.25	amtraore22@yahoo.fr amidoutraore222@hotmail.com stp@timbagga.com.ml	+
	Mohamed Koité	Direction Nationale de la météorologie	229.62.03	Koite_mohamed@caramail.com mohamedkoite@yahoo.fr	+
	Dr Abdou Maiga	IER	222.26.06 223.19.05 644.95.83	abdou.maiga@ier.ml	+
	Dr Cheick Hamala Diakité	LABOSEP/IER	224.61.66	hamala.diakite@ier.ml	+
	Mahamadou S. Keita				+
NIGER					
Utilisation/occupation des sols - SIG et interprétation des images	Maiga Alirou Ide	INRAN Cerra Niamey BP 429	(227) 725389	inran@intnet.ne	+
	Andre Nonguierma	Agrhymet (GIS, LUCL, Modelisation)	(227) 733116	A.nonguierma@agrhymet.ne	+
	Alfari	Agrhymet			-
	Job	Agrhymet			-
	Garba Mallan Annou	INRAN Cerra Niamey BP 429	(227) 742967	garbaam@yahoo.fr , inran@intnet.ne	+
	Dr Mahamane Issaka	INRAN		inran@intnet.ne	-
	Habibou Mamadou	Direction de l'Environnement			-
	Issa Ada	Direction de l'Environnement			-
	Abdou Nouhou	Direction de l'Environnement			-
	Hamani Saley	Direction de l'Environnement			-
	Amadou Seydou	Direction de l'Environnement	(227) 733329	amaseyda@yahoo.fr	+
Mesure de carbone (sol, biomasse)	Salou Moussa	INRAN Cerra Niamey BP 429	(227) 885352	inran@intnet.ne	+
	Guero Yadji	Faculte d'Agronomie BP 10960, Niamey	(227) 737238	cresa@intnet.ne	+

	Dr Mahamane Issaka	INRAN		inran@intnet.ne	-
	Djaby Bakary	Agrhymet		b.djaby@agrhymet.ne	-
	Danso Abdoulie	CILSS		abdoulie.danso@cilss.org	-
	Ichaou	INRAN			-
	Moussa Hassane	INRAN			-
	Amadou Moustapha	INRAN	(227) 963085	Moustapha-amadou@netcourrier.com	+
	Maiyaki	INRAN			-
	Nomao	Université			-
	Traoré	Agrhymet			-
Modélisation biochimique	Amadou Moustapha	INRAN	(227) 963085	Moustapha-amadou@netcourrier.com	+
	Dr. Mahamadou Gandah	INRAN		inran@intnet.ne	-
	Traoré Seydou	Agrhymet		s.traore@agrhymet.ne	-
	Benoit Sarr	Agrhymet		b.sarr@agrhymet.ne	-
	Salou Moussa	INRAN Cerra Niamey BP 429	(227) 885352	inran@intnet.ne	+
	Dr Hubert Djafa Ouaga	Agrhymet (geographe)	(227) 733116	N.ouaga@agrhymet.ne	+
	Andre Nonguierma	Agrhymet (GIS, LUCL, Modelisation)	(227) 733116	A.nonguierma@agrhymet.ne	+
	Adamou Issakha Ounteni	SE/CNEDD (Conseil National de l'Environnement pour un Développement Durable), BP 10193	(227) 722559	ftppount@intnet.ne	+
	Boukar Attari	SE/CNEDD, BP 10193	(227) 722559	attariboukar@yahoo.fr	+
	M. Issaka	INRAN		inran@intnet.ne	-
	Abou Hamani	Agrhymet			-
	Amadou Seydu	Diredction de l'Environnement			+
	Jean-Louis Rajot	IRD			-
	Bruno Gérard	ICRISAT			-
	Amadou Bassirou	Direction de l'Agriculture			-
Recherche socio-économique et/ou adaptation	Tahirou Abdoulaye	INRAN Cerra Niamey BP 429	(227) 983290	t.abdoulaye@coraf.org	+
	Germaine Ibro	INRAN Cerra Niamey BP 429	(227) 979659	geribro@yahoo.fr	+
	Abdoulaye Mohamadou	Faculte Agronomie		azawagh@yahoo.fr	+

ET Systèmes agraires et de vulgarisation agricole/forestière (pratiques de gestion des ressources)	Moussa Hassane	INRAN Cerra Niamey BP 429	(227) 980457	Khmoussa_2@hotmail.com	+
	Moussa Boureima	INRAN			-
	Idrissa Oumarou	INRAN			-
	Abdoulaye Mohamadou	Université			-
	Kore Harouna	Université			-
	Dr Hubert Djafa Ouaga	Agrhymet (geographe)	(227) 733116	N.ouaga@agrhymet.ne	+
	Sacko	Agrhymet			-
	Laouli	Agrhymet			-
	Gousmane Moussa	SE/CNEDD (Conseil National de l'Environnement pour un Développement Durable), BP 10193	(227) 722559	biocnedd@intnet.ne	+
	Mme Manou Ai	CNEDD			-
	Adamou Issakha Ounteni	SE/CNEDD, BP 10193	(227) 722559	ftppount@intnet.ne	+
Mise en œuvre de projets-formalités et contenu	Dr. Mahamadou Gandah	INRAN		inran@intnet.ne	-
	Gousmane Moussa	SE/CNEDD (Conseil National de l'Environnement pour un Développement Durable), BP 10193	(227) 722559	gmoussa@caramail.com	+
	Dr Hubert Djafa Ouaga	Agrhymet (geographe)	(227) 733116	N.ouaga@agrhymet.ne	+
	Bertrand Zida	CILSS		bertrand.zida@cilss.org	-
Information et communication	Mme Adamou Hadiza Gabey	INRAN	(227) 725389	inran@intnet.ne hadizagabey@yahoo.fr	+
	Kanfideni Boureima	INRAN / CLRV	(227) 981876	inran@intnet.ne	+
BURKINA FASO					
Utilisation/occupation des sols - SIG et interprétation des images	Jean Abdias Compaoré	PNGIM-SP/CONEDD MECV	(226) 50307343	abdiasj@netscape.net	+
	Patrice Sanou	Centre SIGET-A	(226) 50399578 (226) 70239412	sanoup@fasonet.bf	+

	Georges Yameogo	INERA	(226) 31920208	georges.yameogo@messrs.gov.bf	+
	Alexis Soulama	BUMIGEB	(226) 70249942	soulalex@yahoo.com	+
	Souleymane Mihin	BUMIGEB	(226) 70265966	mihin_souley@yahoo.com	+
	Serge Assim Da	Centre SIGIT-A	(226) 70260586	asergeda@yahoo.fr	+
	Louis Blanc Traoré	SP/CONEDD	(226) 70267951	lbtraore@yahoo.fr	+
	Coulibaly Sia	Direction National des Forets			-
	Roger Kissou	BUNASOLS	(226) 50361103	kissouroger@yahoo.fr	+
Mesure de carbone (sol, biomasse)	Roger Kissou	BUNASOLS	(226) 50361103	kissouroger@yahoo.fr	+
	Edmond Hien	INERA	(226) 70263636	edmondhien@hotmail.com	+
	Victor Hien	INERA	(226) 70254872		-
	Enmmanuel Bandré	Université Ouaga	(226)		-
	Léopold Somé	INERA	(226) 78801371		-
	Jean Baptiste Toanda	INERA/SIGET-A	(226) 70262244		-
	Coulibaly Sia	Direction National des Forets			-
	Rouamba Tenga	Direction National des Forets			-
	Kaboré Cyrille	Direction National des Forets			-
Modélisation biochimique	Moussa Bonzi	INERA			-
	Edmond Hien	INERA	(226) 70263636	edmondhien@hotmail.com	+
	Ouattara Korodjouma	INERA			-
	Moussa Sanou	INERA			-
	Patrice Sanou	Centre SIGET-A	(226)	sanoup@fasonet.bf	+

			50399578 (226) 70239412		
	Léopold Somé	INERA/SIGET-A	(226) 78801371	lsome@lipinfor.bf	+
	Jean Baptiste Taonda	SIGET-A			-
	Jean Abdias Compaoré	PNGIM-SP/CONEDD MECV	(226) 50307343	abdiasj@netscape.net	+
	Louis Blanc Traoré	SP/CONEDD	(226) 70267951	lbtraore@yahoo.fr	+
	Adama Diallo	CONEDD			-
	Cyrille Kabore	CONEDD			-
	Lambert Ouedraogo	CONEDD			-
	Ali Garane	Direction de la Météo			-
	Frederic Ouattara	Direction de la Météo			-
	Pascal Yaka	Direction de la Météo			-
Recherche socio-économique et/ou adaptation ET Systèmes agraires et de vulgarisation agricole/forestière (pratiques de gestion des ressources)	Alfred Ouedraoago	INERA	(226) 70277851	alfredouedraogo@yahoo.com	+
	Honoré Somé	Project ENRECA, Université Ouaga	(226) 70262915	poyouor.some@univ_ouaga.bf	+
	Fulgence T. Idani	ENSK/Université Ouaga	(226) 70284875	fulgencetalaridia@yahoo.fr	+
	Daniel Kaboré	INERA			-
	Georges Yameogo	INERA	(226) 31920208	georges.yameogo@messrs.gov.bf	+
	Louis Blanc Traoré	SP/CONEDD	(226) 70267951	lbtraore@yahoo.fr	+
	Bila	Statistiques Agricoles			-
	Patrice Sanou	Centre SIGET-A	(226) 50399578 (226) 70239412	sanoup@fasonet.bf	+
	Dominique Zongo	PNGT			-
	Pamoussa Zongo	PNGT			-
	Félicité Kaboré	PDRDP-B/K	(226)	kabfeli@yahoo.fr	+

			70269430		
Mise en œuvre de projets-formalités et contenu	Mamadou Honadia	Ministère Environnement, Point Focal Changements Climatiques	(226) 70240240	honadia@voila.fr, honadia@fasonet.bf	+
	Michel Tankoano	DCLD/MECV	(226)76667167	mjtankoano@yahoo.fr	+
Information et communication	Souleymane Mihin	BUMIGEB	(226) 70265966	mihin_souley@yahoo.com	+
	Paul Tapsoba	SP/CONEDD			-
	Janvier Bazoun	SP/CONEDD			-
	Boris Yameogo	SIGET-A			+
	Patrice Sanou	Centre SIGET-A	(226) 50399578 (226) 70239412	sanoup@fasonet.bf	+

APPENDIX 3 (a-d): Individual Country Reports

Ghana: pp. 52-141

Niger: pp. 142-154

Burkina Faso: pp 155-182

Mali: pp 183-240

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).

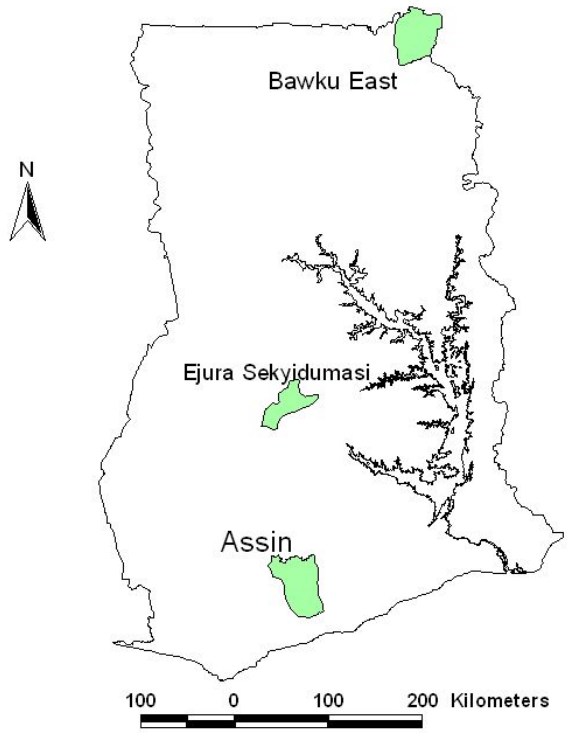


Figure1: Location of the three study areas in Ghana

1. Land Use/Land Cover Change Assessment

1.1. Objectives

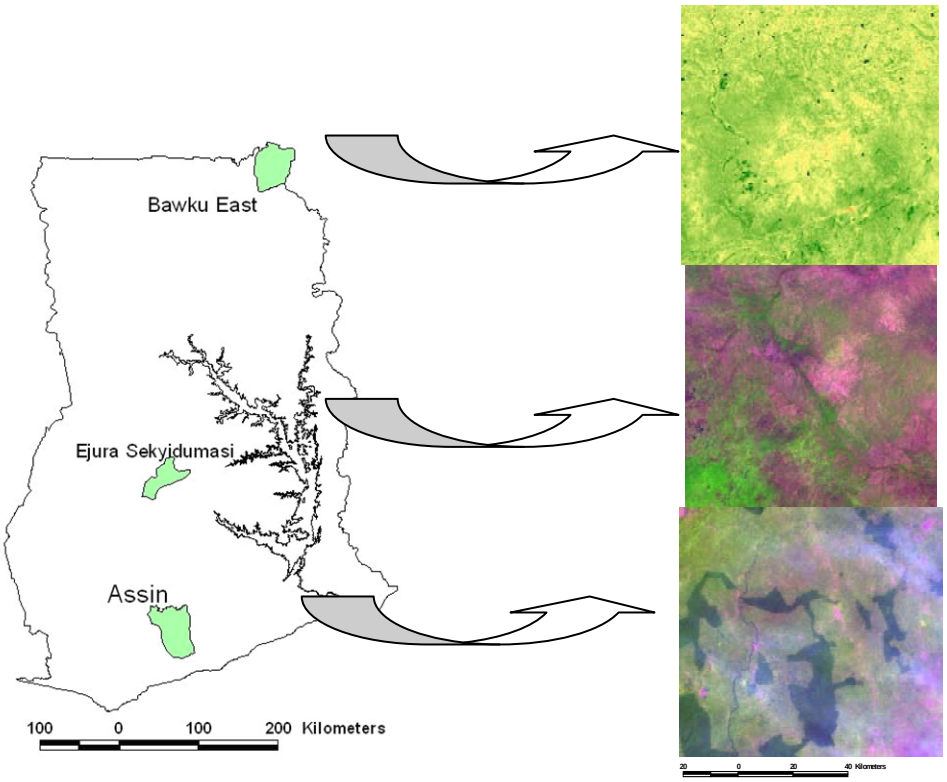
The principal purpose of the mapping project was to provide an in-depth assessment of land use change and identification of land resource improvement and degradation. The specific objectives include:

- 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

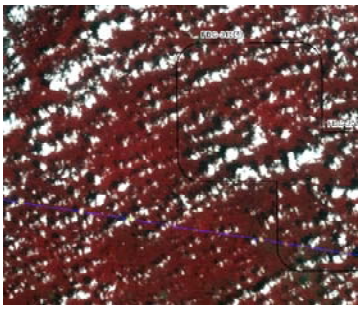
Approach

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:

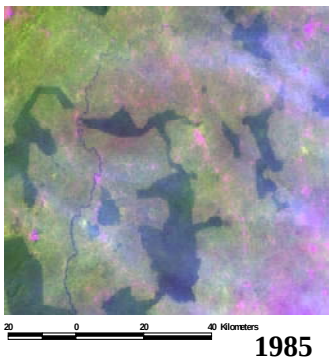
- 1985 and 2000 for Assin district due to clouded Landsat image of 1986 (fig.2)
- 1972 and 2000 for Bawku district due to the fact that 1985 Landsat images for mosaic were not in the same resolution (figure 4) and
- 1972, 1985/6 and 2000/01 for Ejura-Sekyedumasi district (figure 3)

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

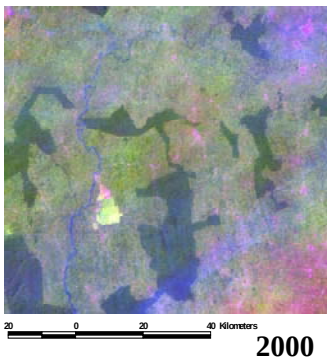


1986

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

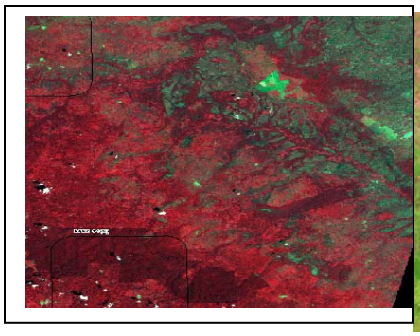


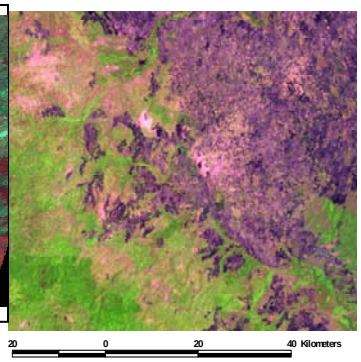
1985

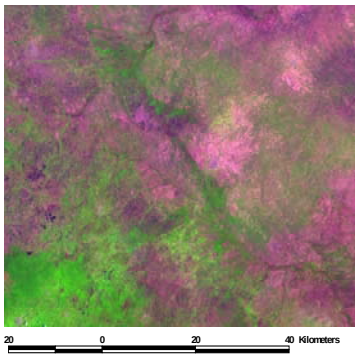


2000

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



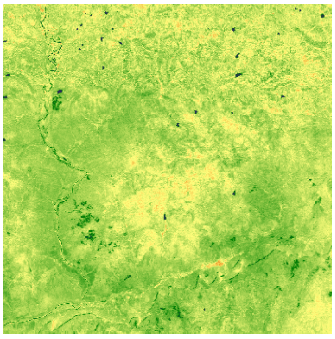




1972 **1986** **2000**

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.

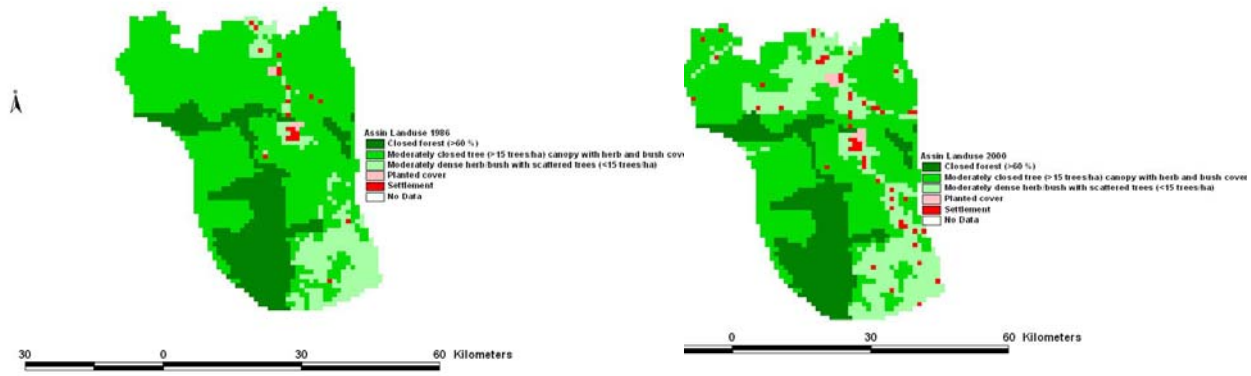


Figure 6: *Land use and land cover maps of 1986 and 2000*

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

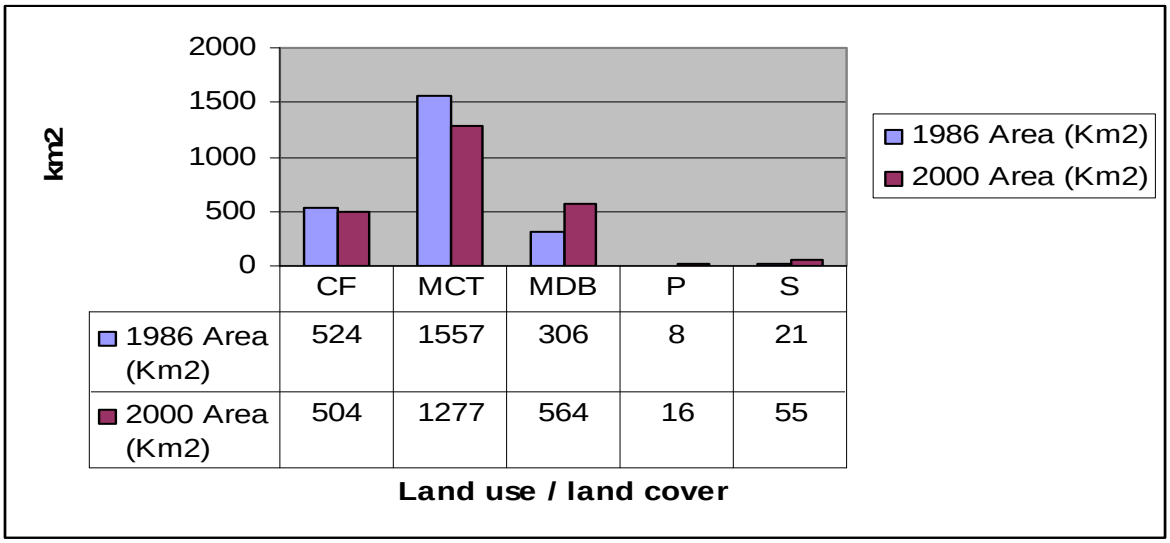


Figure 7: *A graph showing changes (km^2) of cover types between 1985 and 2000*

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.

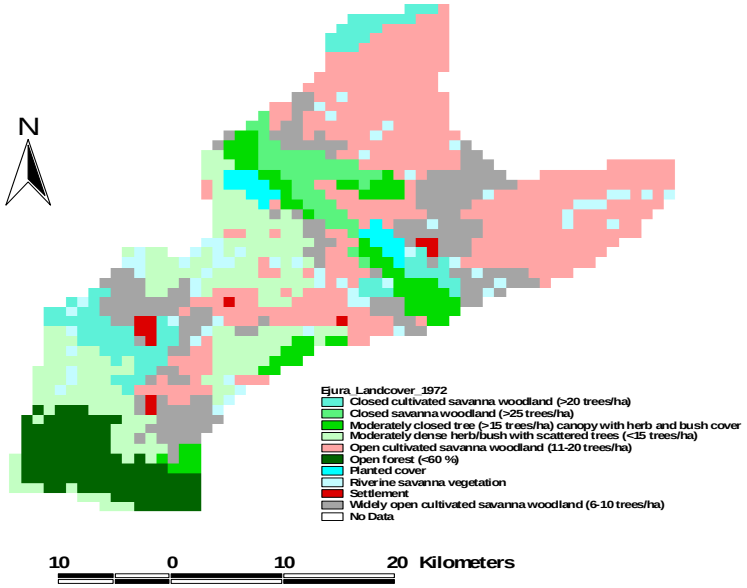
With increasing environmental awareness and the desire to protect tropical forests with local participation, it is expected that buffer zones could be created around the forest reserves to keep human activities away from the protected forest reserves.

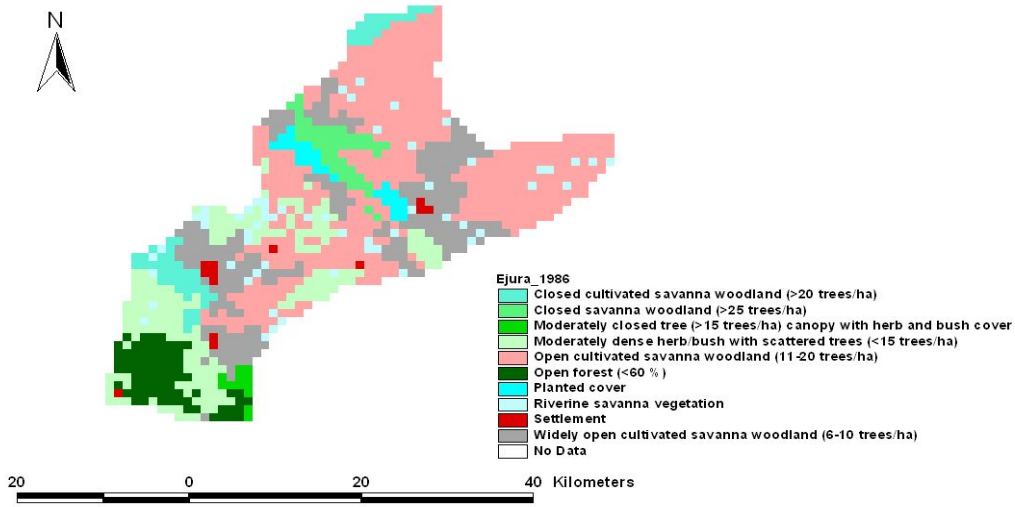
Alternative livelihood support projects and cottage industries, which could possibly help ensure sustainable use of agricultural lands, alleviate poverty and reduce pressure on the remaining forestlands, must be encouraged as a means of protecting the remaining resources.

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)





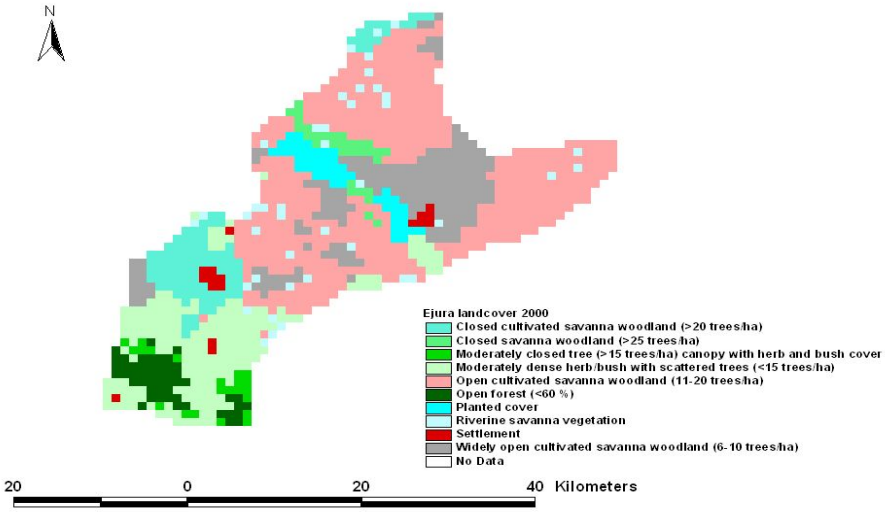


Figure 8: *Land use and land cover maps of 1972, 1985 and 2000*

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 savanna	50	57	100	7	43	50	1.79
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

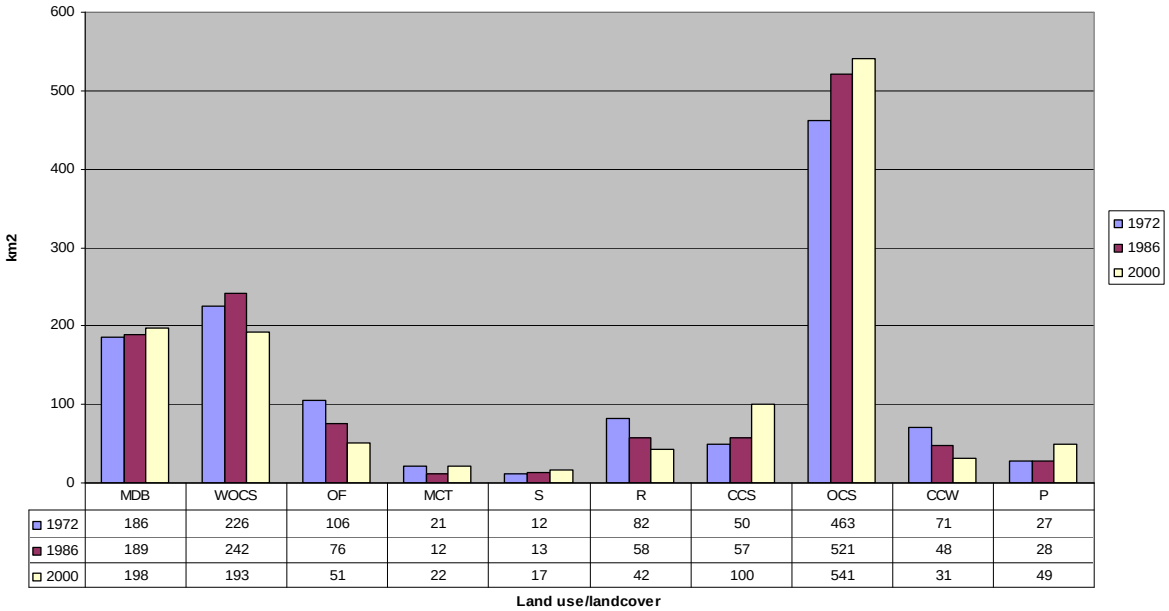


Figure 9: *A graph showing areas and changes (km^2) of cover types between 1985 and 2000*

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.

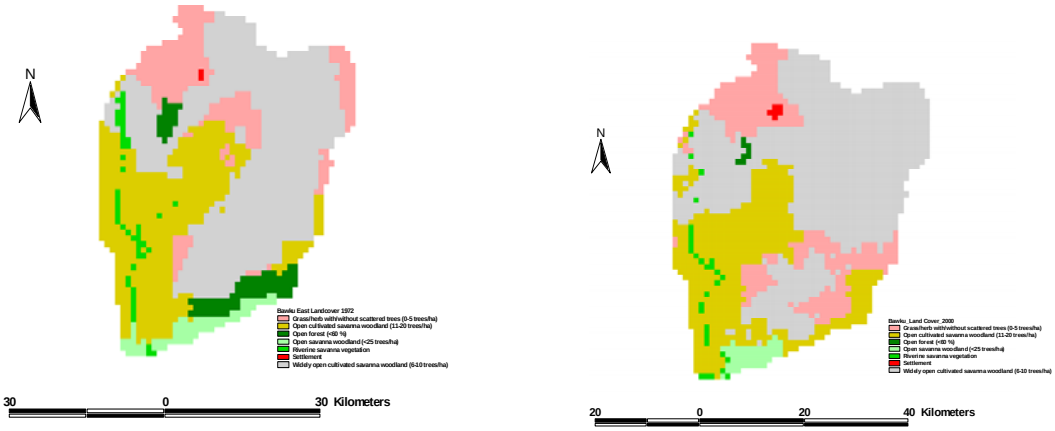


***Figure 10**: Land use and land cover maps of197 and 2000*

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.

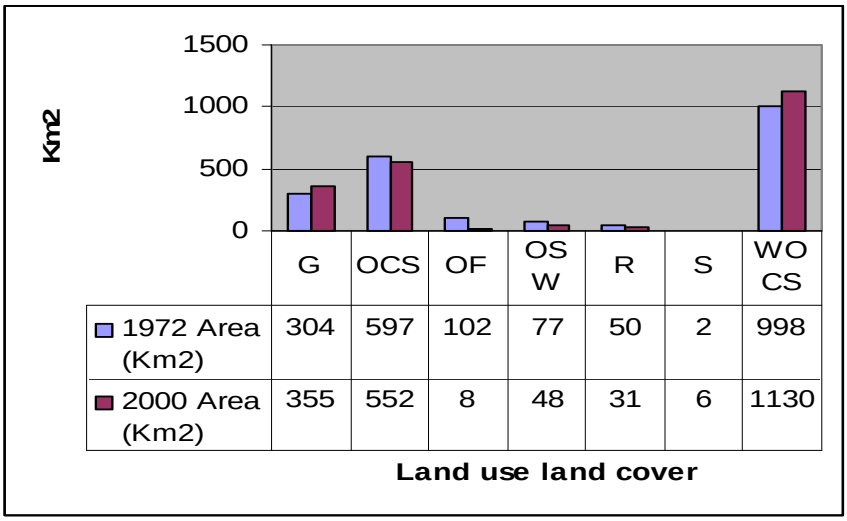


Figure 11: *A graph showing areas and changes (km^2) of cover types between 1985 and 2000*

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°'W and latitudes 7°12' – 7°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.

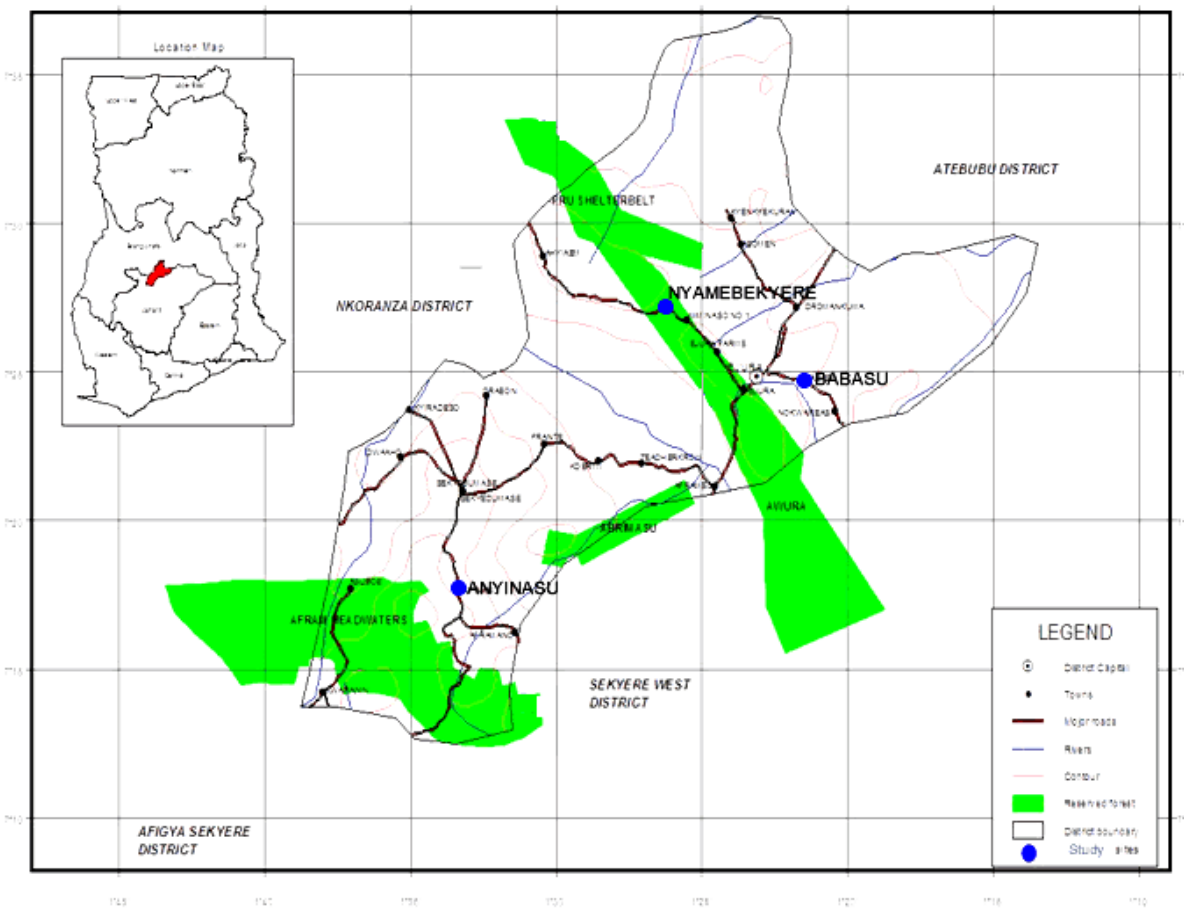
Climate
This district is located within the transitional zone of the Semi – deciduous Forest and the Guinea Savanna zones, thereby experiencing both climatic conditions. Two rainfall patterns, the bi-modal in the southern part and unimodal in the northern part occur in the district. Annual rainfall varies 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.

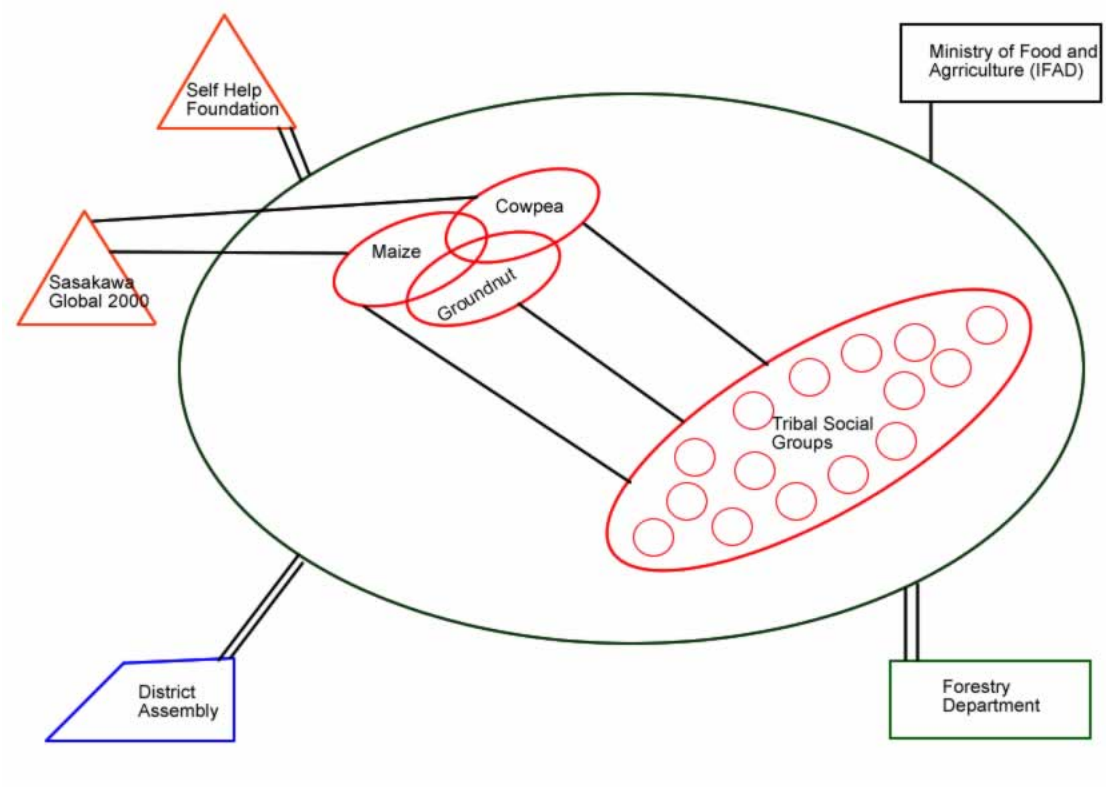


Diagram 4.1 Social networks that exist in *Nyamebekyere* showing linkages within the community and outside the community. A double line (=) indicates both physical and financial support; a single line (-) indicates either a physical or financial support or they have similar objectives.

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.

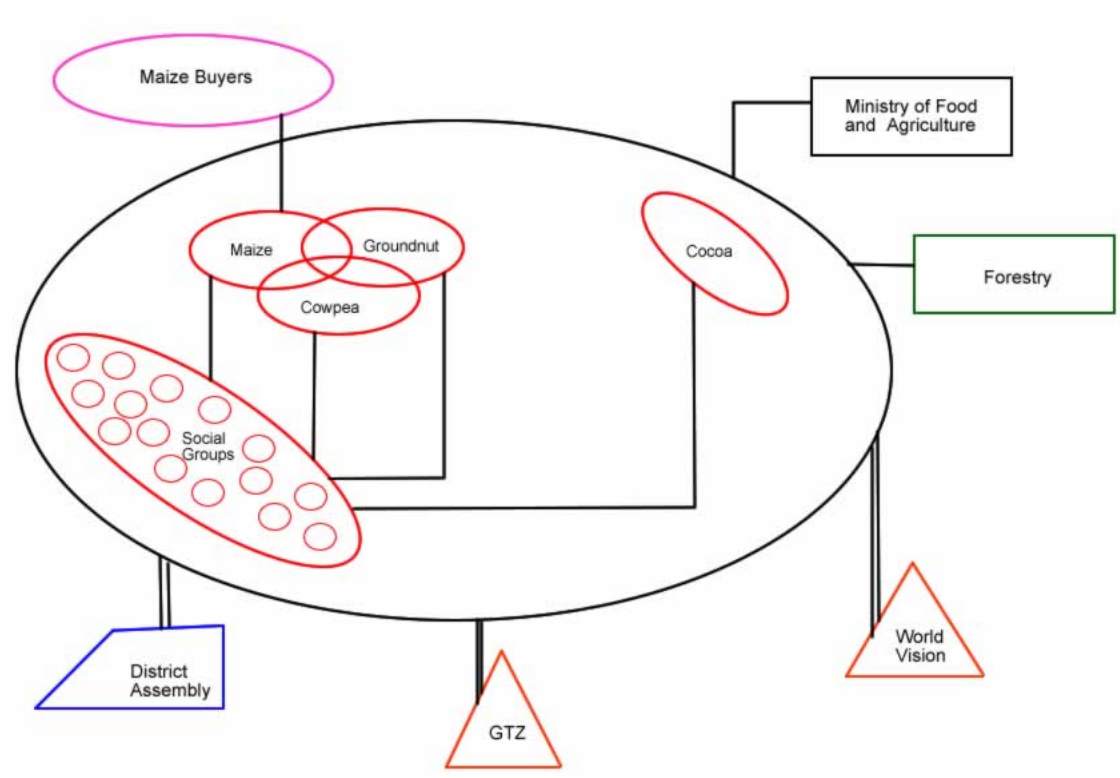


Diagram 4.2 Social networks for *Anyinasu* showing linkages between social groups within the community. A double line (=) indicates both physical and financial support; a single line (-) indicates either a physical or financial support or they have similar objectives.

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.

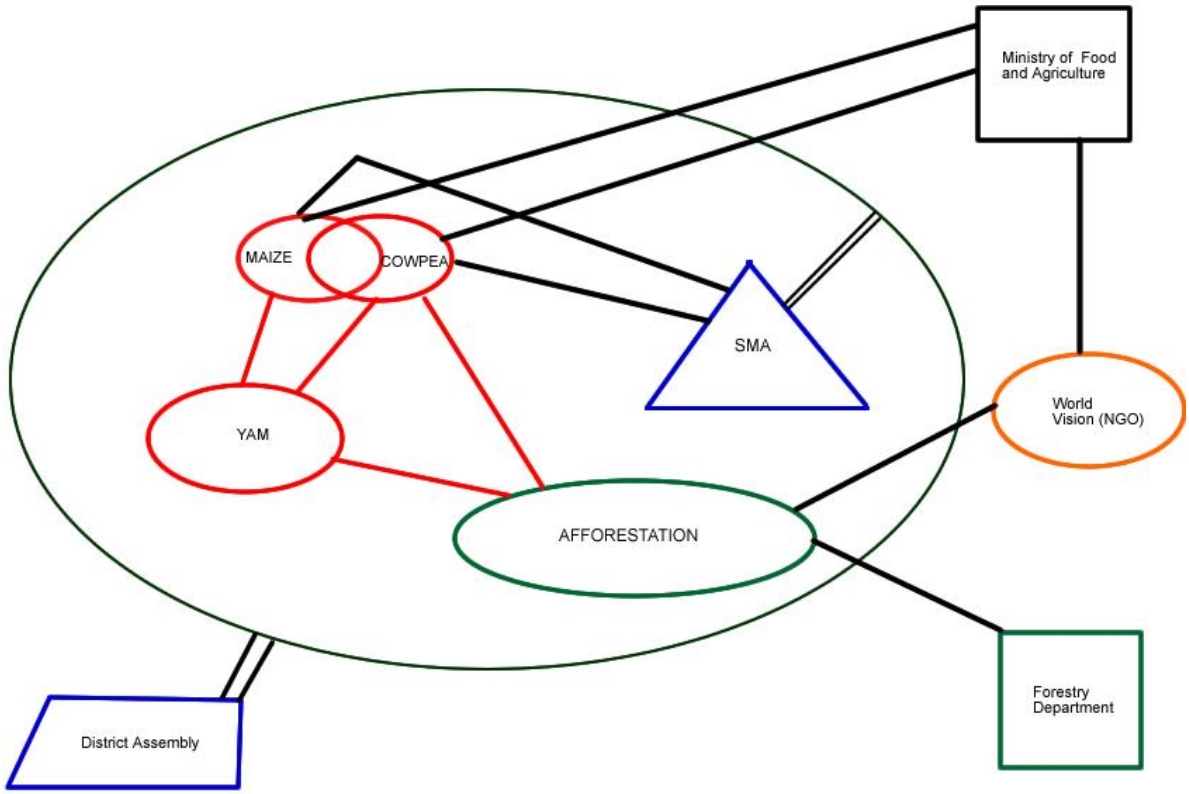


Diagram 4.3 Social networks for B*abaso* showing linkages between social groups within the community. A double line (=) indicates both physical or technical and financial support; a single line (-) indicates either a physical, material, technical or financial support or they have similar objectives.

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.

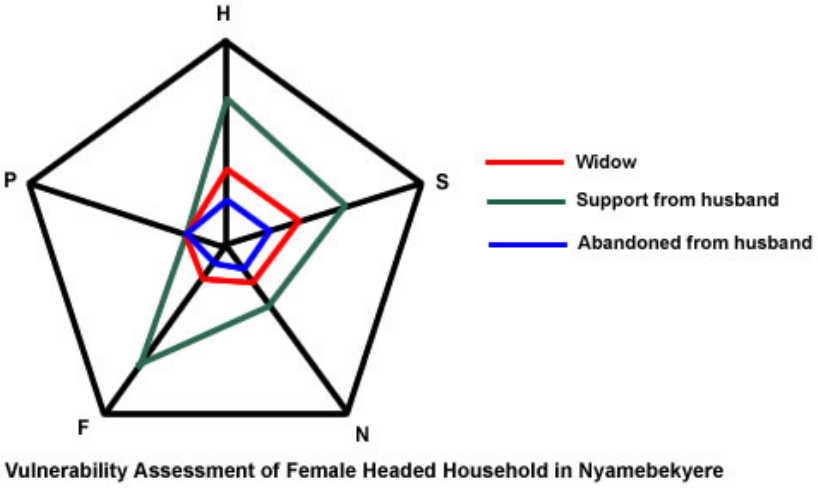


Diagram 5.1: Vulnerability as indicated by Female household heads in *Nyamebekyere*. H- Human assets; N - Natural capital: P - Physical assets: F – Financial assets: S - Social assets.

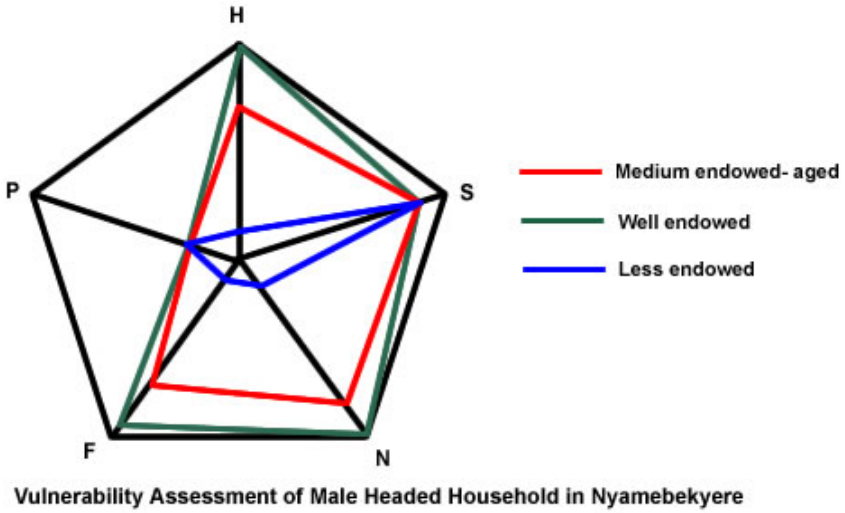


Diagram 5.2: Vulnerability as indicated by Male household heads in *Nyamebekyere*. H - Human assets:N - Natural capital: P - Physical assets: F – Financial assets: S - Social assets.

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.

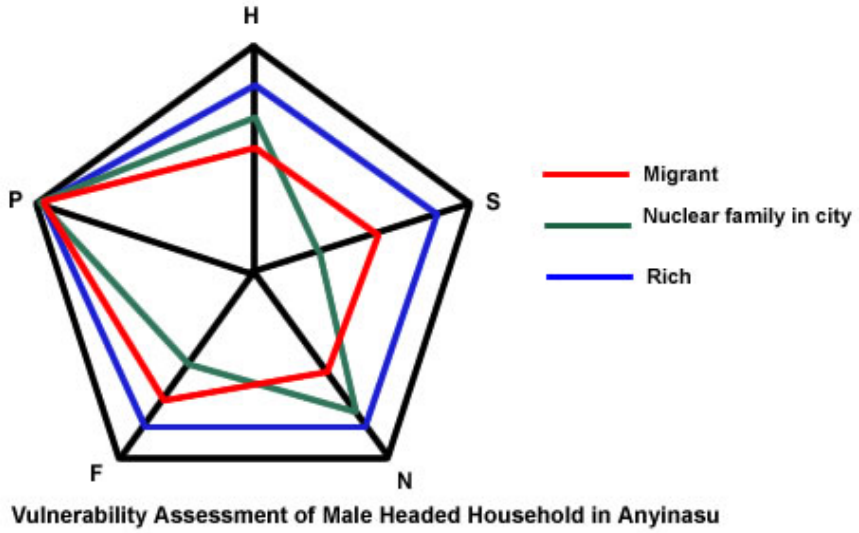


Diagram 5.3: Vulnerability as indicated by Male household heads in *Anyinasu*. H- Human assets; N - Natural capital; P - Physical assets; F – Financial assets; S - Social assets

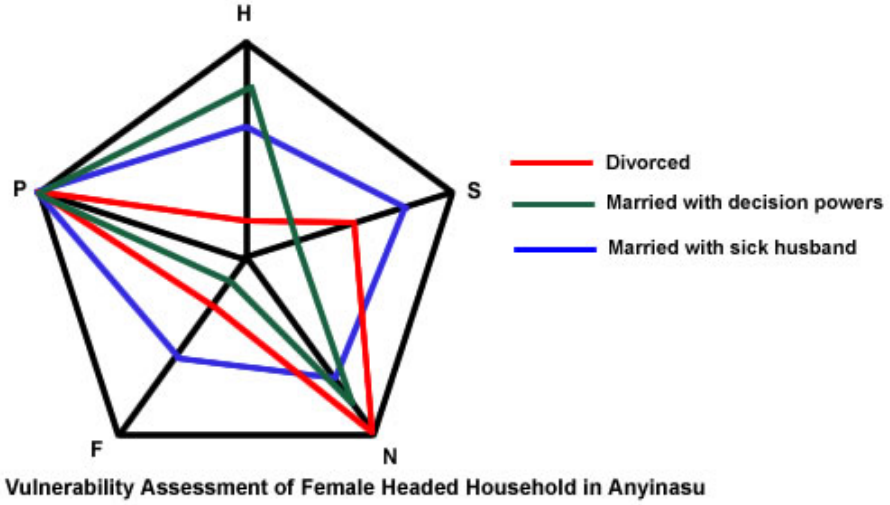


Diagram 5.4: Vulnerability as indicated by Female household heads in *Anyinasu*. H- Human assets; N - Natural capital; P - Physical assets; F – Financial assets; S - Social assets

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.

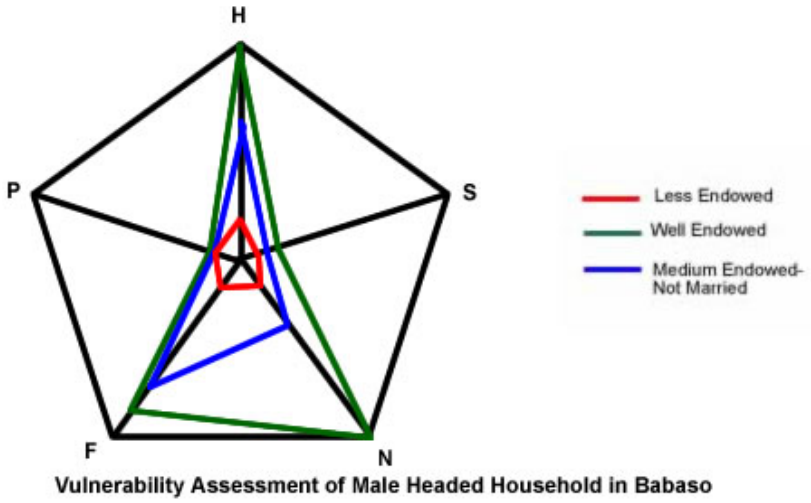


Diagram 5.5: Vulnerability as indicated by Male household heads in *Babaso*. H- Human assets; N - Natural capital; P - Physical assets; F – Financial assets; S - Social assets

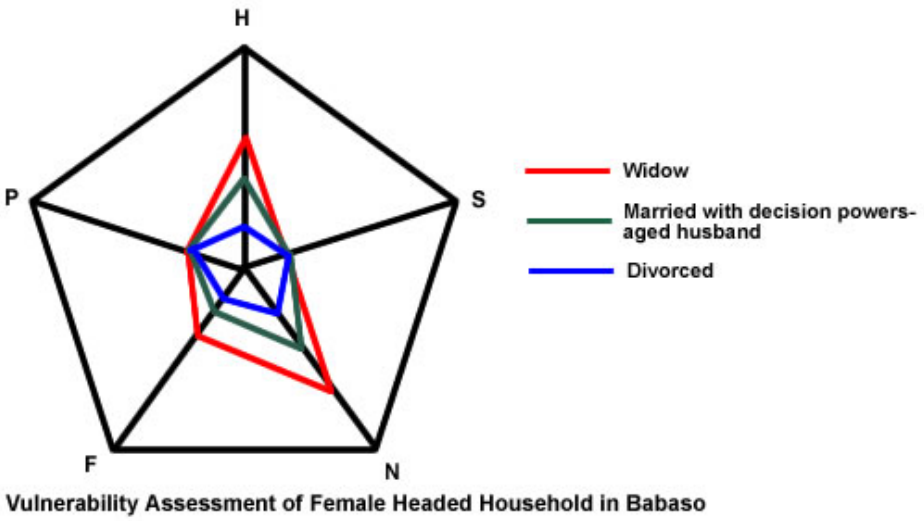


Diagram 5.6: Vulnerability as indicated by Female household heads in *Babaso*. H- Human assets; N - Natural capital; P - Physical assets; F – Financial assets; S - Social assets

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)**

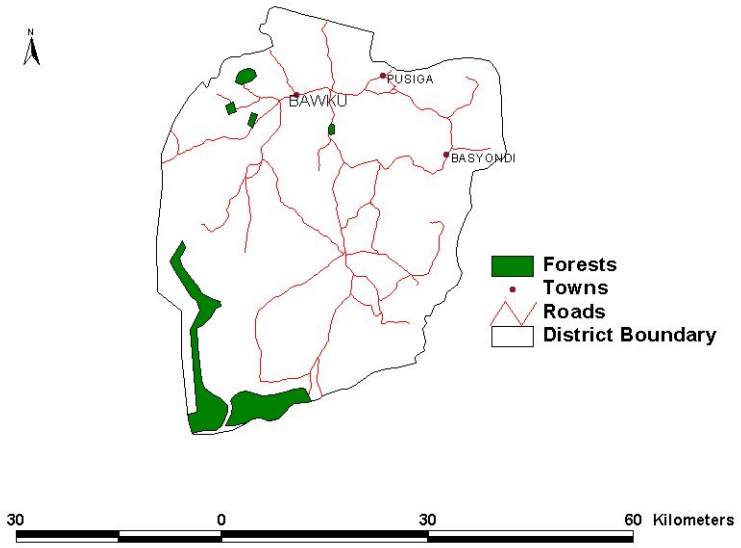
2.4. BAWKU EAST DISTRICT

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°18'W – 0°06'E and latitude 10°40' – 11°10'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° – 28°C. High temperatures of about 38° - 45°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 the *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.

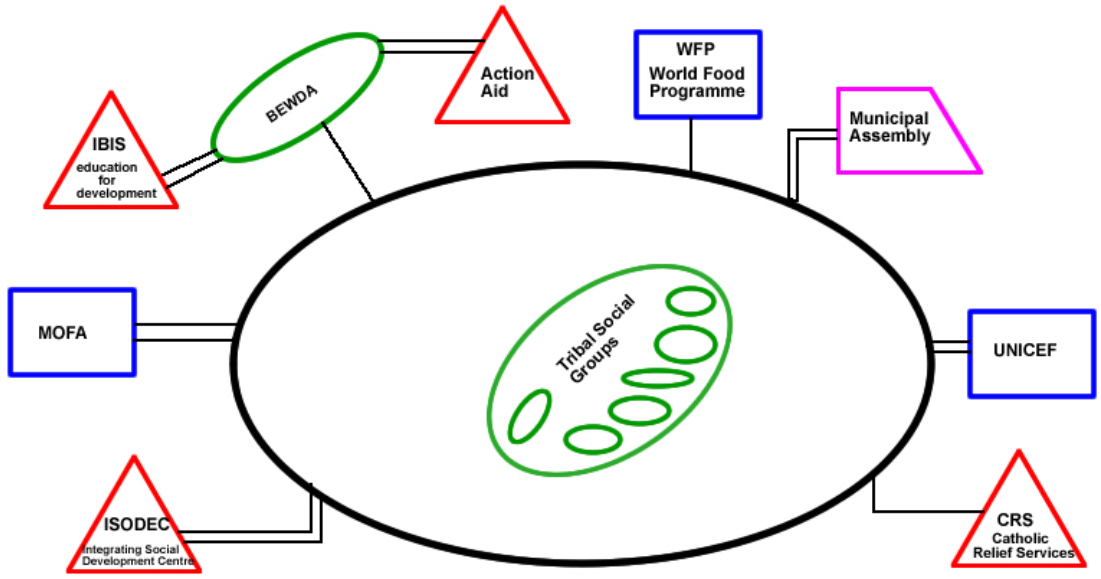
There is one rural bank in Pusiga. Community members who have relatives outside rarely receive remittances. Other source of financial capital is from the social groups these groups provide financial assistance to members in time of need or when a member is bereaved.

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.



Social Networks 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.

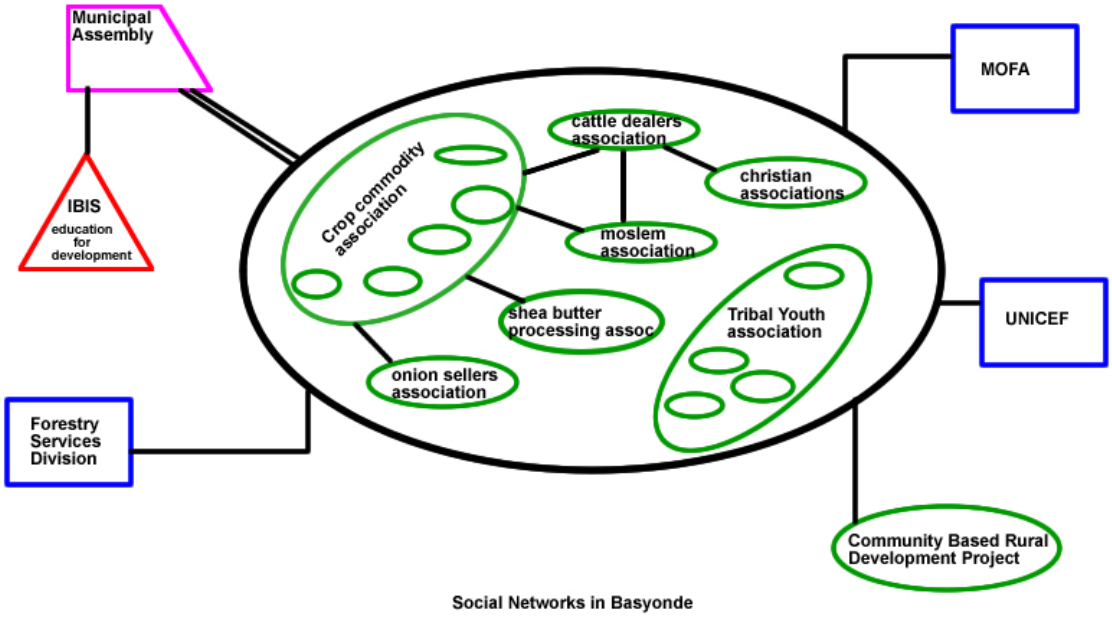


Diagram 7.2: Social networks within *Basyonde Sabzunde* showing linkages and institutional networks

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.

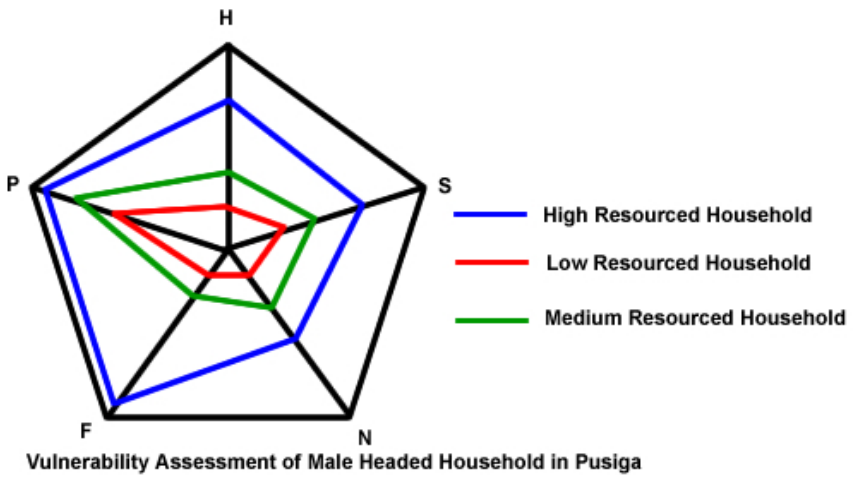


Diagram 8.1: Vulnerability as indicated by Male household heads in *Pusiga*. H - human assets; P – physical assets; N – natural assets; F- financial assets; S – social assets

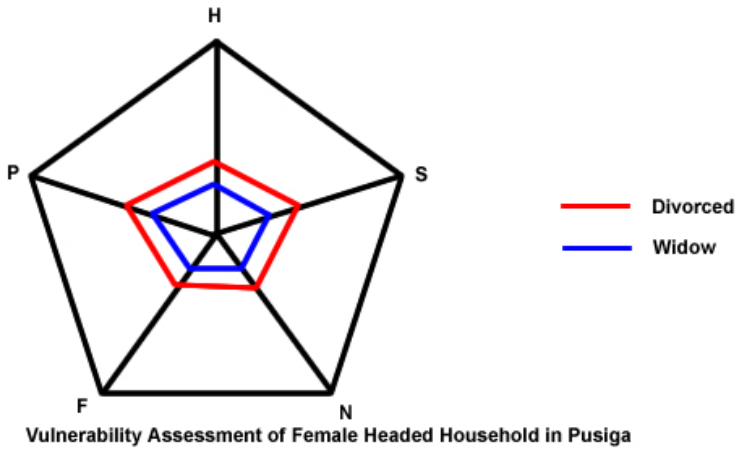


Diagram 8.2: Vulnerability as indicated by Female household heads in *Pusiga.* H - human assets; P – physical assets; N – natural assets; F- financial assets; S – social assets

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.

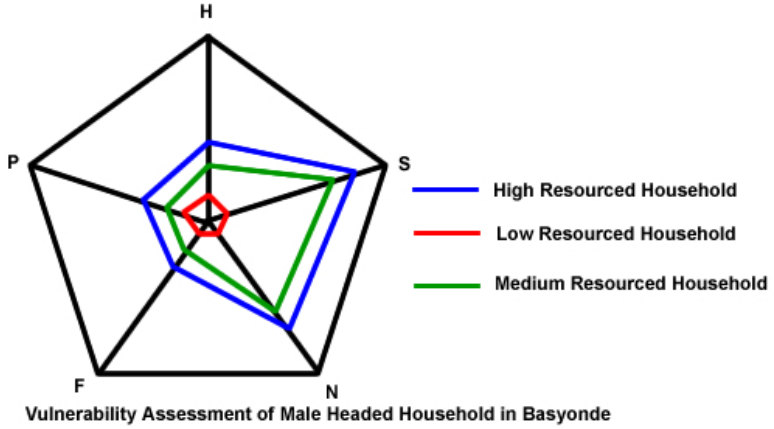


Diagram 8.3: Vulnerability as indicated by male household heads during the study; H – Human assets, P – Physical assets, S – Social assets, F – Financial assets, N – Natural assets.

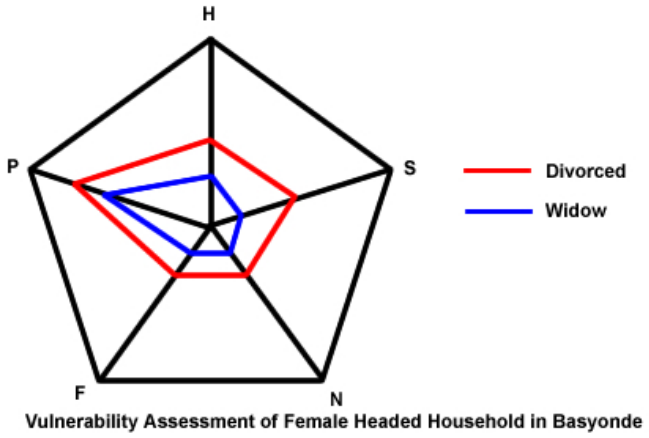


Diagram 8.4: Vulnerability as indicated by female household heads (Basyonde) during the study; H – Human assets, P – Physical assets, S – Social assets, F – Financial assets, N – Natural assets.

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.*

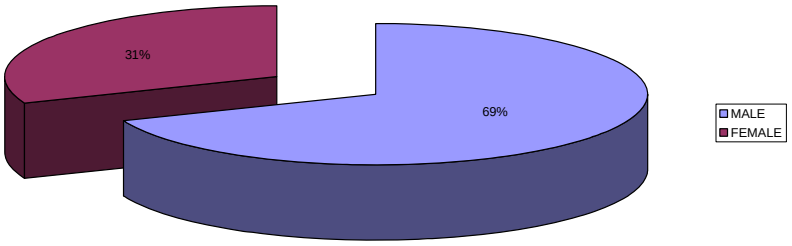


FIGURE 8.1: Percent contribution of gender to the real world stressors in the Bawku East district

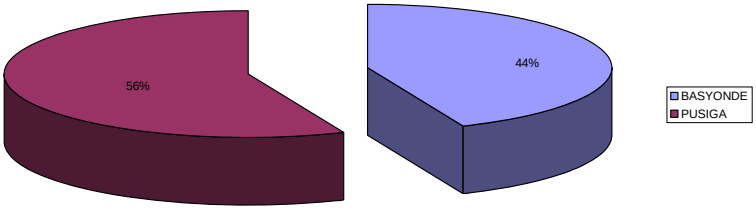


FIGURE 8.2: Percent distribution by the various communities to real world hazards in the *Bawku East* district

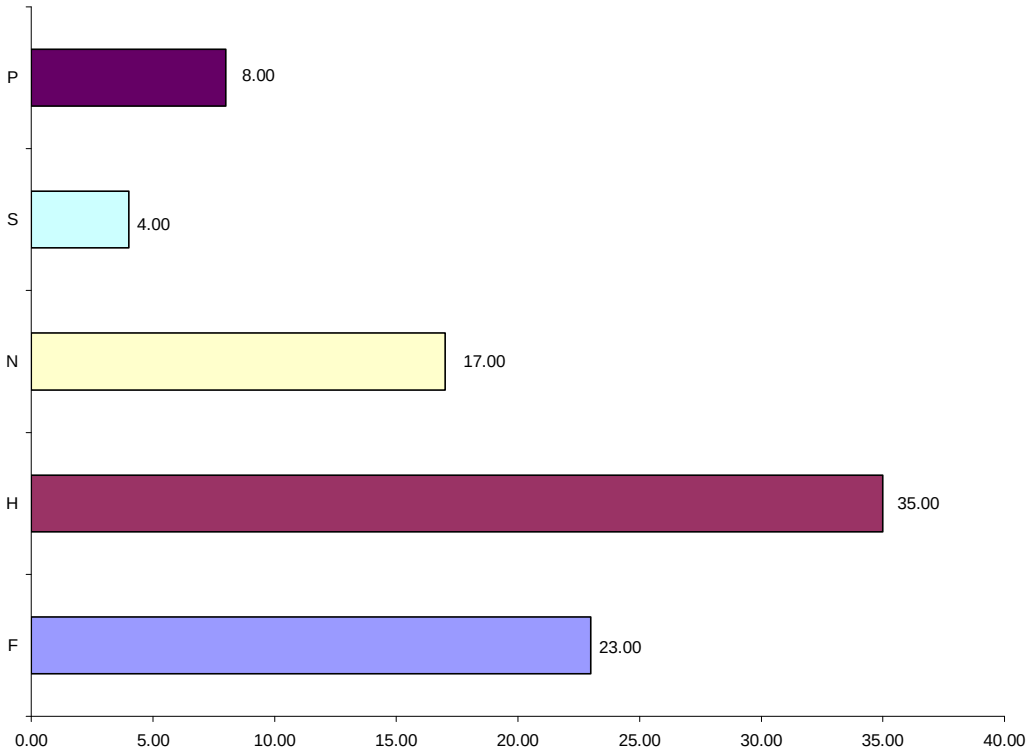


FIGURE 8.3: A bar chart showing distribution of livelihoods assets in relation to real world stressors; F- financial capital, H- human capital, N – natural capital, S – social capital, P – physical capital

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
. St Theresa of the Child Jesus(Religious)	To assist members in times of sickness, death, child 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

RANK	STRESSORS	PSS	GENDER	Severity index Sj	Incidence Ij	RISK INDEX	Rj
BASYONDE SABZUNDE MEDIUM RESOURCED HOUSEHOLD							
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^oC 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 % 0-20 cm	silt + clay % 20-40 cm	soil C t/ha 0-20 cm	soil C t/ha 20-40 cm	Total soil C 0-40 cm
Awura forest reserve	27.59 (9.73)	25.49 (8.60)	18.21 (6.52)	12.67 (5.33)	30.88 (10.76)
Teak plantation	21.79 (0.99)	27.35 (5.61)	33.93 (15.69)	13.64 (4.90)	47.57 (19.70)
Cultivated field	23.52 (2.57)	22.66 (3.19)	16.12 (2.84)	12.15 (2.25)	28.37 (4.45)
Fallow plot	50.38 (4.76)	50.48 (4.95)	31.09 (12.89)	25.69 (4.85)	56.72 (20.02)

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

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

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

Land use type	silt + clay % 0-20 cm	silt + clay % 20-40 cm	soil C t/ha 0-20 cm	soil C t/ha 20-40 cm	Total soil C t/ha 0-40 cm
Forest reserve	24.70 (5.29)	26.65 (5.49)	22.28 (6.24)	9.86 (2.74)	32.14 (7.86)
Teak plantation	26.19 (10.13)	36.37 (17.22)	15.33 (5.42)	8.31 (1.09)	23.64 (6.46)
Cultivated field	26.95 (9.98)	35.70 (15.04)	21.45 (2.00)	10.57 (1.54)	32.02 (2.59)
Fallow plot	27.60 (5.44)	28.98 (11.04)	22.89 (4.19)	11.16 (2.20)	34.05 (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

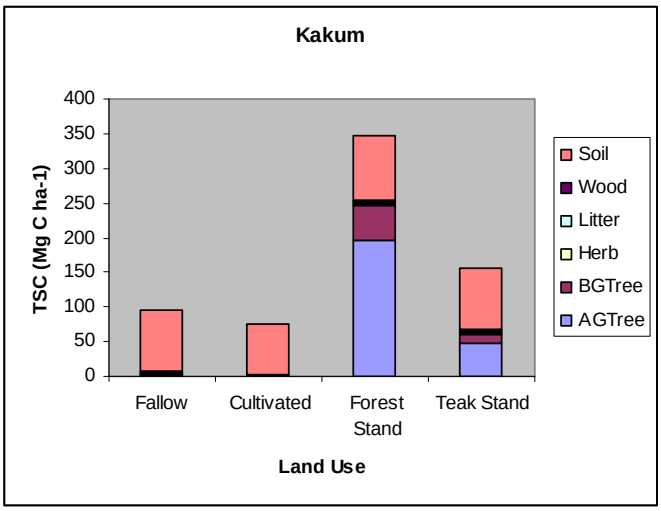

Fig. 1a. Total system carbon accumulated under various land use systems at Kakum.

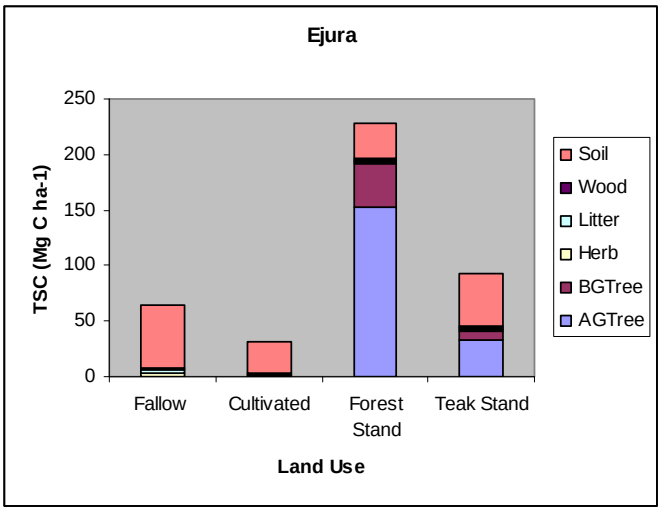

Fig. 1b. Total system carbon accumulated under various land use systems at Ejura.

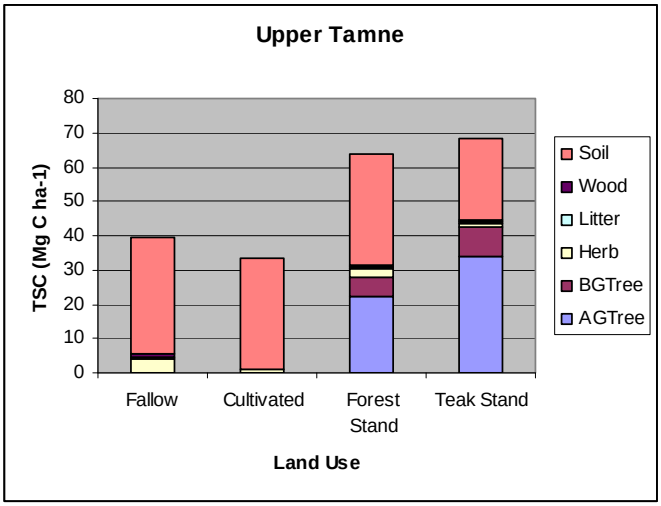

Fig. 1c. Total system carbon accumulated under various land use systems at Upper Tamne.

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)

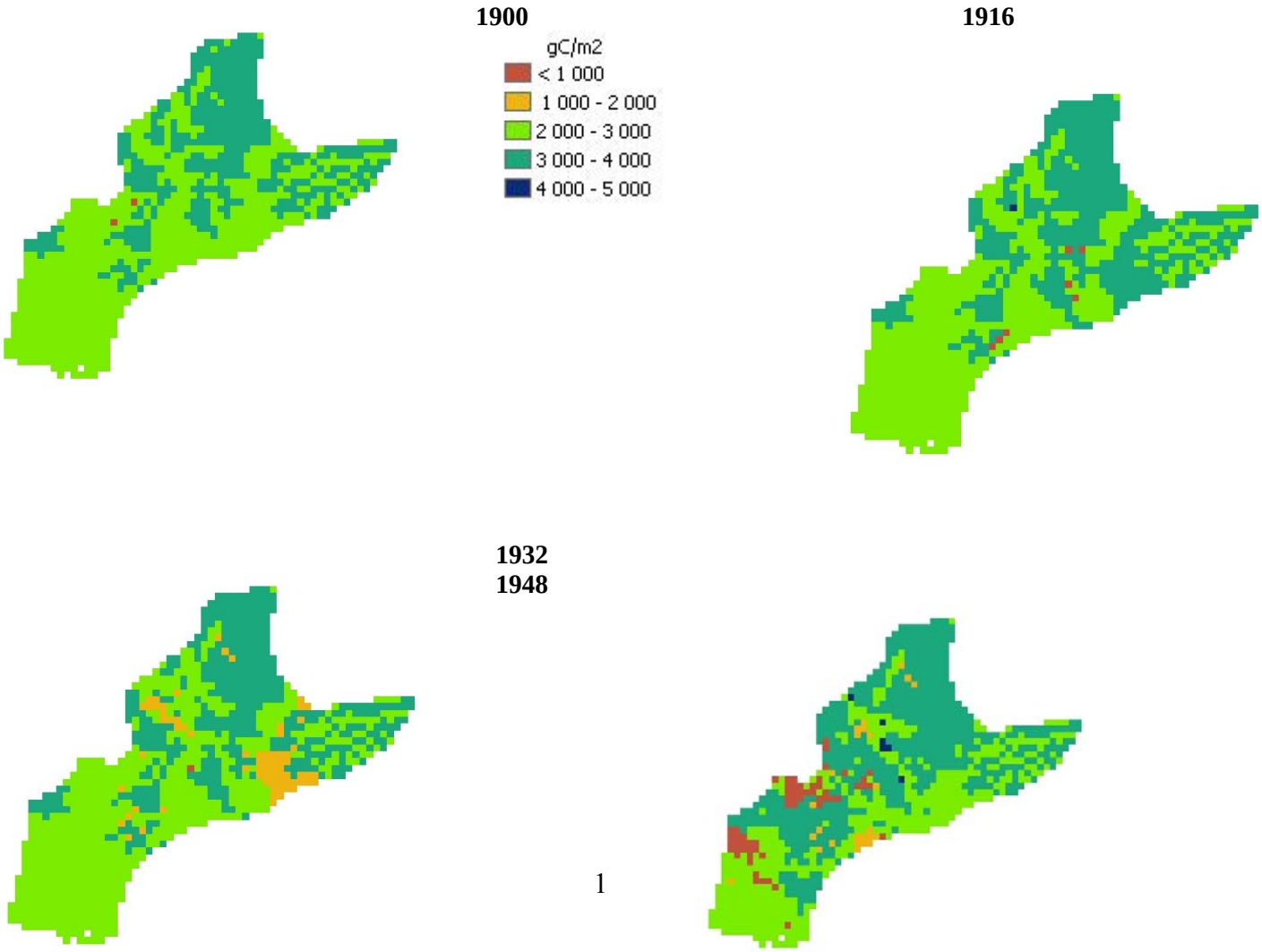
- Annual accumulator of Carbon production in grass/crop + forest = net primary production (g/m2/year)

- 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



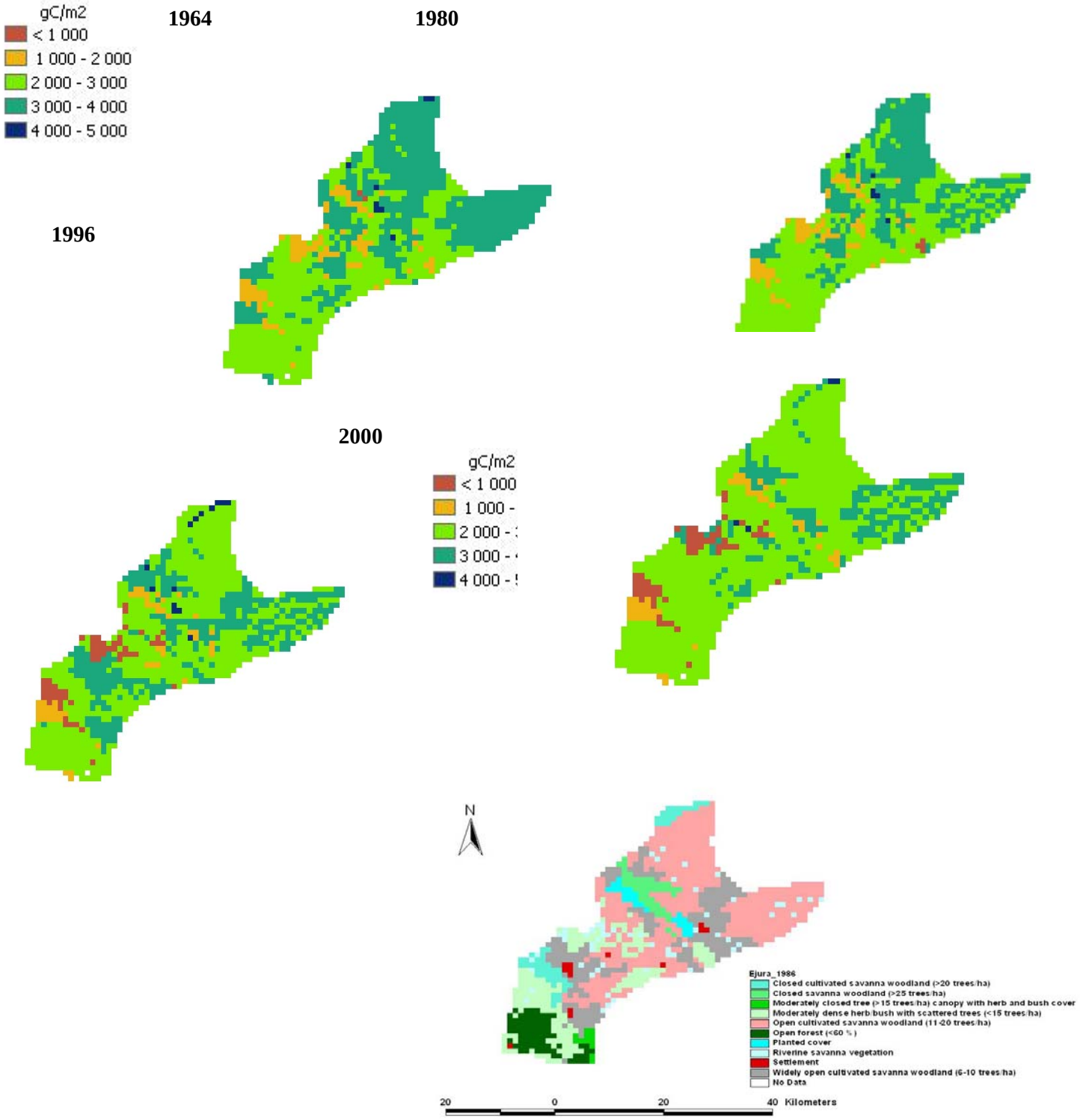


Figure 2a: Observed landcover – Ejura, 2000

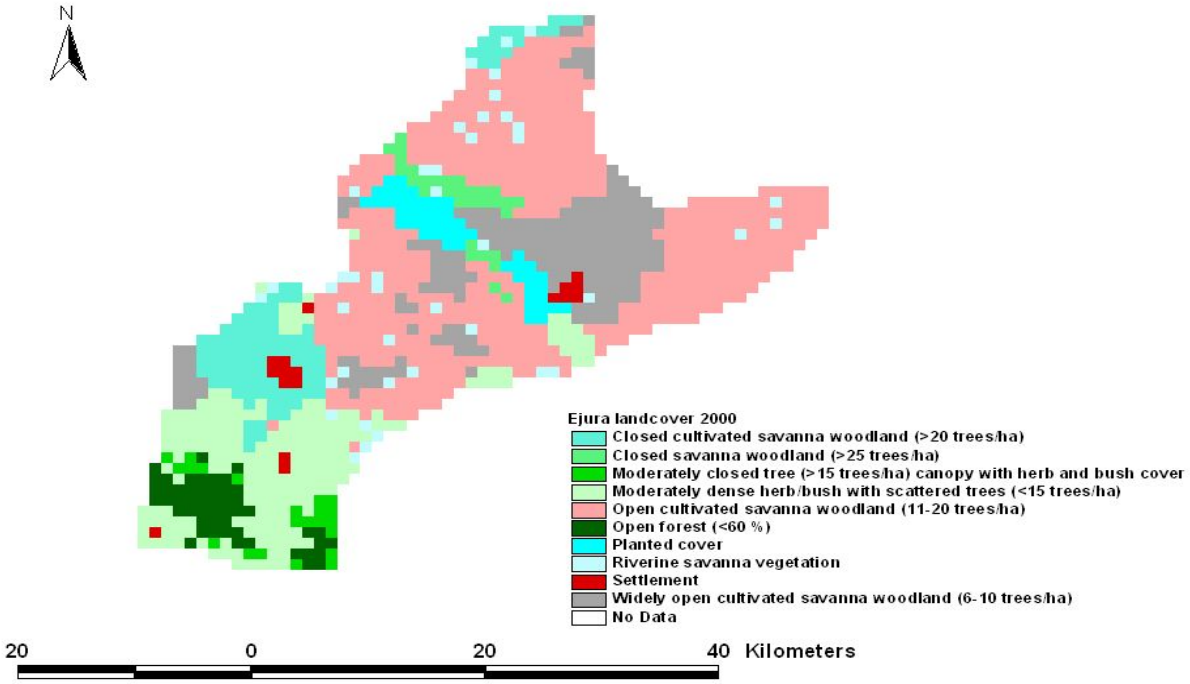


Table 1: Modeled average total soil carbon per hectare, Ejura.

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.

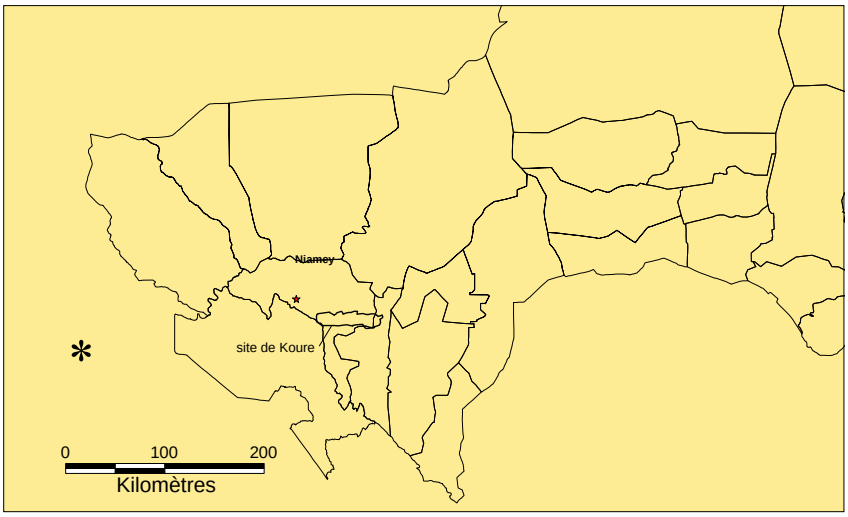
The next step of the investigation is to run the model for the period 2001 to 2100 using climate change scenarios that have been developed for assessing climate change impacts on the country. The model outputs for the two other study areas are yet to be completed and analyzed, and this will also be done.

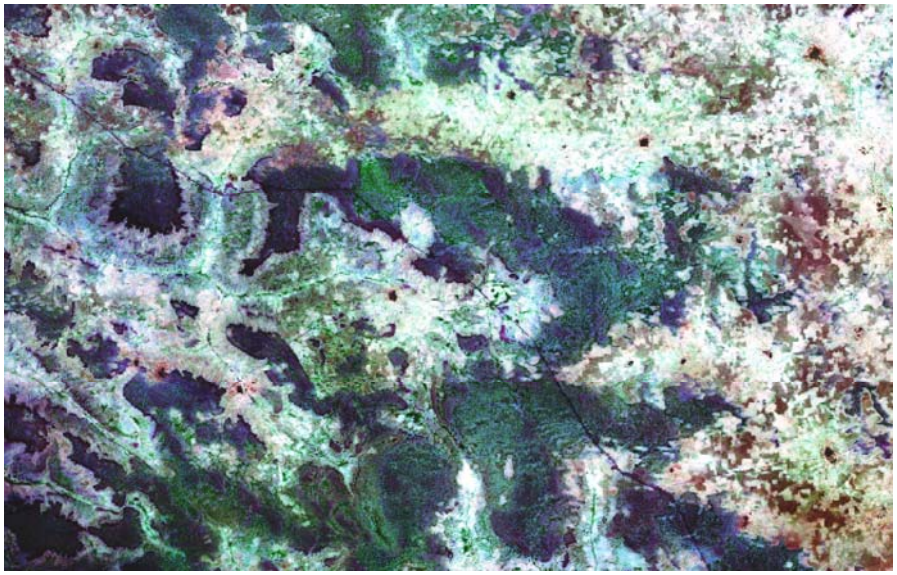
The main reason for the delay is the initial difficulty in getting the model to run. There was also the problem of waiting for data from the other groups involved in the project. The pledge is that the work will continue until it is fully completed.

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.

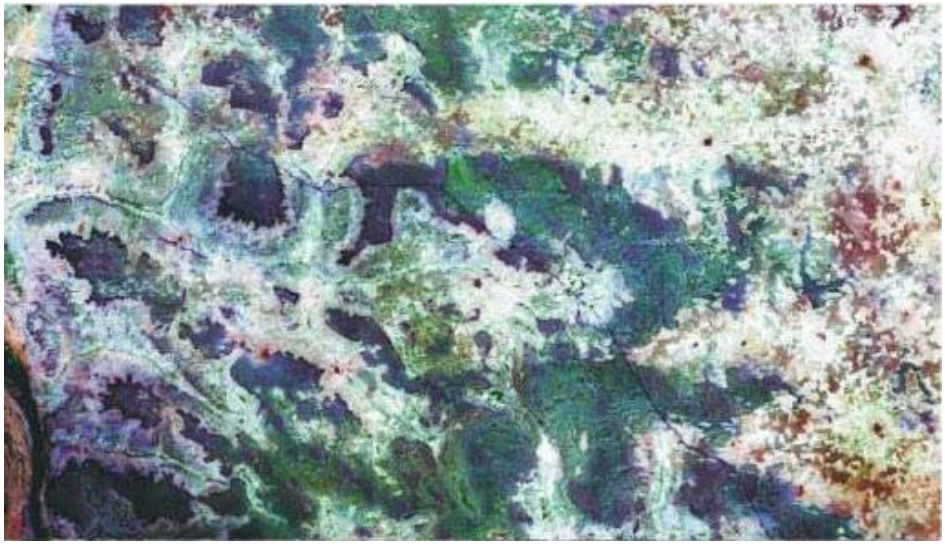
NIGER

1.Site and Characteristics :

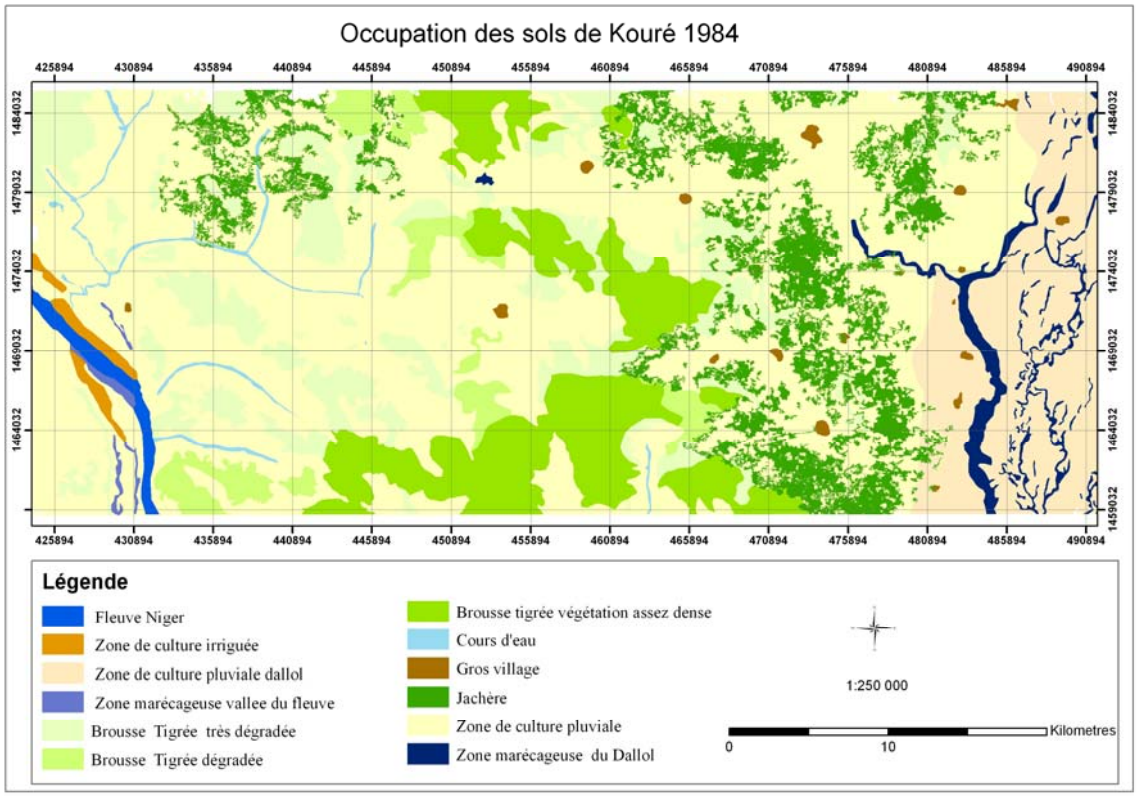


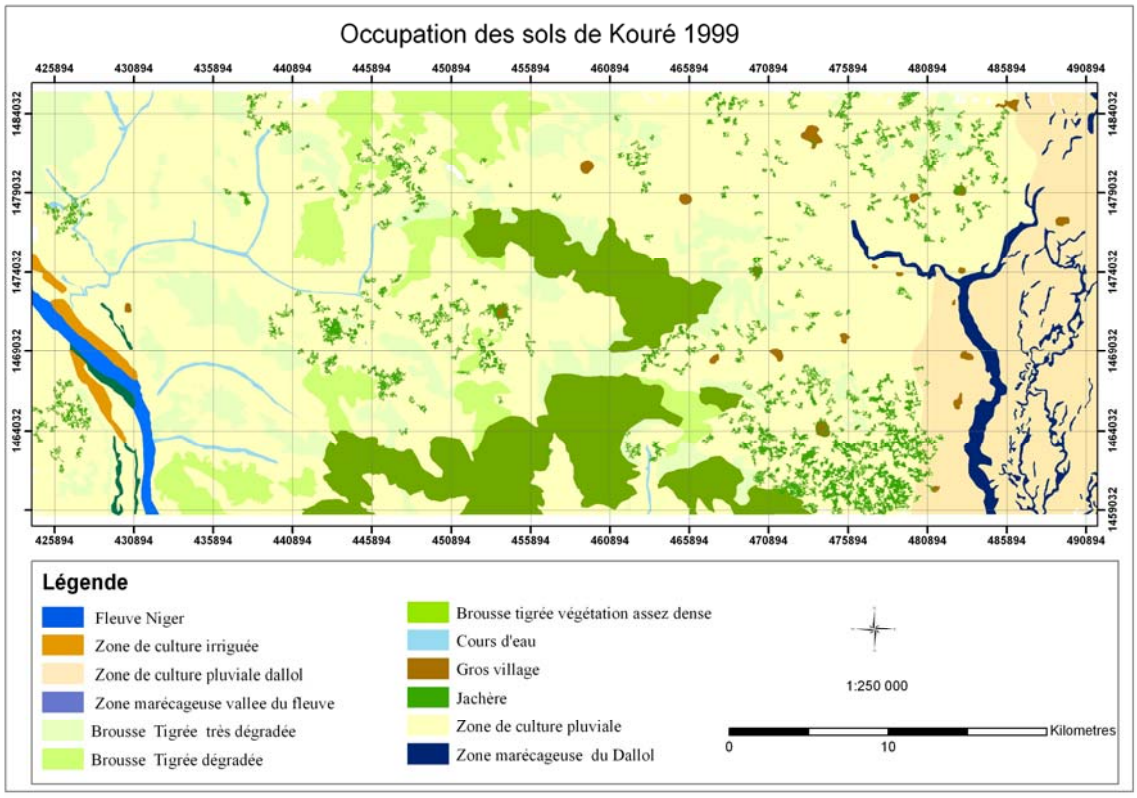


1984



1999





2. Socio-Economic Assessment (Moussa Boureima)

« RISQUE, VULNERABILITE, CAPACITE ADAPTATIVE ET PRISE DE DECISION FACE A DES STRESS DIVERS »

ETUDE SOCIO - ECONOMIQUE

(PRESENTATION DES RESULTATS : VILLAGES DE HARIKANASSOU ET DE KOURE)

2.1. CONTEXTE

Des « Méthodes Participatives pour des Analyses d' Adaptation » a été le thème de l'atelier de formation qui s'est tenu à Bamako dans la deuxième quinzaine d'Août 2005 (15 au 18). Au cours de cette rencontre des participants du Mali, du Burkina Faso et du Niger ont abordé des sujets relatifs aux risques et catastrophes auxquels sont exposés les populations en Afrique tels que les sécheresses, les famines, les inondations, la malnutrition, les conflits. Ils se sont aussi familiarisés avec certains concepts relatifs à la sécurisation des conditions de vie des ménages tels que : chocs/ risques/ stress, adaptation, vulnérabilité, indice de risque, moyens d'existence etc…, mais ont aussi procédé à des exercices de groupes sur des thèmes comme la caractérisation de partenaires, le cadre conceptuel de vulnérabilité, la nature de chocs/risques, menaces de la vie réelle. Cette étude socio – économique conduite dans deux (2) des trois (3) sites d'ancrage des activités du Projet DMP que sont Harikanassou (Dallol Bosso) et Kouré (Zone de plateau), se veut comme une tentative de mise en pratique des connaissances reçues à cette formation.

2.2. METHODOLOGIE

Cette étude a utilisé une procédure qui a combiné deux techniques à savoir :

- La recherche documentaire
- Le questionnaire

La mise au point du questionnaire a été précédée d'une mission exploratoire qui nous permis de présenter le Projet SEMSOC aux populations des trois sites retenus et de consulter les bases de sondage de ces villages. En effet, dans chaque village un document ou registre dans lequel sont consignées des informations relatives à la population totale, au nombre des ménages, au sexe du chef de ménage etc… a été présenté à la mission. Sur la base de ces caractéristiques de la population totale, nous avons procédé à un sondage aléatoire ou probabiliste.
Dans chaque village, faute de pouvoir toucher tous les ménages et compte tenu de la modicité de l'enveloppe (325.000 frs CFA) utilisée pour l'étude, nous avons retenu quarante (40) ménages.

Le ménage est défini comme une unité de production et de consommation. Le noyau d'un ménage est la famille composée d'un homme avec une ou plusieurs femmes et leurs enfants, parfois d'autres parents comme les grands parents. Pour faciliter la recherche au niveau des ménages cette définition a servi de base de travail.

Tableau n° 1: Ménages interrogés par village

Village	Ménage dirigé par des hommes	Ménage dirigé par des femmes	Total
Harikanassou	31	9	40
Kouré	30	10	40

Ces « quotas » ont été choisis dans une boite contenant tous les ménages dirigés par des hommes pour le premier cas, et tous les ménages dirigés par des femmes pour le second. En d'autres termes tous les ménages avaient la même probabilité d'être tirés au hasard .
Après cette mission exploratoire, nous avons conçu deux types de questionnaire : un questionnaire village et un questionnaire chef de ménage.

Ces deux instruments ont été établis pour connaître la situation économique et sociale des villages, leurs potentialités et leurs contraintes, mais aussi pour pouvoir disposer de facteurs descriptifs nécessaires à la caractérisation de la situation sociale et économique de la population cible, c'est à dire des ménages.
L' enquête intensive a duré un (1) mois et a été fait par un enquêteur ayant séjourné dans ces villages.
Il est bon de rappeler, qu'il a été demandé aux participants de l'atelier de formation d'éviter si possible le questionnaire et de privilégier les outils des méthodes participatives tels que la matrice de changements, le diagramme de Venn, les cartes communautaires, les questions semi-structurées. Cependant, compte tenu des coûts que peuvent engendrer les déplacements de l'équipe de socio-économistes pour réaliser des focus groupes, nous avons préféré le questionnaire.
Le questionnaire village est structuré en cinq points:

- Profil historique et démographie
- Infrastructures socio- économiques
- Institutions et Associations socio-professionnelles/organisations paysannes
- Ressources naturelles/capital physique
- Gestion Risques

Le questionnaire chef de ménage comporte deux (2) points :

- Identification du chef de ménage
- Ressources/Moyens d'existence du ménage
  Ce dernier point est subdivisé en sept (7) composantes :
  - La terre
  - La gestion de la fertilité des sols
  - Les semences
  - Le cheptel
  - Autres activités génératrices de revenus
  - Nutrition et santé
  - Gestion des chocs/risques.

2.3. PRESENTATION DES RESULTATS DE L' ETUDE

2.3.1. Village de Harikanassou

Profil historique et Démographie
Le village de Harikanassou érigé en commune rurale en 2005, est situé dans le Département de boboye, Région de Dosso. Les premières familles fondatrices ont quitté le village de kalabéri (Boboye) pour créer Harikanassou en 1902. Depuis sa création, Harikanassou a connu six (6) chefs :

Tableau n°2 : Succession des chefs dans le village

Nom et Prénom du chef	Règne	Durée
Sidikou Hama Fandou	1902 - 1917	15 ans
Monzon Hama Fandou	1917 - 1926	9 ans
Moumouni Hama Fandou	1926 - 1934	8 ans
Magagi Ounteni Hama Fandou	1934 - 1963	29 ans
Seyni Magagi Ounteni Hama Fandou	1969 - 1974	5 ans
Maidanda Magagi Ounteni Hama Fandou	Depuis 1974	/

La population à majorité Zarma est de 1760 habitants réparties en 857 hommes et 903 femmes ; on dénombre 142 ménages.
La commune rurale de Harikanassou est limitée à :

- l' Est par les villages de Alphabéry, Fandou Djibo, Samdey Seydou, Kouboubi Koura ;
- l' Ouest par les villages de Kanaré, Ahamane Dey, Doulwal ;
- Nord par le village de Bagol Hima ;
- Sud par les villages de Samdey Moussa et Daniyara

Infrastructures Socio-Economiques
Le village de Harikanassou est accessible en toute saison . Il y'a une voie latéritique qui lie Harikanassou à Kodo, Kanaré, Koygolo, Balléyara. Le village de Harikanassou est doté des infrastructures utilitaires suivantes:

Tableau n°3: Infrastructures socio-économiques

Nature	Nombre	Année de création	Etat
Ecole primaire	2 (enseignement française et enseignement franco-arabe)	1962 pour le 1er et 2000 pour le second	Fonctionnel
Collège secondaire	1	1996	//
Case de santé/ CSI	1	1964	Réhabilité en CSI en 1982, fonctionnel
Mosquée	1	1982	Réhabilité en 2002, fonctionnel
Magasin	1	1978	Fonctionnel
Marché	1	1989	//
Château d'eau	1	1996	Non fonctionnel
Puits modernes	5	1962	Fonctionnel
Bureau OPT	1	1987	//
CDA	1	1968	//
Moulin	1	2005	//
Mairie	1	2005	//
Piste latéritique	2	1981	//

Même si ces réalisations citées existent, il faut noter que certaines contraintes en matière d'infrastructure ont été identifiées notamment :

- Le manque de table et le vieillissement des bâtiments de l'école primaire ;
- L'absence d'un CEG Maderesa ;
- Le manque d'électricité, de latrines et de micro dans la mosquée ;
- Le manque de vivres dans le magasin ;
- La création d'une boutique d'intrants ;
- La non fonctionnalité du château d'eau et sa faible capacité ;
- Le manque de clôture, l'état des chambres, le manque d'électricité et surtout l'insuffisance du personnel du CSI ;
- L'insuffisance des puits modernes et la mauvaise qualité de l'eau.

A tous ces problèmes soulevés, les populations ne proposent comme solution que l'intervention de l' Etat . Cette situation dénote une faiblesse qui se traduit par une absence de stratégie de mobilisation des ressources financières. Les moyens d'existence ne sont pas durables parce qu'ils dépendent d'un soutien externe, lui même non durable.

Institutions et Associations Socio-professionnelles/Organisations paysannes
Dans le village de Harikanassou il existe les associations et organisations suivantes :

- Association Islamique
- Groupement Farey Mazada (agriculteurs)
- Tabibanou (féminin)
- Groupement des pêcheurs (pêcheurs)
- Groupement Bonkaney (féminin)
- Wadata Souji (féminin)
- Sabi (féminin)
- Gomni (féminin)
- Koy Dadjina (féminin)

- Groupement Adiyelé
- Groupement Tadeyel
- Association des Jeunes
- Association des Agriculteurs
- Association des Parents d'élèves
- Groupement Sourou

Toutes ces Associations sont fonctionnelles et les objectifs qu'elles visent sont les suivantes :
- Améliorer les revenus des membres
- Gérer les ressources du terroir

Les principales activités de ces associations sont les activités génératrices de revenus (AGR), la pratique des cultures de contre-saison, l'épargne, le crédit, la gestion des ressources naturelles.

Le mouvement associatif prend de l'ampleur et on constate une mobilisation des femmes par l'existence d'au moins cinq associations féminines Cet état de fait dénote une prise de conscience collective. Cependant, même si il n'y a aucun doute de leur existence, ces associations ont besoin d'être appuyées en surtout en matière de formation notamment sur la vie associatives en techniques de communication etc…

Comme auto-encadrement villageois il faut noter la présence de :
- Un secouriste (santé animale)
- Trois (3) matrones
- Six (6) Ex stagiaires : 2 formés au CPR de Harikanassou et 4 formé au CFJA de Bélindé
- Un agent de vulgarisation

Plusieurs projets de développement et ONG opèrent dans le village de Harikanassou, au nombre desquels on peut citer :

Tableau n°3 : Projets opérant dans le village

Nom du Projet	Actions menées
Association Sauvegarde de la Girafe au Niger (ASGN)	Micro crédit pour les femmes, sensibilisation, restauration des mares, installation du moulin
DMP	Tests en milieu paysan, compostage, introduction de semences améliorées, conservations des ressources naturelles
PSSA	Transformation produits agricoles(gari), prêt de charrettes, don de18 motopompes,embouche Ovine, élevage de la volaille, boutique d'intrants, houe asine
ANPIP	Prêt de grillage, motopompe niya da kokari
FAO	Don de matériel de jardinage et financement du warrantage
ECOPAS	Suivi de la girafe, appui aux pépinières forestiers, formation des guides
Coop Tanadi	Financement du warrantage et caisse villageoise
PADER	Crédit
Coop Belge	Santé
Souteba	Financement des caped, équipement en matériel scolaire
Programme Spécial Tandja	Micro pour l'embouche

Même si nous constatons qu'il existe dans le village, des Projets qui octroient des crédits, nous ne pouvons pas affirmer, qu'il y'a dans le village des institutions spécialisées en épargne et crédit. Nous savons également que les projets ont une durée de vie très limitée, toute chose qui met fin à l'octroi des crédits.

Au vu de ce qui précède nous pouvons affirmer que les moyens d'existence des populations de Harikanassou ne sont durables parceque dépendant d'un soutien externe lui même non durable

Ressources Naturelles / Capital Physique

Le village de Harikanassou ne dispose d'aucun cours d'eau et n'est pas traversé par un fleuve. Il n'existe pas non plus de mini adduction d'eau potable. Cependant, on dénombre quatre mares importantes et des puisards (nombre non précisé) pour les besoins en eaux des humains et des animaux.

La faune sauvage du village est constituée des animaux suivants :
Kourédjé, Tobey, Kabi, Zounkou, Sounfey Karey, Kodoro, Akoussi, komni, Gandji Yo. Certaines espèces comme moussoubéri, Koro, Djéri, Weiss, Zohon ont disparues.
Les espèces d'oiseaux du village sont : Handaou, Korko, Gabou, Sorwando,, tchourbéra, darfanda, Tchouki,, Garou, Toutou, Ko, Toka, Sassa, Bibi, tchaktchaka, Tcholu tcholi, Werou, Garou Gaba, Koukou, Bogbogo, walia, bargoutoutou, kourkourou, Kolgney, Gouto, kolgney, Maidadara, Fitafita, koysa, boubbouga

La flore est composée de plusieurs espèces parmi lesquelles on peut citer : kouloume, Bérikarissikani gandji, Dani, Gadigui, Maalkou, Harandan, Borborta, Garzé, Soubgna, Balassé, Djirbiizé, Gosso, Kongori, Tchankabé, Malli, Ganda bani, Kourkoutou, kongno zara, Sida, dossari, kolgney Wa, Kolgney Héni, Dangawani, Hanti Tchiria, Danfanahangoy, Ganda kessi, Nafanafa, Foubey, Daradara, Kirmitikoli, kaney, Foy youto, Fokou.

Le mode d'appropriation de la terre le plus répandu est l'héritage. Toutes les terres de culture appartiennent aux différentes familles du village. L'Etat ne dispose pas de terres dans le village et les terres appartenant à des groupements ou associations ou au chef de village sont peu importantes.
Les Champs de culture sont des terres réservées par ordre d'importance à la culture du mil celle du sorgho et à l'association de ces cultures.

La qualité des terres et la taille d'une exploitation sont des facteurs clés pour la production agricole, qui déterminent aussi indirectement la situation économique et sociale de la famille rurale. Dans la région d'étude, il existe apparemment une pénurie des terres cultivables. Les terres qui sont abondantes sont des terres marginales.

Les moyens d'existence ne sont pas durables parce qu'ils ne maintiennent pas la productivité à long terme des ressources naturelles.

Gestion des risques

Plusieurs évènements ont marqué l'histoire du village de Harikanassou. Ces évènements ont pour noms, les grandes famines les invasions de criquets, les sécheresses et les inondations et les incendies.

- Grandes famines :
  (1900) Zamakano ; (1912) Koubodjiré ; (1914) Gandabéri ; (1924) Tiguiri ; (1929) Zarmagandakana ; (1931) Dassey ; (1932) Harey Kaina ; (1947) Soolodjiré ; (1954) Gorodjirey ; et tout récemment les famines de 1973 et de 1984.
- Invasions de criquets :
  L' année 1929 reste dans la mémoire des hommes comme celle d'une année où toute les cultures ont été détruites par les acridiens.
- Sécheresses:
  Les années 1931 et 1984 rappellent encore aux hommes les sécheresses qui ont sévit, entravant la vie des personnes et des animaux
- Innodations et incendies
  Le village a connu des innodations et des incendies mais selon le chef de village les dates ne sont pas mentionnées ni le règne sous lequel ces phénomènes ont eu lieu.

Synthèse des questionnaires ménages dont les chefs sont des femmes

<u>Description des ménages dirigés par des femmes</u>

Identification

Les ménages dirigés par des femmes ont un effectif compris entre 2 et 10 membres avec une moyenne de 5 membres. L'âge des chefs de ménage se situe entre 35 et 58 ans avec une moyenne d' âge de 48 ans. Elles

sont (80%) veuves ; Les divorcées sont relativement jeunes ; avec un âge moyen de 40 ans. Elles sont agricultrices, éleveuses, artisanes et commerçantes. Enfin, elles sont à 90% illetrées et n'ont suivi aucun enseignement.

Ressources/Moyens d'existence des ménages dirigés par des femmes

- Ces ménages possèdent 1 à 2 champs de 2 ha en moyenne réservés aux cultures pluviales. Ces champs sont dans la plupart des cas hérités, seuls 10 % font l'objet de prêt.
- Les cultures pratiquées sont le mil en pur, l'association mil-niébé et quelques cas d'association mil-niébé-sésame-oseille.
- En culture pluviale, la majorité des ménages utilise la main d'œuvre familiale, seul 1 ménage sur les 9 enquêtés utilise la main d'œuvre salariale pour des travaux comme le labour.
- Les productions sont faibles comptent tenu de la pauvreté des sols, toute chose qui ne compense pas les efforts fournis.
- Tous les ménages font la culture de contre- saison, et 90 des terres réservées à cette pratique sont prêtées aux ménages.
- Tous les ménages sur 10 utilisent la main d'œuvre salariale en maraîchage.

Tableau 4 : Les spéculations cultivées par ordre d'importance

Spéculations	Moyenne/ superficie(m2)	Proportion des ménages (%)
Courges	44,8	90
Choux	13,7	90
Salade	10,7	90
Oignon	17,5	80
Tomate	5	30
Poivron	4,5	20
Carotte	3	10

Les produits du maraîchage sont utilisés comme complément alimentaire des ménages et comme un moyen d'améliorer le revenu du ménage.

Gestion de la fertilité des sols

Ces ménages sont conscients des changements climatiques qui se traduisent par une baisse de la pluviosité, la dégradation des sols (base de la production) et souvent une prolifération des ennemies des cultures (sauterelles, chenilles). Pour redresser leurs champs, les ménages dirigés par des femmes apportent la fumure organique sous forme de fumier et d'ordures ménagers. La fumure minérale reste faiblement utilisée par seulement 10% des ménages à cause de la chereté de l'engrais . Le sac du composé (15-15-15) coûte 12 000 frs sur le marché.

Semence

Les ménages dirigés par les femmes n'utilisent pas des semences sélectionnées, qui pourraient peut être améliorer leur production dans ce contexte de changements climatiques. Il ressort de l'enquête, que seul un ménage a utilisé en 2005 des semences améliorées de mil dans son champs. La quantité utilisée est très insignifiante (moins de 2 kg) et est obtenue sous forme de don.

Cheptel

Environ 80% des ménages possèdent des animaux, l'espèce dominante est l'espèce ovine détenue par 60% des ménages. Seules 20% possèdent des bœufs. Les animaux procurent aux ménages par leur vente(ovins) de l'argent pour les cérémonies, mais sont aussi utilisés pour le transport des biens et des personnes.
La valeur totale des animaux des ménages se situe entre 25 000 et 205 000 frs ; la valeur moyenne du cheptel des ménages dirigés par des femme est de 100 00frs.

Autres activités génératrices de revenus

La totalité des ménages dirigés par des femmes exercent des activités génératrices de revenus. Parmi ces activités, il faut citer l'embouche ovine, le tissage des nattes, la vente des produits maraîchers, la vente d'une partie du niébé produit en hivernage etc…
Le revenu des ménages se situe entre 20.000 et 150. 000 frs avec une moyenne de 56.000frs.
Les principales dépenses des ménages sont occasionnées par l'impôt, l'achat des vivres et d'aliments, l'habillement des membres du ménages et leur santé.
Le montant des dépenses des ménages se situe entre 100.000 et 250.000 Frs , avec une moyenne de 162. 625 frs. Les besoins des ménages sont nettement supérieurs à leur revenu, et ils ne disposent pas d'un réseau social durable.

Nutrition et santé
La production des ménages ne couvrent pas leurs besoins nutritionnels. Selon les ménages les productions couvrent entre 1 et 4 mois dans l'année.
Les besoins en eau des ménages sont couvertes et satisfaites par des puits modernes.
Les maladies les plus fréquentes chez les adultes sont le paludisme, le rhume et la collique ; chez les enfants et les nourissons le paludisme, la rougeole et la coqueluche.
Tous les ménages font recours au Centre de Soins Intégrés en cas de maladie. Il faut noter que 7 0% des ménages ont des difficultés de se soigner en cas de maladie, et c'est dû selon ces ménages la chèreté des coûts des soins. Pourtant le carnet de soins ne coûte que 1000 coûte frs.

Gestion de risque
Un des évenements récents qui a le plus marqué ces ménages est la sécheresse de 2005 qui a occasionné une famine dans le village.
Environ 70% des ménages ont ressenti cette famine parce que n'ayant aucun soutien durable, sauf quelques bonnes volontés et quelques aides du gouvernement. Les 30% qui n'ont pas souffert de ce phénomène sont les ménages dont certains membres travaillent en ville, ou ceux qui ont des enfants dans les pays voisins.

Chocs/risques/menaces de la vie réelles des ménages dirigés par des femmes
Trois ménages sur les neuf dirigés ont été retenus pour faire l'objet de cet exercice.

Tableau n° 5 : Calcul indices

Ménage	Type de choc/stress/menace le plus fréquent dans le ménage	Indice de sévérité (Sj)	Incidence (Ij)	Indice de risque (Rj)
1	1- l'alimentation de ma famille	1	1	1
	2- la faible productivité de mon champs	1,33	0,33	0, 24
	3- La santé de ma famille	1,66	1	0, 60
	4 – La pauvreté(comment améliorer mon revenu)	2	1	0, 5
2	1-Le manque de moyen pour acquérir mon propre champs	1	0, 33	0, 33
	2- Alimentation de ma famille	1,25	1	0, 8
	3- La pauvreté (comment améliorer mon revenu)	1,5	1	0, 66
	4 – La santé de ma famille	1,75	1	0, 57
	5 - Mon cadre de vie (comment l'améliorer)	2	0,66	0, 33
3	1- la santé de ma famille	1	1	1
	2- l'alimentation de ma famille	1, 33	1	0, 75

	3 – La pauvreté (comment améliorer mon revenu)	1,66	1	0, 60
	4 – mon cadre de vie (comment l'améliorer)	2	0,66	0, 33

Toutes les valeurs de l'indice sont comprises entre 1 et 2. Plus l'indice est faible, plus la menace est sévère.
Sj= 1+ (rang de la menace – 1) ((nombre de menace) – 1)
Ex ménage n°1 :
1ère menace 1 + (1-1) / (4 –1) =1
2ème menace 1 + (2-1) / (4 – 1) = 1, 33
3ème menace 1+ (3 – 1) / (4 – 1) = 1, 66
4ème menace 1 + (4 – 1) / (4 – 1) = 2

Indice Ij= type de menace x .fois listé/ nombre de participants
Indice de risque Rj= Ij / Sj ; indice est compris entre 0 – 1
Ex : Alimentation de ma famille = 3/3= 1
Baisse de productivité de mon champs = 1/ 3= 0,33
Santé de ma famille = 3 / 3 = 1
Pauvreté (comment améliorer mon revenu) = 3 / 3 = 1
Mon cadre de vie (comment l'améliorer) = 2 / 3 = 0, 66
Mon propre champs (comment l'acquérir) = 1 / 3 = 0, 33

Synthèse des données relatives aux ménages dirigés par des hommes

Description des ménages

Identification
Ces chefs de ménage ont entre 30 et 76 ans avec un âge moyen de 52 ans . Ils sont tous mariés et pratiquent l'agriculture comme activité principale. La majorité de ces chefs de ménage sont monogames (76%) . La taille moyenne de ces ménages est de 8 membres et 59 % des chefs de ménage sont lettrés (niveau primaire, secondaire, études coraniques, alphabétisation).

Ressources/moyens d'existence
Ces ménages possèdent en moyenne 3 champs avec une superficie moyenne de 4 ha. Le mode d'acquisition de 90% de ces champs est l'héritage et ils sont destinés aux cultures pluviales (mil, mil- niébé-oseille, sorgho, niébé et même le riz pluvial).
Tous ces ménages utilisent la main d'œuvre familiale, mais 34% de ces ménages utilisent la main d'œuvre salariale en appui pour des activités comme le labour et la récolte.
La culture de contre saison est pratiquée par 34 % des ménages, et les terres permettant cette pratique sont prêtées par 37 % de ceux qui font la culture de contre saison.
Les spéculations cultivées par ordre d'importance en terme de superficie sont :
- oignon 42, 75 m2
- courge 32 m2
- choux 23 m2
- salade 13,28 m2
- carotte 10m2
- poivron 9 m2
- Piment 5,25 m2

Gestion de la fertilité
Les terres de culture sont très pauvres. Aussi pour pouvoir espérer produire, les chefs de ménages utilisent la fumure organique. Même si la quantité apportée semble importante, elle est très en dé ça de la quantité préconisée pour ces types qui de 20 tonnes/ha. La fumure minérale est utilisée en faible quantité par 44% des

chefs de ménage. L'engrais 15-15-15 est conditionné dans de petits sachets et vendu à 100frs l'unité. Les chefs de ménage trouvent que l'engrais coûte cher.

Semence
Les semences sélectionnées sont connues mais demeurent inutilisées par les chefs de ménages. Seuls trois nous ont affirmé avoir utilisé en moyenne 86 kg de semences améliorées de mil.

Cheptel
Environ 76% des ménages disposent d'animaux. L'espèce bovine est possédée par 59% de ceux qui ont des animaux. On retrouve dans ces ménages les ovins, les asins, et quelques rares équins.
Les animaux procurent aux ménages de l'argent par leur vente, des services (transport de personnes et des biens.
La valeur totale moyenne des animaux des ménages est de 172.000 frs. Cependant, il faut souligner qu'il y'a des ménages qui ont un troupeau important comme le cas d'un ménage dont la valeur totale de son cheptel peut être estimé à 733 000frs.
Les maladies les plus fréquentes chez les animaux sont la péripneumonie, la diarrhée, chez les ovins.

Autres activités génératrices de revenu
Les activités exercées par les chefs de ménage sont les travaux manuels (confection de briques, maçon, manœuvre, main d'œuvre dans les champs) vente de produits de vergers, vente de bois, de chauffe, vente d'herbe.
Le revenu moyen des ménages est de 262 000 frs, la moyenne des dépenses est 356000frs ;
Les principales dépenses des ménages sont les taxes, l'alimentation, l'habillement la santé, etc…

Nutrition/santé
La production des ménages dirigée par des hommes est supérieure à celle des ménages dirigés par des femmes. Cette production dure en moyenne six mois.
Environ 50% de ces ménages ont des difficultés de se soigner par manque d'argent.

Gestion de risque
Près de la moitié de ces ménages ont souffert de la sécheresse de 2005 parce qu'ils ne possèdent pas de réseau social assez développé.

Conclusion partielle
Les ménages dirigés par les hommes disposent de plus de moyens d'existence que les ménages dirigés par les femmes. Cependant, même si ils disposent de plus de champs que les femmes, leur production ne couvre pas la totalité de leurs besoins alimentaires. La terre qui est la base de la production est très pauvre et la moitié de ces ménages ne sont pas durables parce que ne résistant pas aux chocs et aux pressions externes.

2.3.2. Village de Kouré

Profil historique et Démographie
Le village de Kouré est érigé en commune rurale en 2005 . Il est situé dans le Département de Kollo, Région de Tillabéry. Les premières familles fondatrices ont quitté Sargane- Namari. De Namari, un certain Hama Koumbo quitta pour fonder Karbédji. C'est un de ces enfants du nom de Kadda qui alla fonder Sébéri, puis de Sébéri a quitté pour créer Kouré.
Le village de Kouré a connu 13 chefs qui se sont succédés dans le temps.

Tableau n° 6 : succession des chefs dans le village

Nom et Prénom du chef	Règne	Durée (an)
Kadda Hama Koumbo	-	-
Dagara Kadda	-	-
Illo Dioda	1779- 1818	39
Kodado Kadda	1818- 1820	2

Dioffo Dagara Kadda	1820- 1855	35
Marou Dagara Kadda	1874- 1892	18
Soumana Dagara Kadda Dioffo	1892- 1896	4
Soumana Dagara Kadda dit Gouniakoye	1896- 1900	4
Ali Baddara Madi Kodado Kadda	1900- 1916	16
Sidikou Marou dit Sounnadé	1920- 1935	15
Harouna Sidikou	1935- 1965	30
Abdou Sidikou	1965- 1973	8
Garba Sidikou	1973-	33

La population de Kouré est 5000 habitants réparties en 2600 femmes et 2400 hommes.
La commune rurale de Kouré est limitée par :

- A l'est : Tchoubi, Sinakoira, Boktchili, N'Gandey, Ahamandey, Boula
- A l'ouest : Karbédji, Sekekoirazéno, Kongou, Sekekoiratedji
- Au nord : Babousey, Dolahin, Balansadjé, Gassagoungné
- Au sud : Dondo

Infrastructures socio- économiques
Le village de Kouré est accessible par route . Mais en période d'hivernage , les voies d'accès sont impratiquables. Le village est doté des infrastructures utilitaires suivantes :

Tableau n° 7 : infrastructures socio-économiques

Nature	Nombre	Année de création
Ecole primaire	2	1958 et 2003
Collège secondaire	1	2004
Case de santé/CSI	1	1976 et réhabilité en 1999
Mosquée	2	1997 et 2005
Magasin	1	1982
Marchés	1	1994
Forages	5	1982
Château	1	-
Puits modernes	6	Entre 1956 et 1990
Service agricole	1	1969
Mairie	1	2005

Les principales contraintes en matière d'infrastructures sont :

- manque de tables banc au niveau de l'école primaire
- Pénurie de produits médicaux au niveau du CSI
- Trois des cinq forages ne sont pas fonctionnels
- Insuffisance du débit d'eau du château
- Non fonctionnalité du service agricole

Institutions et Associations Socio-Professionnelles/organisations paysannes
Les différentes associations présentes dans le village sont les suivantes :

- L'association des femmes ;au sein de cette structure les femmes font le commerce, l'embouche, l'agriculture et les travaux d'intérêt commun
- L' association des jeunes ; entretien des infrastructures du village, sensibilisation des jeunes
- Association islamique ; promotion de l'islam
- Comité des paysans, les membres de cette structure reçoivent du DMP des formations pour la récupération des terres dégradées et de l'environnement

- La COFOB gère les transactions foncières
- L'association des parents d'élèves

Comme auto-encadrement il y'a deux matrones, quatre ex-stagiaires agricoles, et un agent de vulgarisation qui sert de représentant de DMP.
Les projets de développement et institutions qui opèrent dans le village sont :

Nom de l'institution	Actions menées
DMP	-CES/DRS, jardins, formation des paysans en technique de multiplication de semences
PAC	mise à disposition des producteurs de l'engrais sous forme de prêt
Rotary club	réhabilitation du dispensaire en VSI
Coopération Allemande	Etude de l'installation d'un château
ECOPAS	Suivi des girafes et formation des guides
ASGM	Sensibilisation sur la sauvegarde des girafes

Il existe dans le village une structure d'épargne et de crédit dénommée wafakoye mise en place par l' association des jeunes.

Ressources naturelles/Capital physique
On dénombre dans le village un cours d'eau, un puits traditionnel, cinq pompes. Il existe également plusieurs espèces d'oiseaux et d'animaux . Les services qu'offre la nature sont la chasse et la cueillette. Les modes d'appropriation de la terre sont l'héritage et le prêt. Il y' a suffisamment de terre de culture mais les terres marginales sont également abondantes. Les terres sont pauvres et utilisées surtout pour la culture du mil.

Gestion de risque
Les événements qui ont marqué le village sont :
- Grande famine : Hareybéri, Gandabéri (1914), Garodjiré (1952), saladjiré (1947), Kagadjiré (1984)
- Incendie : incendie de 1982 et de1997
- Innondation : 1999 et 2003
- Invasion de criquets : Hareybérodjirey
- Secheresse :Kogadjiré (1984)
- Invasion d'oiseaux migrateurs : pratiquement chaque année

Pour la résolution des problèmes liés à ces évènements, il y' a eu l'intervention de l'état, la mobilisation des populations vivant dans le village et celle des enfants du village vivant à l'extérieur

Synthèse des données relatives aux ménages dirigés par des hommes
(Pour le village de Kouré, seules les données des ménages dirigés par des hommes ont été traités)

Description des ménages
Les chefs des ménages ont entre 28 et 73 ans, avec un âge moyen de 51 ans. 73% de ces chefs sont monogames. 46% sont illettrés et l'effectif moyen des ménages est de 8 membres.

Ressources moyens d'existence
Les chefs de ménage ont entre 1 et 5 champs, avec une moyenne de 3 champs par personne. La superficie moyenne des champs est de 4 ha. Le mode dominant d'acquisition des champs est l'héritage suivi du prêt qui est moins négligeable et atteint 38%.Les champs sont réservés par ordre d'importance à la culture de l'asssociation mil-niébé, à la culture pure du mil et l'association mil-sorgho-oseille.

Il est démontré que les productions des cultures pluviales n'arrivent pas à elles seules à satisfaire les besoins alimentaires des ménages , surtout à cause de la pauvreté des types de sols sur lesquelles sont pratiquées. Cependant, si ce type de déficit est tenté d'être comblé par la pratique des cultures de contre saison par quelques hommes à Harikanassou, à Kouré aucun de ménage de ce genre ne pratique de culture de contre saison. Sueles quelques femmes pratiquent le maraîchage.

Gestion de la fertilité
Les champs sont très pauvres et les rendements faibles.. Les chefs de ménage utilisent tous la fumure organique pour relever le niveau fertilité de leurs champs, mais à des doses qui sont en deçà de celles préconisées. L'utilisation de la fumure minérale se fait timidement. Environ 30% des ménages mélangent le 15-15-15 au semence au moment des semis. 20% des ménages disposent d'une unité de culture attelée.

Cheptel
Tous les ménages possèdent des animaux, mais surtout l'espèce bovine qui domine. 70% des ménages possèdent en moyenne 4 bœufs. Les animaux procurent du fumier pour les champs, du lait de lait et de l'argent par leur vente en cas de besoin. Ils sont aussi utilisé aussi pour le transport et la traction pour le labour.

Autres activités génératrices de revenus
Les activités exercées par les chefs de ménage du village sont les suivantes : main d'œuvre salariale, vente de bois , vente de paille , vente des sous produits agricoles, embouche.
Le revenu moyen est de l'ordre de 287000frs CFA. La moyenne des dépenses est de 343000frs CFA. Les principales dépenses sont l'impôt, l'alimentation, la santé et l'habillement des membres des ménages.

Nutrition/santé
La production des ménages ne couvrent pas leurs besoins alimentaires. Leur récolte arrive à couvrir en moyenne cinq mois de l'année.
Les ménages n'ont pas de problèmes de soins, parce qu'ils détiennent des carnets de soins achetés au CSI à 700 frs CFA.

2.4. CONCLUSION

Il se dégage de cette étude les tendances suivantes :

- Une diminution des espaces cultivables et surtout une baisse progressive de la production qui est due en partie à la pauvreté des sols ;
- Une non durabilité des moyens d'existence des ménages, parce que la production est compromise à long terme ;
- Une insuffisance des revenus des ménages alors que les besoins sont de plus en plus en élevés ;
- Une absence ou insuffisance de réseau social des ménages ;
- Une absence de stratégie de mobilisation de ressources qui se traduit par une paupérisation et une situation de vulnérabilité des ménages.

NB : Après la collecte des données la secrétaire qui s'est chargée de leurs saisies, ne se rappelle plus où avoir placé les questionnaires du village de Sébéri. C'est ce qui explique dans ce rapport de fin de projet, le village de Sébéri n'a pas été pris en compte. Mais dès que les questionnaires seront retrouvés, nous vous ferons parvenir les résultats de ce village.

BURKINA FASO

INTRODUCTION

Le projet SEMSOC poursuit l'objectif global suivant : identifier les opportunités d'adaptation et de réduction à partir de l'établissement de la sensibilité des ressources naturelles (incluant les stocks de Carbone) aux changements climatiques et les réponses de réduction pouvant améliorer la fertilité des sols, une agriculture durable et augmenter la sécurité alimentaire, évaluer les besoins pour des réponses adaptées aux changements climatiques.

1. La zone d'intervention du projet

Deux sites ont été identifiés selon trois critères principaux :

- les zones climatiques basées sur la pluviométrie
  - zone sahélienne de 300 à 600mm
  - zone soudanienne de 900 à 1200mm

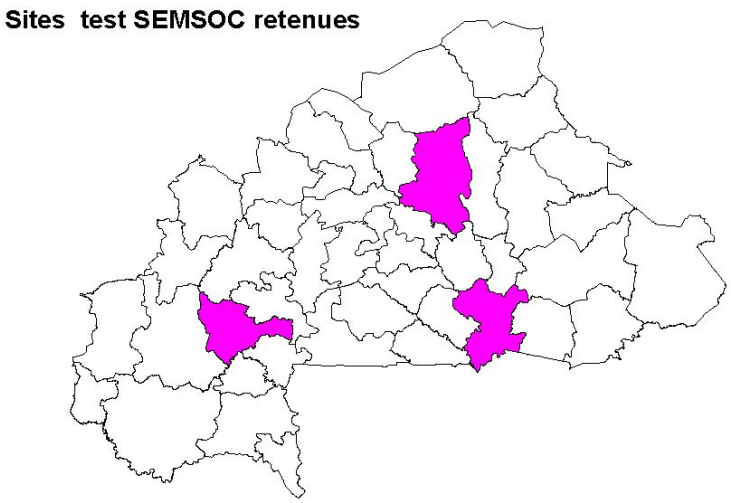
- la disponibilité de données anciennes appropriées à l'étude pour les années :
  - 1980s
  - 1990s
  - 2000s

- l'accessibilité en toute saison, notamment en saison agricole (hivernage) pour les mesures et descriptions sur les cultures.
-

Au terme des évaluations, les sites suivants sont retenus :

- dans la zone soudanienne, la zone de Koumbia/Houndé dans le Tuy, sur l'axe Ouaga-Bobo est retenue. C'est une zone cotonnière où l'INERA a assuré des travaux de traitement d'images SPOT en 1989. L'installation de migrants y est importante et la biodiversité est conservée dans une forêt classée. Là, les hauteurs d'eau se situent entre 900 et 1200mm.

- La zone sahélienne sera représentée par la zone de Kaya, centrée sur le terroir de Bindogo, sur l'axe Kaya-Dori, une région où un travail d'analyse de l'impact des aménagements CES a été conduit de 2002 à 2003 par un panel de chercheurs de l'INERA, l'Université de Ouagadougou, des cabinets et institutions publiques et privées du Burkina, des Etats Unis et des Pays Bas. L'évaluation a concerné les années 1960s, 1980s et 2000s. La zone reçoit des précipitations entre 300 et 600mm.



2. Méthodes de recherche

2.1. Utilisation/occupation des sols

Cette étude s'est basée sur de nombreux travaux conduits par l'INERA et le PNGT dans cette zone et qui offrent des connaissances fortes sur la population, les systèmes de production et les ressources naturelles. Parmi ces travaux, il y a les activités du programme recherche sur les systèmes de production que conduisit le Dr. Philippe Morant pour une analyse de la fragilité écologique et des potentialités agronomiques de la région. Aussi, de nombreuses collectes de données socioéconomiques et techniques sur les populations, les sols et les activités ont-elles été effectuées sur une période de trois ans. Ces travaux ont intégré une caractérisation des états de surface à partir d'image SPOT couvrant 60X60km. Les images utilisées sont référencées K50-J327.

2.2. Mesure du carbone dans les sols et la biomasse

Elle comporte les étapes suivantes :

Photo-interprétation : son objectif est la réalisation d'une carte de base (carte géomorphologique) qui sera utilisée pour la prospection pédologique. Ainsi, les prises de vue aériennes, à l'échelle du 1/50.000 éme, acquises à l'IGB ont été interprétées. Les unités géomorphologiques ont été délimitées sur la base des caractéristiques suivantes qui influencent la pédogenèse : la topographie, la nature et l'intensité des phénomènes morpho dynamiques (érosion, ruissellement...), la végétation, la nature du substratum. Il faut préciser aussi qu'une triangulation a été réalisée afin de corriger les déformations sur les photographies aériennes.

Les travaux de terrain
Il s'agit de la prospection pédologique. L'approche méthodologique utilisée est le type toposéquentiel. Cette méthode consiste à tracer des transects de telle sorte qu'ils passent par le maximum d'unités géomorphologiques. Les observations (fosses et sondages pédologiques) sont placées du point le plus haut (buttes cuirassées ou rocheuses) au point le plus bas (talwegs) et à des distances variables en fonction de la complexité du milieu physique. Le positionnement des observations sur les prises de vue aériennes se fait par photo-identification.
Les fosses pédologiques qui ont été ouvertes, ont été décrites selon les directives FAO (1994), leur couleur a été déterminée à l'aide du code Munsell (version 1975), la texture a été déterminée à partir du triangle de texture USDA. Les unités pédologiques ont été classées selon la CPCS (1967) avec leur référence dans la WRB, 1999.

Remarque : pour ce présent rapport, seules les caractéristiques morphologiques des sols sont décrites car les caractéristiques physico-chimiques ne sont pas encore disponibles

2.3. Activités socioéconomiques

Etant donné le temps imparti pour l'étude et la diversité des points à traiter, une méthode permettant de collecter rapidement les informations tout garantissant leur qualité devait être envisagée. C'est ainsi qu'une interview avec une assemblée de producteurs composée essentiellement de personnes ressource a été réalisée dans chaque village. Cette méthode contraste avec l'enquête- ménage qui requiert plus de temps.
Quatre (4) villages ont été retenus dans le site de Koumbia. Ce sont Waly et Kongolékan qui sont des villages à dominance bwaba (autochtones) et à vocation agricole, Rabounilaye qui est un village composé essentiellement d'agro pasteurs Mossi immigrés et un campement peulh comptant des agro pasteurs avec une prédominance de l'élevage sur l'agriculture.
Ces sites ont été choisis après avoir rencontré des difficultés à trouver des sites à typologies variées (agriculteurs, éleveurs et agro pasteurs) pouvant composer une assemblée d'enquêtés commune, et également dans l'objectif de déceler d'éventuelles différences dans la gestion des ressources naturelles par les différentes communautés existant dans la zone de Koumbia.

2.4. Modélisation

Le formatage des données a été la première étape du volet modélisation pour atteindre les résultats visés.
Les données formatées des pratiques de gestion des ressources naturelles pour l'exercice ont porté :

- sur la composition des cultures (Crop_composition)
- sur la rotation des cultures (Crop_rotation)
- sur le changement des pratiques de moisson (Harvest)
- sur la jachère (Fallow)
- spécifiant les feux de brousse, la coupe du bois et du pâturage.

Les autres données traitées et générées à partir des logiciels SIG sont celles répertoriées dans le tableau suivant :

Intitule de la donnée	**Nom en fichier shp**	**Nom fichier grid**	**Nom fichier txt**	**Observation**
L'occupation du sol	ocsols1992.shp	ocsolGRID92		
	ocsols2002.shp	ocsolGRID02		
Aires protégées et réserves		AIRESGRID		
végétation potentielle		VegetGRID78		
Les sols		SolsGRID	solsGRID.txt solkoumbiadrain.txt	Drainage
Le climat		Komint	Komint.txt.	Combine
		Komaxt	Komaxt.txt	Combine
		korain	korain.txt	Combine
		Koclimat	Koclimat.txt	Combine KKK
		KOUMBIA JFD (Combine Koclimat ; AiresGRD ; VegetGRD78 ; ocsolGRD92 ; ocsolGRD02 ; solsGRD) KoumbiaJFD		

NB : En dehors du volet socioéconomique où les investigations ont porté sur les sites de Koumbia et Bindogo, les autres volets se sont intéressés au seul site de Koumbia.
Le thème Information, communication, échanges n'a pas été abordé dans le présent rapport.

3. Evaluation de l'utilisation/ occupation du sol

3.1.Géologie

La région est dominée par le socle précambrien rapporté au Birrimien (2milliards d'années). C'est essentiellement des volcano-sédimentaires, plissées et métamorphisées lors du phénomène birrimien, d'orientation NNE - SSO :

- les schistes birimiens sont fortement altérés
- les roches andésitiques (andésites, amphibolites, andésites quartzitiques

A la fin du tertiaire, sous forêt tropicale humide, la migration du fer en profondeur a engendré un cuirassement généralisé. Sur les andésites, les cuirasses latéritiques sont bien développées.

3.2.Climat

La saison pluvieuse va de mai à octobre. Nous sommes dans la partie Nord de la zone soudanienne. Le régime pluviométrique présente une variation cyclique avec l'isohyète inférieure placée à 900mm. La variabilité du régime entraîne une disparité dans le développement végétatif des plantes cultivées.

3.3. Végétation

Les formations végétales se réduisent en majorité à la savane avec tapis de graminées sous un étage arboré. Les espèces largement en présence sont le Butyrospermum parkii, le Parkia biglobosa, le Ptérocarpus érinaceus, le Terminalia avicennoïdes, le Détarium microcarpum et le Ximenia americana. Pour les graminées, dominent l'Andropogon gayanus, l'Andropogon pseudapricus, le Pennisetum purpureum et le Pennisetum pedicellatum. Sur les bowé (surfaces cuirassés) la végétation est de type sahélien avec des espèces arborées de la famille des acacias : Acacia seyal, Acacia sénégal et des espèces herbacées comme le Loudetia togoensis. Dans les bas-fonds et les galeries forestières se rencontrent des espèces arborées comme le Khaya sénégalensis, l'Anogeissus leiocarpus et le Cassia siberiana. Les zones cultivées et les jachères développent des savane-parc avec des espèces utiles (karité, néré).

3.4. Répartition des états de surfaces en 1989

La répartition des états de surface est ainsi faite :
- domaine du cultivé : se compose des jachères récentes et des champs cultivés. Là, le sol est nu ou faiblement recouvert. Il occupe 15.6% des terres.
- le domaine non cultivé présente deux types de surface :
  - les surfaces cultivables, soit 50% des terres comprennent la savane arborée ou arbustive claire à très claire (39.5%) ; la savane arborée ou arbustive dense à mi-dense (9%) et les boisements (1.5%).
  - Les surfaces non ou très difficilement cultivables, soit 34.5% des terres, proposent 25.8% des terres en savane arborée ou arbustive sur dômes, dalles cuirassées ou affleurements rocheux et 8.7% faites de dalles cuirassées nues, d'affleurements rocheux avec végétation nulle ou très claire.

Le domaine du cultivé et les surfaces cultivables représentent un milieu sensible aux processus de dégradation superficielle. Les associations de sols sont des sols ferrugineux tropicaux lessivés appauvris sur altérations de schistes. Ils sont souvent sableux en surface, limono-sableux et gravillonnaires en profondeur. L'épaisseur est moyenne à faible. On a aussi des associations de sols bruns eutrophes tropicaux modaux, hydromorphes ou vertiques autour des collines de roches vertes. Ce sont des sols structurés, en général profonds, souvent caillouteux et à bonne fertilité. Enfin on rencontre les sols hydromorphes et vertisols

hydromorphes dans les alluvions argileuses. Au niveau des surfaces non ou difficilement cultivables, il y a absence de sol ou ce sont des lithosols sur blocs et amas de cailloux.

3.5. Les unités d'occupation des terres en 2002

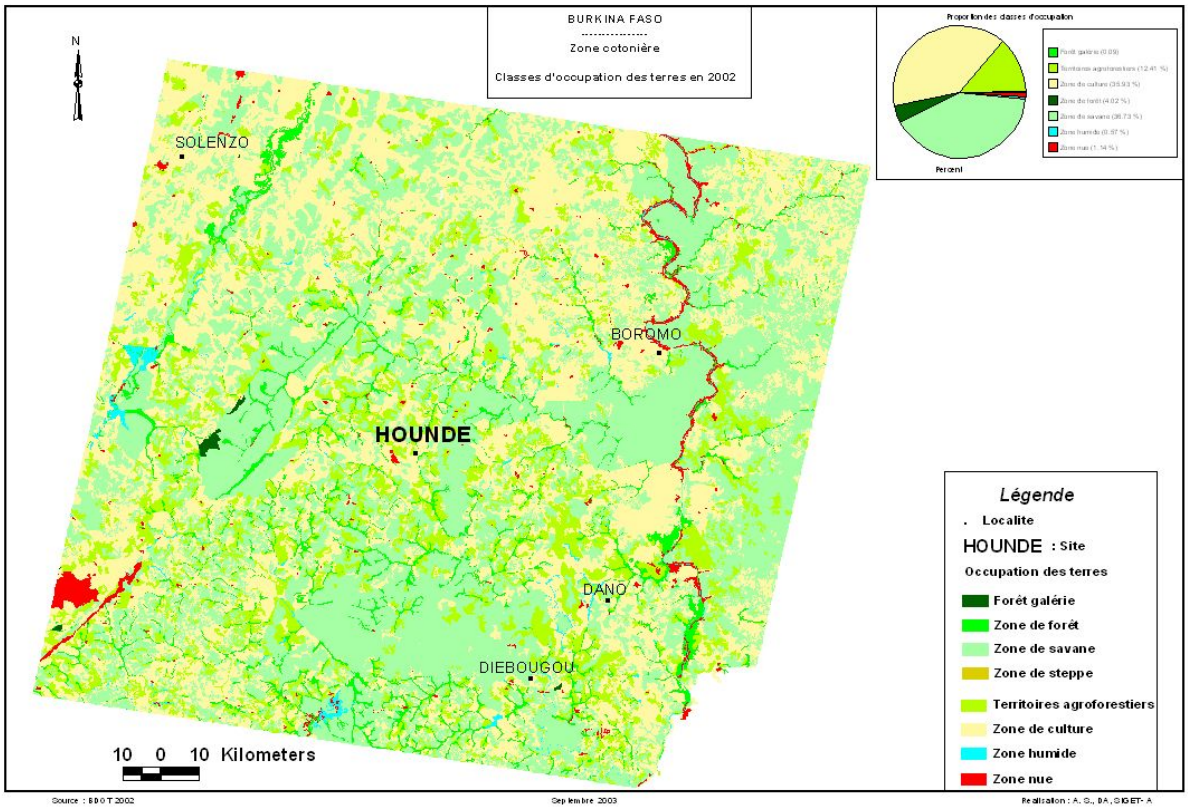
Un travail de caractérisation des unités d'occupation des terres a été faites sur l'image LANDSAT 196-52. Cette classification a conservé les unités dans des classes exploitables dans le modèle. Les résultats figurent dans la carte des classes d'occupation des terres :

- les savanes ont la proportion la plus élevée en 2002 avec plus de 38% des terres. On y a intégré toutes les catégories de savanes.
- le cultivé occupe la deuxième position avec 36% des terres. Comparé à la situation de 1989, on constate une nette progression des surfaces en culture de 1 à 2,5 fois.
- les territoires agro-forestiers viennent en 3ème position avec 12,40% des terres
- les forêts sont évaluées à 4% de la zone couverte par l'image
- les zones nues avec les dalles de cuirasse, les roches affleurantes font 1,14%
- les forêts galeries occupent à peine 1% de l'image
- on recense quelques marécages herbeuses sur 0,5% des terres.

3.6. Les systèmes de culture et exploitations agricoles

Dans la région de Houndé il existe de grandes exploitations. Les petites exploitations se limitent à 3 à 5ha. Trois cultures occupent l'essentiel des parcelles agricoles. Ces sont le coton, très généralisé, le maïs et le sorgho. En fait, la région de Houndé est la première zone où la vulgarisation agricole s'est fortement implantée. L'objectif principal était l'introduction de la culture du cotonnier et l'équipement en matériel de culture attelée bovine des exploitations. Cela a accru les surfaces cultivées, prioritairement pour le cotonnier mais aussi pour les cultures vivrières. Une exploitation non équipée ne dépasse guère 2.3ha alors que les exploitations équipées sont au dessus de 5ha. Sur le plan social, il y a eu éclatement de la famille qui s'est exprimée sur l'activité de production agricole. Les grandes exploitations familiales ont éclatées en exploitations nucléaires réduites aux ménages comprenant chacun le chef d'exploitation, sa ou ses femmes et ses enfants.

Chez les populations autochtones, les superficies du cotonnier augmentent avec la taille de l'exploitation. Dans les grandes exploitations, 50% de l'exploitation est en cotonnier ; puis vient le maïs, la céréale vivrière, et enfin le sorgho, rouge principalement, pour la bière de mil (« dolo »). Chez les populations allochtones (migrants), les surfaces du cotonnier s'accroissent en fonction de l'ancienneté de l'exploitant. A l'arrivée, la stratégie est d'abord l'autosuffisance alimentaire ; en outre, ils sont sous-équipés et n'ont que de petites portions de terre. Le sorgho (blanc) est la principale production à l'arrivée avec 66% des surfaces. Ces migrants sont généralement des agriculteurs venus du Nord où les sols sont épuisés. Souvent les installations ne sont pas organisées, ce qui crée une gestion anarchique des terres.



4. Mesures de carbone dans les sols et la biomasse

4.1. Monographie des sols

Les sols décrits sur l'ensemble de la zone de Koumbia, appartiennent à trois classes de sol selon la taxonomie française des sols (CPCS, 1967). Ce sont :

- la classe des sols minéraux bruts
- la classe des sols à sesquioxydes de fer et ou de manganèse
- la classe des sols hydromorphes

4.2. La classe des sols minéraux bruts

Les sols minéraux bruts sont caractérisés par l'absence d'évolution pédologique due soit à des conditions climatiques ne permettant pas l'altération des roches (sols minéraux bruts d'origine climatique), soit à des facteurs mécaniques (sols minéraux bruts d'origine non climatique). Sur le site de Koumbia, un seul type d'unité pédologique a été rencontré et appartient à la sous classe des sols minéraux bruts non climatique et au groupe des lithosols; il s'agit de :

*** les lithosols (LR, LC) ;** ils rassemblent les Lithosols sur cuirasse ferrugineuse et les Lithosols sur roches diverses. Les premiers sont localisés au niveau des buttes cuirassées et des zones d'affleurement de cuirasse ferrugineuse tandis que les seconds correspondent aux niveaux rocheux à processus pédogénétique nul ou embryonnaire. Ce sont des sols à profil squelettique par endroit avec un pourcentage très élevé (environ 80 à 90 %) d'éléments grossiers sous forme de recouvrement : graviers, cailloux, blocs de cuirasse ferrugineuse ou de roche. Il faut noter également des affleurements de cuirasse ferrugineuse et de roches diverses. Aucune activité champêtre n'y est pratiquée. Ils correspondent dans le système WRB, 1999, aux **plinthosols épipétriques** pour les Lithosols sur cuirasse ferrugineuse et aux **leptosols épilithiques hypersqueletiques** pour les Lithosols sur roches diverses.

4.3. La classe des sols à sesquioxydes de fer et/ou de manganèse

Elle est représentée ici par la sous classe des sols ferrugineux tropicaux (lessivés). Elle est la plus représentative tant par le nombre de types de sol que par son étendue. Les processus de pédogenèse qui se manifestent au sein de ce sous classe de sol sont la ferruginisation, le concrétionnement, le lessivage et l'induration. Leur couleur caractéristique est surtout liée à une individualisation des sesquioxydes de fer. Les types de sols ci-dessous y ont été distingués :

*** Les sols ferrugineux tropicaux lessivés indurés superficiels**

Ils sont caractérisés par des affleurements de cuirasse ferrugineuse ou souvent de carapace ferrugineuse entre 10 et 20 cm de profondeur. La texture est en surface Limono-sableuse (LS) et Limono-argilleuse (LAS) dans l'horizon de profondeur. La couleur varie du brun grisâtre sombre (10YR 4/2) en surface au jaune brunâtre (10YR 6/6) en profondeur. La structure est polyédrique subangulaire faiblement développée en éléments moyens et fins avec une charge graveleuse importante variant entre 25 et 70 %. Le profil du sol se caractérise par de nombreux pores et d'assez nombreuses racines fines, très fines et moyennes. L'activité biologique est bien développée.
La végétation est une savane parc à dominance de *Vitelaria paradoxa* et de quelques *Parkia biglobosa*. Le drainage est normal à légèrement excessif. Ces sols se rencontrent généralement dans les alentours immédiats des buttes et affleurements cuirassés. Ils correspondent aux **plinthosols épipétriques** selon la WRB, 1999.

*** Les sols ferrugineux tropicaux lessivés indurés peu à moyennement profonds**

L'induration ferrugineuse apparaît ici entre 20 et 60 cm de profondeur. Ces sols se rencontrent généralement sur les plateaux des glacis moyens. La couleur varie du brun grisâtre (10YR 5/2) en surface au brun très pale (10YR 6/4) en profondeur en passant par le brun jaunâtre clair (10 YR 6/4) en profondeur. La texture est Limono-sableuse (LS) en surface et argileuse (A) en profondeur. La charge graveleuse varie de 10 à 30% et comprend des gravillons et concrétions ferrugineuses et des concrétions ferro-manganifères. La structure est polyédrique subangulaire faiblement développée avec des éléments moyens et fins. Cette structure, il faut le noter, est souvent massive dans les horizons de profondeur. Le profil racinaire est bien développé avec de très nombreuses racines fines, très fines et moyennes. Les pores sont nombreux et l'activité biologique est assez bien développée.
La végétation est tout comme le précédent une savane parc à dominance de *Vitelaria paradoxa* et de quelques *Parkia biglobosa*. Le drainage est dans l'ensemble normal. Ils correspondent dans le système WRB, 1999, aux **Lixisols épi ou endo pétroplinthiques**.

*** Les sols ferrugineux tropicaux lessivés à taches et concrétions**

Ce sont des sols profonds caractérisés par la présence de quelques taches d'oxydo-réduction et de nombreuses concrétions ferrugineuses et ferro-manganifères de consistance souvent friable liée à une hydromorphie temporaire observée dans les horizons de profondeur. La couleur varie du brun pale (10YR 6/3) en surface au jaune rougeâtre (7,5 YR 7/6) en profondeur avec de nombreuses taches d'oxydoréduction de type rougeâtre (2,5YR 4/8) et brun jaunâtre (10YR 5/8) en profondeur. La texture est Limono-sableuse (LS) en surface, Limono-argilo-sableuse (LAS) dans les horizons intermédiaires et Argileuse (A) en profondeur. La structure est polyédrique subangulaire, faiblement développée avec des éléments grossiers, moyens et fins. Cette structure est massive dans les horizons de profondeur La charge graveleuse est assez importante pouvant atteindre 20 % dans les horizons de profondeur. Le profil racinaire est très bien fourni en racines fines, très fines et moyennes. La végétation est également une savane parc à dominance de *Parkia biglobosa*, de *Vitelaria paradoxa* et de quelque *Tamarindus indica*. Le drainage est dans l'ensemble normal. Ces sols se rencontrent généralement sur les pentes des glacis moyens. On note la présence en profondeur (>80 cm) de cuirasse ou de carapace ferrugineuse. Ils correspondent dans le système WRB, 1999, aux **Lixisols hypogleyiques ferriques**.

*** Les sols ferrugineux tropicaux lessivés hydromorphes**

Ces sols présentent presque les mêmes caractéristiques que les précédents : ce sont des sols profonds avec la présence de taches d'oxydo-réduction mais une absence quasi-totale de concrétions ferrugineuses et ferro-manganifères en surface comme en profondeur. La couleur varie du gris brunâtre clair (10 YR 6/2) en surface au brun pale (10 YR 6/3) dans les horizons intermédiaires et brun très pale (10YR 7/4) en profondeur avec de nombreuses taches d'oxydoréduction de type rougeâtre (2,5YR4/8) et brun jaunâtre (10YR 5/8) lui conférant ainsi un aspect bariolé. La texture est Limoneuse (L) à Limono-argileuse (LA) en surface et Argileuse (A) en profondeur. La structure est polyédrique subangulaire, faiblement développée avec des éléments moyens et fins. La charge graveleuse est nulle. Le profil racinaire est très bien fourni en racines fines, très fines et moyennes. La végétation est tout comme le précédent une savane parc à dominance de *Vitelaria paradoxa* et de quelques *Parkia biglobosa*. Le drainage est dans l'ensemble imparfait. Ils correspondent dans le système WRB, 1999, aux **Lixisols gleyiques**. Ces sols se rencontrent généralement au niveau des zones basses sous forme de dépressions localisées.

4.4. La classe des sols hydromorphes

Les sols qui constituent cette classe sont formés à partir d'alluvions et le processus pédogénétique dominant reste l'hydromorphie qui affecte tout le profil. Les caractéristiques générales qui en découlent sont : la présence de pseudogley, des taches d'oxydo-réduction et des concrétions ferro-manganifères très friables localisées surtout en profondeur. Une seule unité pédologique y a été rencontrée:

***Les sols hydromorphes peu humifères à pseudogley d'ensemble**

Ce sont des sols profonds (>120cm) caractérisés par la présence en profondeur de pseudogley bien individualisés et de taches d'oxydo-réduction abondantes. Ces sols ont été rencontrés essentiellement dans les bas-fonds, les plaines et les vallons colluvio-alluviaux. La couleur de la matrice varie du gris clair (10 YR 6/1) en surface et du brun (10 YR 5/3) au brun très clair (10YR 7/3) en profondeur avec de nombreuses taches d'oxydo-réduction de type rouille, gris clair (10 YR 7/2) et brun jaunâtre (10YR 5/8) lui conférant ainsi un aspect bariolé. La texture est Argilo-limoneuse (AL) en surface et Argileuse (A) en profondeur. La structure est polyédrique subangulaire, moyennement à faiblement développée avec des éléments moyens et fins. La charge graveleuse est nulle. Le profil racinaire est très bien fourni en racines fines, très fines et moyennes. La végétation est de type ripicole à dominance de *Mytragina inermis* et de *Acaccia sp.*. Le drainage est dans l'ensemble imparfait. Ils correspondent dans le système WRB, 1999, aux **Gleysols eutriques**.

Tableau récapitulatif des caractéristiques morphologiques des sols rencontrés

Caractéristiques morphologiques Type de sol	Aspects superficiels du sol	Profondeur (cm)	Couleur de la matrice	Couleur des taches	Structure	Induration	Eléments grossiers	Erosion	Drainage
Lithosols sur cuirasse ferrugineuse *Plinthosols épipétriques* Lithosols sur roches diverses *Leptosols épilithiques hypersqueletiques*	Affleurements de cuirasse ferrugineuse et/ou de roches diverses, Concrétions et gravillons ferrugineux, Fragments de roches	0 – 5	-	-	-	Cuirasse ferrugineuse et ou affleurement de roche	80	en nappe	Excessif
Sols ferrugineux tropicaux lessivés indurés superficiels *Plinthosols épipétriques*	Affleurements de cuirasse ferrugineuse, concrétions et gravillons ferrugineux, recouvrement limono-sableux	10 – 20	Brun grisâtre sombre à jaune brunâtre	-	polyédrique subangulaire faiblement développé	Affleurement de cuirasse ferrugineuse	25 – 70	quelques ravines	Normal à légèrement excessif
Sols ferrugineux tropicaux lessivés indurés peu à moyennement profonds *Lixisols épi ou endo pétroplinthiques*	Concrétions et gravillons ferrugineux, recouvrement limono-sableux	20 - 60	Brun grisâtre à brun jaunâtre clair	-	polyédrique subangulaire faiblement développé	Affleurement de cuirasse ferrugineuse	10 - 30	en nappe	Normal
Sols ferrugineux tropicaux lessivés à taches et concrétions *Lixisols hypogleyiques ferriques*	Recouvrement limono-sableux	> 120	Brun pale à jaune rougeâtre	Rougeâtre et brun jaunâtre	polyédrique subangulaire faiblement développé	-	20	Rares ravines	Normal
Sols ferrugineux tropicaux lessivés hydromorphes *Lixisols gleyiques*	Recouvrement limoneux à limono-argileux	> 120	Gris brunâtre clair à brun très pale	Rougeâtre et brun jaunâtre	polyédrique subangulaire faiblement développé	-	-	en nappe avec quelques ravines	imparfait
Les sols hydromorphes peu humifères à pseudogley d'ensemble *Gleysols eutriques*	Recouvrement argilo-limoneux et fentes de retrait	> 120	Brun clair, brun et brun très clair	Rouille, brun jaunâtre, gris clair	polyédrique subangulaire moyennement développé	-	-	en nappe avec quelques ravines	imparfait

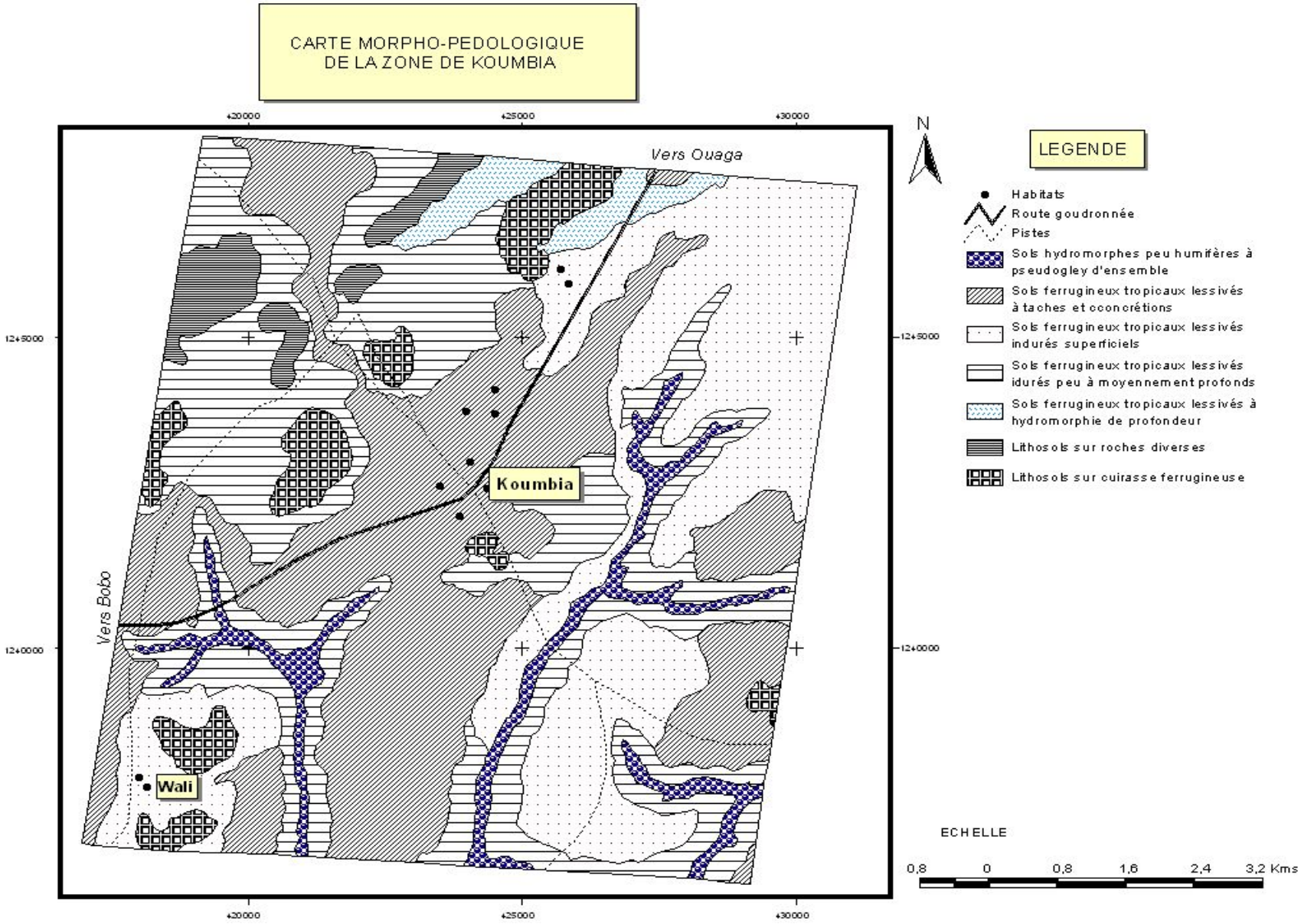
4.5. Notice explicative de la carte des sols

L'établissement de la carte des sols de la zone de Koumbia s'est effectué comme suit :

- une photo-interprétation détaillée des prises de vue aérienne qui a permis de dresser une carte des unités géomorphologiques ;
- une vérification de terrain de cette carte géomorphologiques ;
- une mesure des points GPS sur le terrain en vue d'une géoréferentiation ;
- une prospection pédologique de type toposequentiel qui a permis de déterminer pour chaque unité géomorphologique le type de sol correspondant.

Ainsi en fonction des unités géomorphologiques, les sols suivants ont été inventoriés :

Unités géomorphologiques	**Unités pédologiques**	**Autres caractéristiques**
Zone inondable et bas-fond	Sols hydromorphes peu humifères à pseudogley d'ensemble *Gleysols eutriques*	Sol argilo-limoneux en surface, champs
	Sols ferrugineux tropicaux lessivés hydromorphes *Lixisols gleyiques*	Sol limoneux en surface, champs
Glacis versant (zone de pente) et bas glacis	Sols ferrugineux tropicaux lessivés indurés superficiels *Plinthosols épipétriques*	Affleurements de cuirasse ferrugineuse, concrétions et gravillons ferrugineux
	Sols ferrugineux tropicaux lessivés indurés peu à moyennement profonds *Lixisols épi ou endo pétroplinthiques*	Concrétions et gravillons ferrugineux, recouvrement limono-sableux
Glacis versant (zone de plateau)	Sols ferrugineux tropicaux lessivés à taches et concrétions *Lixisols hypogleyiques ferriques*	Recouvrement limono-sableux, champs
Buttes et Affleurement de cuirasse ferrugineuse et de roches	Lithosol sur cuirasse ferrugineuse *Plinthosols épipétriques*	Cuirasse ferrugineuse, recouvrement gravillonnaire,
	Lithosol sur roches diverses *Leptosols épilithiques hypersqueletiques*	Affleurement rocheux Fragment de roche


CARTE MORPHO-PEDOLOGIQUE
DE LA ZONE DE KOUMBIA
420000
425000
430000
1245000
1240000
Vers Ouaga
Vers Bobo
Koumbia
Wali
N
LEGENDE
Habitats
Route goudronnée
Pistes
Sols hydromorphes peu humifères à pseudogley d'ensemble
Sols ferrugineux tropicaux lessivés à taches et cconcrétions
Sols ferrugineux tropicaux lessivés indurés superficiels
Sols ferrugineux tropicaux lessivés idurés peu à moyennement profonds
Sols ferrugineux tropicaux lessivés à hydromorphie de profondeur
Lithosols sur roches diverses
Lithosols sur cuirasse ferrugineuse
ECHELLE
0,8 0 0,8 1,6 2,4 3,2 Kms

4.6. Conclusion partielle

L'étude pédologique de la zone cotonnière de Koumbia une très faible hétérogénéité des sols de part leur nature morphologique que leur classification pédologique.
Ainsi seulement sept (07) types de sol ont été individualisés au sein de trois (03) classes de sols que sont:
- la classe des sols minéraux brutes
- la classe des sols à sesquioxydes de fer et/ou de manganèse
- la classe des sols hydromorphes

Ces sept (07) types de sols présentent du point de vue morphologique, les caractéristiques suivantes :
- pour les **lithosols** sur cuirasse ferrugineuse et les lithosols sur roches diverses, ils sont caractérisés par un facteur limitant leur profondeur qui est soit la cuirasse ferrugineuse ou une roche et une charge graveleuse très importante. Cela lui confère une valeur agronomique faible à nulle. Aucune activité agricole n'y est pratiquée, cependant on y note la présence d'une végétation assez abondante et variée du point de vue espèces.

* pour **les sols ferrugineux tropicaux lessivés**, ils présentent plusieurs caractéristiques dont les plus importantes sont : une texture assez légère en surface, une profondeur utile limitée au niveau de certaines unités pédologiques suite à l'apparition d'un niveau d'induration ferrugineuse jumelé à la présence d'un fort taux de concrétionnement. On y note une activité agricole assez intense au niveau des unités pédologiques ayant une profondeur supérieure à 40 cm. La végétation est de type savane parc.

* pour les **sols hydromorphes**, les caractéristiques physiques sont : une texture lourde, souvent un engorgement prolongé mais temporaire, une topographie ondulée et une structure souvent massive en profondeur mais moyennement développée en surface. On y rencontre également une activité agricole intense au niveau de certaines portions du bas-fond. La végétation est de type ripicole avec des espèces caractéristiques de ce milieu.

En résumé, les sols inventoriés présentent plusieurs facteurs morphologiques qui peuvent limiter leur exploitation agricole. Ainsi l'estimation du carbone au laboratoire permettra à n'en pas douter de mieux cerner les problèmes liés à la gestion du carbone dans ces sols

5. Activités socioéconomiques

5.1. Site de Koumbia

5.1.1. Campement Peulh

5.1.1.1 Typologie des ménages

Les producteurs racontent être uniquement des éleveurs au moment de leur installation dans la zone de Koumbia, il y a une trentaine d'années. Mais de nos jours l'agriculture fait partie intégrante de leurs activités de production. Cependant on note une prédominance de l'élevage sur l'agriculture.
Le campement peulh compte environs 140 habitants, répartis entre 7 ménages.

5.1.1.2. Sources d'énergie domestique

La principale source d'énergie utilisée est le bois de chauffe. Un ménage moyen (20 à 25 membres) consomme 12 charretées de bois par an, soit environ 2.4 tonnes[*].
La paille est utilisée dans la confection des toits de case, la bouse des animaux sert de fumure pour fertiliser les champs tandis que les tiges de céréales trouvent leur utilité dans la confection des toits des hangars et dans l'alimentation des animaux.

5.1.1.3. Analyse des pratiques de gestion des ressources naturelles

[*] 1 charretée de bois de chauffe est estimée entre 200-250 kg.

- cordons pierreux et épandage de fumure

C'est la principale technique de gestion des ressources naturelles pratiquées dans le campement Peulh.

- Avantages : selon les producteurs cette technique permet de récupérer les terres dégradées et de freiner l'érosion hydrique
- Inconvénients : les inconvénients liés à la confection des cordons pierreux est le manque de matériel de transport des moellons, de même que les outils de confection (pelles, pioches, …).

Les producteurs expliquent cependant que le taux de réalisation de cette technologie est resté faible du fait de leur statut foncier. En effet les Peulhs étant des emprunteurs de terre hésitent à investir dans cette technologie coûteuse tout en courant le risque d'être dépossédés des parcelles à tout moment. Ce statut ne leur permet pas non plus d'entreprendre des aménagements de formations végétales, perçus par les propriétaires terriens comme un moyen d'appropriation des parcelles.

5.1.1.4. Chocs et stress

Les chocs et stress se manifestent par une irrégularité des pluies ces dernières années, la dégradation croissante des terres et parfois par des inondations.
Ceux-ci sont dus selon les paysans à la coupe abusive du bois et au manque de reboisement pour pallier cette coupe excessive de bois.

5.1.1.5. Les stratégies d'adaptation

Les stratégies adoptées par les Peulhs pour s'adapter à la situation sont :

- Utilisation de variétés de semence à cycle court

Ces variétés permettent d'éviter les crises alimentaires pendant la période de soudure. Cependant leur prix n'est pas à la portée de tous les producteurs et leur rendement n'est pas haut.

- Les reboisements

De par le passé (temps de la révolution), des reboisements ont été effectués et des résultats probants avaient été obtenus notamment de bonnes pluviométries et une plus grande fertilisation des sols.

5.1.1.6. Impacts des politiques et mesures d'atténuation

Les producteurs ont soumis des microprojets au PNGT2 qui se résument à la délimitation d'une piste à bétail, la confection des fosses fumières et un examen du problème foncier.
Une seule fosse fumière a été réalisée dans le village au titre du groupement villageois au cours de cette année. Une partie de la fumure organique extraite sera utilisée pour fertiliser le champ du groupement et le reste vendu à des producteurs individuels désireux.

5.1.2. Village de Kongolékan

5.1.2.1. Typologie des ménages

Dans le village de Kongolékan, on estime les agriculteurs à 90% de la population composée essentiellement des autochtones (Bwabas) contre 10% d'éleveurs (Peulh).

5.1.2.2. Sources d'énergie domestique

A Kongolékan, le bois de chauffe est également la principale source d'énergie. La consommation est estimée à 6 charretées /an/ ménage (8 membres), soit 1.2 tonnes.
Les tiges de céréales servent à l'alimentation animale.
La paille sert à confectionner des seccos pour hangar.
La bouse de vache est utilisée comme fumier pour fertiliser les champs.

5.1.2.3. Analyse des pratiques de gestion des ressources naturelles

Pratiques de gestion	Avantages	Inconvénients
Cordons pierreux + fumure organique	• rendements plus élevés • conservation de l'eau • freine l'érosion hydrique	• manque de matériel de travail • site des moellons très éloigné • travail pénible et risqué
Bosquet villageois	• prévoir du bois de chauffe pour les générations futures • fertilité des sols	• difficulté de gestion due au fait que c'est un bien collectif (entretien)

5.1.2.4. Chocs et stress

Selon la population de Kongolékan, il y a 20 ans on constatait des poches de sécheresse qui n'affectait pas significativement l'agriculture. Les sécheresses actuelles ont des effets néfastes sur l'agriculture. Elles sont imputables à la coupe abusive du bois, au manque de reboisement, aux mauvaises pratiques culturales.

5.1.2.5. Les stratégies d'adaptation

Les paysans de Kongolékan ont adopté des mesures pour s'adapter aux chocs et stress qu'ils subissent. Ces mesures sont entre autres :

Stratégies	Avantages	Inconvénients
Adoption de variétés de semence à cycle court	o réduire les crises alimentaires grâce aux récoltes précoces	o prix élevé o problème de goût (le tô n'est pas bon) o respect rigoureux de l'itinéraire technique (date de semis, engrais, récolte…)
Rotation de cultures (coton/céréales)	o évite l'épuisement et la dégradation des sols o lutte contre le striga	
Adoption de techniques CES (cordons pierreux+ épandage de fumure)	o rendements plus élevés o conservation de l'eau o freine l'érosion hydrique	o manque de matériel de travail o site des moellons très éloigné o travail pénible et risqué

5.1.2.6. Impacts des politiques et mesures d'atténuation

Les paysans de Kongolékan expliquent que la collaboration avec les programmes et projets de développement s'est soldée par des acquis importants. Ils citent pour cela les cordons pierreux réalisés avec l'appui du PDRI H/K/M.
Le PNGT2 et le PDL -Ouest tout en poursuivant les objectifs du PDRI H/K/M ont plutôt mis l'accent sur la confection des fosses fumières. Selon eux le taux de réalisation des fosses fumières atteint 40%.

5.1.3. Village de Waly

5.1.3.1. Typologie des ménages

La population totale de Waly est estimée à 400 habitants. Elle est répartie entre 300 bwabas, 80 mossis qui sont tous des agriculteurs (95%) et 20 peulhs qui sont uniquement éleveurs (5%).

5.1.3.2. Sources d'énergie domestique

a) Le bois de service

C'est le bois qui est utilisé dans les constructions des maisons à type d'habitat. Il sert de chevron dans la confection des toits. On dénombre au moins une construction de ce type de maison par ménage et par an à Waly. Cette construction nécessite 14 bois (chevrons).

b) Le bois d'énergie

La consommation du bois d'énergie est estimée à 2.4 tonnes (12 charretées) /an/ ménage, un ménage comptant 10 à 15 membres.

c) Le charbon de bois

Un ménage consomme 6 sacs de charbon de bois par an.

Comme dans les villages précédents les tiges de céréales, la paille et la bouse de vache sont destinées respectivement à l'alimentation animale, la fabrication de secco et la fertilisation des champs.

5.1.3.3. Analyse des pratiques de gestion des ressources naturelles

Les cordons pierreux avec épandage de fumure organique sont de loin la technique de gestion des ressources naturelles pratiquée à Waly. L'augmentation des rendements agricoles, la conservation des sols et la réduction de l'érosion hydrique en sont les avantages. Cependant leur adoption est souvent contraignante en ce sens qu'ils rendent le travail difficile au moment du sarclage et nécessitent la mobilisation d'une main d'œuvre importante pour leur construction.

Outre cette pratique GRN, les populations de Waly doivent gérer une ressource commune qui est une forêt naturelle située en lisière des champs. Mais malheureusement cette ressource se trouve être dégradée du fait du surpâturage non contrôlé par les éleveurs, la coupe abusive du bois pour l'énergie domestique et les défriches sauvages pour les besoins de cultures par les mossis. Selon les paysans, les services de l'environnement doivent jouer leur rôle en mettant en place une politique réelle de gestion de ce patrimoine sous peine de le voir disparaître un jour.

5.1.3.4. Les chocs et stress

Les chocs et les stress se manifestent par la dégradation croissante des terres amenant à une application intense de fertilisants, la disparition de certaines espèces animales et végétales et un durcissement du climat (harmattans violents, températures élevées…).

Ce bouleversement de la nature est dû à la coupe abusive du bois, aux mauvaises pratiques culturales, la divagation des animaux, l'ensablement des points d'eau…

Les paysans craignent que la situation ne s'empire davantage en l'absence de politique réelle de gestion des ressources naturelles.

5.1.3.5. Les stratégies d'adaptation

- Utilisation de variétés de semence à cycle court

Cette stratégie permet d'avoir de bonnes récoltes surtout en période de bonne pluviométrie. Les inconvénients reconnus à l'usage de ces variétés sont leur faible résistance aux mauvaises herbes, un besoin nécessaire d'engrais, un respect rigoureux de l'itinéraire technique.

- La pratique de la jachère

Elle n'est appliquée que par 2% à 3% des producteurs du village. Avec la pression démographique actuelle conduisant à une exploitation de terres de plus en plus marginale, cette pratique est abandonnée de nos jours bien que permettant d'importantes récupérations et de restaurations des terres.

- L'exploitation des terres disponibles avec des techniques CES, notamment

cordons pierreux + fumure organique + engrais chimiques étant donné la rareté des terres cultivables.

5.1.3.6. Impacts des mesures et politiques d'atténuation

Les acquis engrangés avec le PDRI sont la construction de cordons pierreux, la confection des fosses fumières et une formation de pépiniéristes.
Le PNGT2, puis le PDL- Ouest ont poursuivi les mêmes activités. Au total plus de 30 hectares de cordons pierreux ont été aménagés dans le village.

5.1.4. Village de Rabounilaye

5.1.4.1. Typologie des ménages

Ce village compte 700 à 800 habitants. On y rencontre seulement des mossis, qui sont des agro pasteurs sans une prépondérance d'une activité sur l'autre.

5.1.4.2. Sources d'énergie domestique

Le bois de chauffe est la principale source d'énergie domestique utilisée. Un ménage moyen (10 -15 membres) consomme 2.4 tonnes soit 12 charretées asines par an.
Le bois de service n'est plus usité de nos jours, on ne rencontre plus dans ce village des constructions avec des toits en bois.
Les tiges de céréales, la bouse de vache et la paille sont utilisées pour les mêmes besoins que ceux rencontrés dans les villages précédents.

5.1.4.3. Analyse des pratiques de GRN

La pratique la plus usité, voire l'unique qui est adoptée est le paquet technologique codon pierreux + fumure organique.
Les avantages tirés de cette technologie sont l'augmentation des rendements agricoles, la conservation de l'eau. Le manque de matériel de transport constitue la principale contrainte liée à l'adoption de cette technologie.
Le producteurs de Rabounilaye expliquent être hésitants à investir dans des technologies assez coûteuses, étant donné leur statut d'emprunteurs de terre.
Bien que connaissant les impacts positifs des reboisements sur l'environnement, ils ne peuvent les pratiquer sous peine d'expulsion du village par les autochtones bwabas qui perçoivent les reboisements comme un moyen d'appropriation des terres.

5.1.4.4. Les chocs et les stress

Les manifestations majeures de ces chocs sont les poches de sécheresse récurrentes, la baisse des rendements agricoles, un changement climatique important (températures de plus en plus élevées, de précipitations de plus en plus faibles…). Les causes de ces bouleversements sont la coupe abusive du bois, la pression démographique entraînant une pression sur les ressources naturelles, le striga…

5.1.4.5. Les stratégies d'adaptation

Les différentes stratégies d'adaptation développées par la population de Rabounilaye sont consignées dans le tableau suivant :

Stratégie	Avantages	Inconvénients

Intégration agriculture/ élevage	o permet l'achat de céréales en année de mauvaise pluviométrie grâce à la vente d'animaux o disponibilité de fumier	o augmentation de la pression sur les ressources naturelles o manque de piste à bétail o manque de pâturage
Utilisation de variétés de semence à cycle court	o réduction des crises alimentaires grâce aux récoltes précoces	o prix élevé o problème de goût (le tô n'est pas bon) o respect rigoureux de l'itinéraire technique (date de semis, engrais, récolte…)
Rotation de cultures (coton/céréales)	o évite l'épuisement et la dégradation des sols o lutte contre le striga	
Adoption des techniques CES (cordons pierreux + épandage de fumure)	o augmentation des rendements agricoles o conservation des sols	o manque de matériels de travail

5.1.4.6. Impacts des politiques et mesures d'atténuation

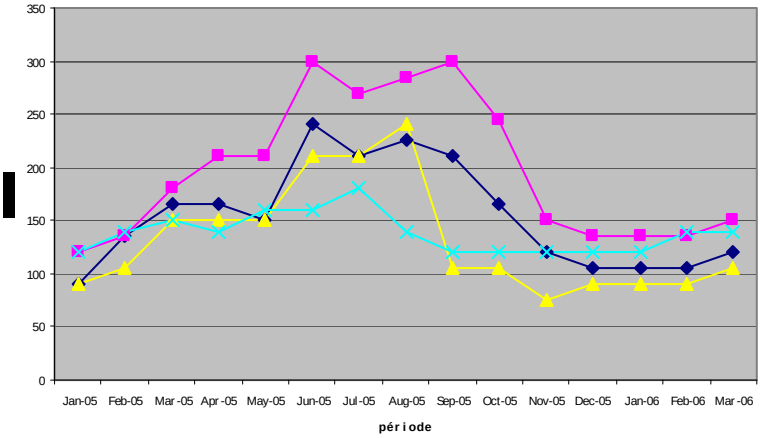
Les producteurs de Rabounilaye racontent n'avoir pas été assistés par un projet ou un programme de développement dans la confection des ouvrages antiérosifs notamment les cordons pierreux. Ils ont importé la technologie du plateau central d'où ils sont ressortissants et où la technologie y est très répandue.
Le PNGT2 les a appuyés dans la confection des fosses fumières et on dénombre au moins une fosse fumière par ménage.

5.1.2. Niveau des prix et évolution dans le temps

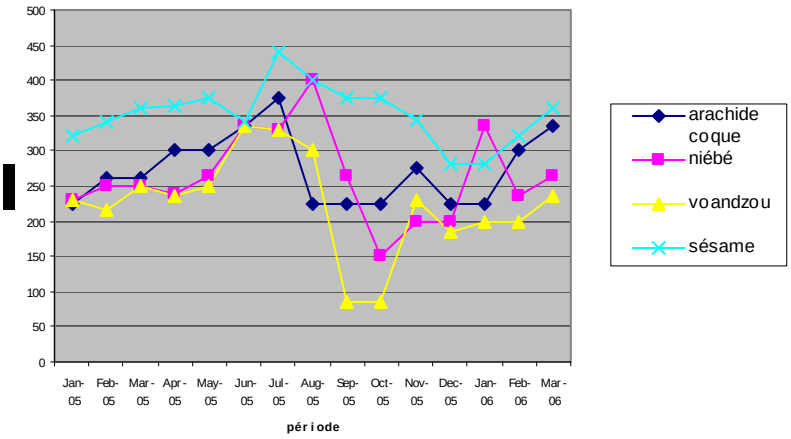
- **Evolution des prix (F CFA / kg) de quelques spéculations sur le marché de Koumbia**

Période	Sorgho	Mil	Maïs	Riz paddy	Arachide coque	Niébé	Voandzou	Sésame
Janvier 05	90	120	90	120	225	230	230	320
Février 05	135	135	105	140	260	250	215	340
Mars 05	165	180	150	150	260	250	250	360
Avril 05	165	210	150	140	300	240	235	365
Mai 05	150	210	150	160	300	265	250	375
Juin 05	240	300	210	160	335	335	335	340
Juillet 05	210	270	210	180	375	330	330	440
Août 05	225	285	240	140	225	400	300	400
Septembre 05	210	300	105	120	225	265	85	375
Octobre 05	165	245	105	120	225	150	85	375
Novembre 05	120	150	75	120	275	200	230	345
Décembre 05	105	135	90	120	225	200	185	280
Janvier 06	105	135	90	120	225	335	200	280
Février 06	105	135	90	140	300	235	200	320
Mars 06	120	150	105	140	335	265	235	360

Graphique1 : Evolution du prix des céréales dans le temps



Graphique2 : Evolution du prix des cultures de rente dans le temps



- **Evolution de prix (F CFA/ kg) du coton graine**

Après avoir connu une hausse de 35F, entre 2003 et 2004 passant de 175F/kg à 210F/kg, le prix du coton graine a baissé progressivement pour atteindre 165F/kg en 2006 alors qu'il était de 210F/kg en 2004.

- **Niveau de prix de quelques produits forestiers non ligneux**

  - Feuilles sèches de baobab : 100-150 F la Grosse Boite de Tomate (GBT)
  - Feuilles de baobab en poudre : 150-250 F /GBT
  - Amande de karité : 75-100 F/GBT
  - Graines de néré : 500-600 F/GBT
  - Pain de singe : 100-150 F/GBT
  - Tamarin : 100-200 F/GBT

- **Niveau de prix du bois de chauffe**

Au niveau des différents sites d'enquête, le bois de chauffe pour les besoins domestiques est ramassé en brousse par chaque ménage sous aucun mécanisme de contrôle à l'échelle du village, ni à l'échelle du département.

Le bois de chauffe est également vendu dans la zone de Koumbia par des producteurs. Ces producteurs vendeurs de bois doivent obtenir des agréments de vente délivrés par les services de l'environnement. La demande est essentiellement composée des dolotières qui sont en nombre important dans la zone et de certains ménages résidant dans le département de Koumbia.
Une charretée de bois de chauffe se vend entre 1000 et 1500 F.

5.1.3. Impacts des politiques et mesures d'atténuation

Selon le service départemental de l'agriculture le PDRI H/K/M fut le premier projet a attiré l'attention des populations de la zone quant à la préservation des ressources naturelles dont la conservation des sols.
A cet effet, le PDRI a réalisé environ 292 ha de cordons pierreux et 200 fosses fumières dans toute la zone de Koumbia. Aussi, un projet de reboisement de 5 ha a été initié par le PDRI avec un taux de réussite insignifiant à cause des feux de brousse.

Le PNGT2 et le PDL- Ouest ont poursuivi les objectifs du PDRI, mais il n'existe pas encore de données chiffrées en terme de réalisation.

5.2. Bindogo

5.2.1. structuration du village

Bindogo est un quartier du village de Firka qui est situé à 12 km au Nord-Ouest de Pissila et comprends 7 quartiers que sont : Firka Natenga, Koumlawaosé, ***Bindogo,*** Koulogin, Sambin, Kiendpalogo et Watinoma. Il ne possède ni une école primaire ni une école secondaire, mais est doté d'un centre d'alphabétisation. Les infrastructures sanitaires de résument e un Poste de Santé Primaire (PSP). On note par ailleurs l'existence d'un parc de vaccination pour le Bétail. La couverture en eau potable du village est assurée par 4 forages fonctionnels et par 2 puits à grands diamètres.

5.2.2.Typologie des exploitations

Firka compte 282 ménages et un total de 1941 habitants dont 935 hommes et 1006 femmes. Les principales activités socio-économiques des populations de Firka sont l'agriculture et l'élevage qui occupent plus de 95 % des actifs (la majorité des agriculteurs sont en même temps des éleveurs et vis versa). Ensuite viennent la sylviculture et l'artisanat.
Les principales spéculations pratiquées dans le village sont les céréales dont notamment, et par ordre d'importance : le sorgho, le maïs et le petit mil, ensuite viennent les légumineuses telles que l'arachide, le niébé et le sésame. On note aussi la culture du Voandzou et du riz. La riziculture est pratiquée le long du bas-fond qui traverse le village sur son coté Nord-Ouest. La pratique de la riziculture est le fait principalement des femmes qui tirent la plus grande partie de leur revenu dans la vente du riz. Dans le village on constate aussi l'exploitation des produits végétaux non ligneux tels que les noix de karité, les feuilles de baobab et le miel.

4.2.1. Sources d'énergie domestique

Le bois est la principale source d'énergie utilisée par les habitants du village. La consommation moyenne de bois de chauffe utilisée par un ménage moyen de 25 membres estimée par les populations varie de 2,5 à 5 charrettes par mois. Les populations dans le village de Firka n'utilisent pas régulièrement le charbon de bois comme énergie. Cette source d'énergie étant seulement utilisée pour la préparation du dolo. Les résidus de récoltes sont par contre utilisé en supplément du bois mais elle n'est pas quantifiée.

Les pailles sont également collectées dans les prés et viennent en complément des résidus de récolte. Cette paille est aussi utilisée dans la confection des chaumes et des seccos pour les concessions. Hors mis pour

la confection d'outils utilitaires (daba ; mortiers, chaises…) et la construction des maisons, le bois est peu utilisé comme bois d'œuvre. La bouse de vache sert essentiellement à la fertilisation des parcelles cultivée et les populations semblent ignoré qu'elle peut être utilisée comme source d'énergie.

Les agriculteurs rencontrent de nombreux problèmes liés aux attaques de vers pathogènes, d'insectes foreurs de tiges ainsi que l'invasion du Striga. Les producteurs disent ne pas disposer de moyens techniques adéquats pour juguler ce problème

4.2.2. Analyse des pratiques de gestion des ressources naturelles

De nombreuses mesures de gestion de la fertilité des sols et de conservation des eaux et des sols sont en cours dans le village et sont mises en œuvre par la grande majorité des habitants. Au nombre de ces mesures figurent le recourt à la fertilisation organique, la pratique de la rotation culturale et de l'assolement, la combinaison de cultures et le recourt aux pratiques de défense et restauration des sols et de conservation des eaux et des sols. En plus de cela s'ajoute des actions de reboisement.

4.2.3. Chocs et Stress

Le village est confronté à un phénomène de désertification depuis près de 30 ans. Les principaux facteurs incriminés sont la forte croissance démographique qui favorise des comportements préjudiciables à l'environnement tels que : l'ouverture intempestif de nouveaux champs, la coupe abusive du bois, les feux de brousse, etc. A cela s'ajoute la précarité du climat caractérisée par la baisse récurrente de la pluviométrie et l'élévation du niveau globale des températures. Les conséquences de ces facteurs sont une disparition progressive de la végétation (certaines espèces ligneuses ayant disparu du village) et la dégradation continue des sols (avec pour corollaire une baisse croissante des productions agricoles). La désertification constitue donc de nos jours une entrave majeure pour le développement socio-économique des populations.

4.2.4. Stratégies d'adaptation aux stress

Afin de juguler le fléau de nombreuses mesures sont mises en œuvre par les populations au nombre desquelles on peut citer : l'utilisation de variétés améliorée, la pratique de la jachère de courte durée, l'installation de cordons pierreux pour limiter le ruissellement, la pratique du zaï pour la récupération des terres dégradées, l'instauration de mesures de régulation de la coupe du bois et des actions de plantation d'arbres.
L'application de ces mesures est différemment perçue par les populations du village :

- Utilisation de variétés améliorées permet d'obtenir de hauts rendements car elles offre la possibilité de s'adapter à l'irrégularité de la pluviométrie et de résister à certains agents pathogènes. Certains inconvénients existent cependant du fait du coût de ces variétés et du faible niveau de technicité des populations quant au respect rigoureux des itinéraires techniques ;
- La pratique de la jachère longue est en net recule dans le village, seuls 2% à 3% des producteurs y ont encore recourt. Cette situation est la conséquence de l'accroissement de la population et de l'extension des cultures de rente ;
- L'utilisation de la fumure organique pose essentiellement des problèmes de disponibilité. Malgré la bonne intégration de l'agriculture et l'élevage, la population rencontrent beaucoup de difficultés à trouver du fumier en quantité suffisante pour leur exploitation. Ceci justifie le fait que l'on constate de plus en plus la pratique du compostage avec l'appui des services techniques de l'état ;
- Compte tenu de la démographie galopante et de l'indisponibilité croissante des terres, on remarque que les fronts de cultures tendent à s'étendre sur les terres marginales. Cependant, l'exploitation de ces terres nécessite l'application systématique de techniques de conservation des eaux et des sols tels que le zaï, les demi-lunes et les cordons pierreux dont l'utilisation est en forte recrudescence dans le village. Le recourt à ces pratiques rencontre des problèmes de disponibilité de moellons et de charge

de travail. En plus le régime foncier en vigueur dans le village n'encourage pas les migrants à dépenser de l'énergie pour la confection des telles ouvrages ;

- La régulation de la coupe de Bois est initiée et gérée par la population avec l'appui et la sensibilisation des services forestiers. La coupe du bois pour les différents besoins est permise un seul mois dans l'année. Et tout contrevenant (e) est astreint (e) à payer une forte amende ;
- Le village compte aussi de nombreux bosquets qui sont le fruit des nombreuses opérations de reboisement initiées par les populations. Les populations estiment à 15 ha la surface totale de terre récupérée grâce au reboisement. Les populations rencontrent ici aussi des difficultés liées à la gestion des parcelles reboisées. Les espèces généralement plantées sont : le Neem, l'Eucalyptus et de nombreux Acacia.

4.2.5. Impacts des politiques et mesures d'atténuation

Les populations ont bénéficié de l'appui de la formation donner par le Projet Plan International pour les méthodes culturales (rotations culturales) la confection des ouvrages anti-érosifs tels que, le scarifiage, les cordons pierreux, le zaï et les demi-lunes. Les producteurs sont aussi organisés en Comités Villageois de Gestion des Terroirs (CVGT) avec l'appui du Programme National de Gestion des Terroirs (PNGT2). Le PNGT2 les appui les populations dans la confection des fosses fumières et leur octroi des micro crédits. Cet appui du PNGT 2 a permis la réalisation de plus 250 ha de cordons pierreux dans le village et la réalisation d'environ une fosse fumière par ménage. On note aussi l'intervention régulière des services techniques de l'état tels que le service des Eaux et Forêt et le Direction Provinciale de l'Agriculture (DPA) qui appui et sensibilisent les populations à la bonne gestion de leurs ressources naturelles.

5.2.8. Niveau des prix et évolution dans le temps

Les coûts des céréales fluctuent beaucoup selon les années et selon les périodes de l'année. La variation annuelle du prix des principales spéculations sont présentées dans le tableau suivant ci-dessous.

Spéculations	Unité de mesure	Prix Saisons Sèche	Prix Saison Pluvieuse
Sorgho	Sac de 100 kg	11 500 à 25 000 selon la saison	12 500 en début de saison pluvieuse
Petit mil	Tine	10 000 à 25 000 selon la saison	12 500 en début de saison pluvieuse
Maïs	Tine	13 500 à 18 000 selon les saisons	11 000 en début de saison pluvieuse
Riz Paddy	Sac de 50 kg	12 500	11 500
Riz décortiqué	Grosse boite de tomate	500	500
Niébé	Tine	3 500	1 500
Arachide	Grosse boite de tomate	250 - 350	200 - 300

Les prix des spéculations varient en fonction de l'année et de la pluviométrie. En année de disette les prix atteignent des niveaux très élevés et hors de portée de la majorité des populations.

5.3. Conclusion partielle

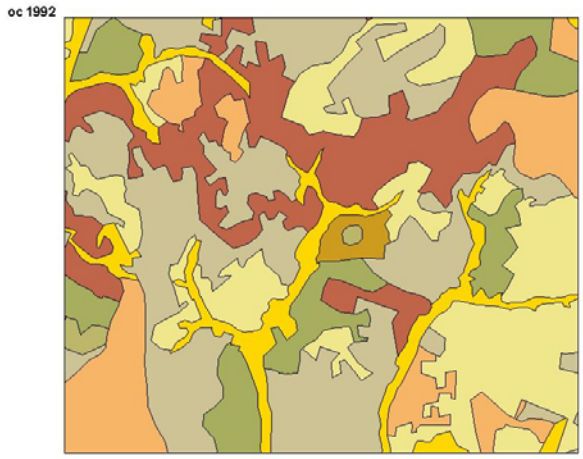
Il ressort de l'étude que les différentes communautés ont recours à la même source d'énergie pour les besoins domestiques à savoir la ressource bois. La pression sur cette est devenue forte. Cette situation est préoccupante en l'absence d'énergie de substitution.
Pour ce qui est des pratiques de GRN, on note que les cordons pierreux sont la technologie la plus pratiquée. Le régime foncier existant à Koumbia ne constitue pas un frein à l'expansion des pratiques GRN, mais cependant l'accord du propriétaire est nécessaire dans le cas de reboisements sur des parcelles empruntées.
Il n'y a pas de différentes fondamentales dans la gestion des ressources naturelles par les différentes communautés installées (autochtones et allochtones).
Les différentes communautés installées sur les terroirs de Koumbia et de Bindogo subissent des chocs et des stress sans exception. Ils essaient de s'adapter à ces stress en développant des stratégies diverses au nombre desquelles on cite l'adoption de variétés de semence à cycle court, la rotation des cultures, l'intégration de l'élevage à l'agriculture….

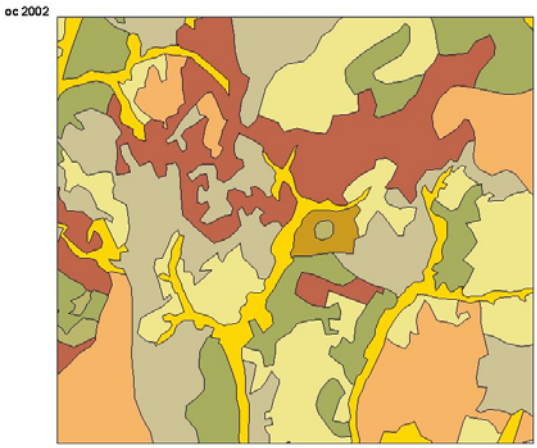
6. Modélisation

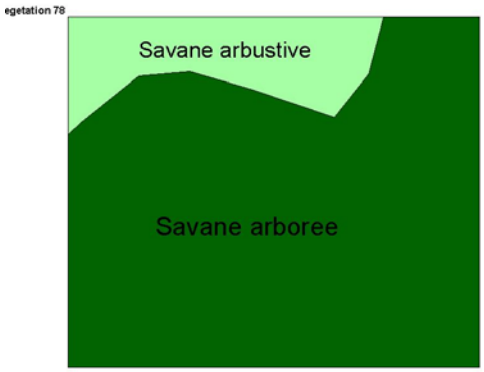
6.1. Résultats des traitements cartographiques

6.1.1. Cartes de l'Occupation des sols

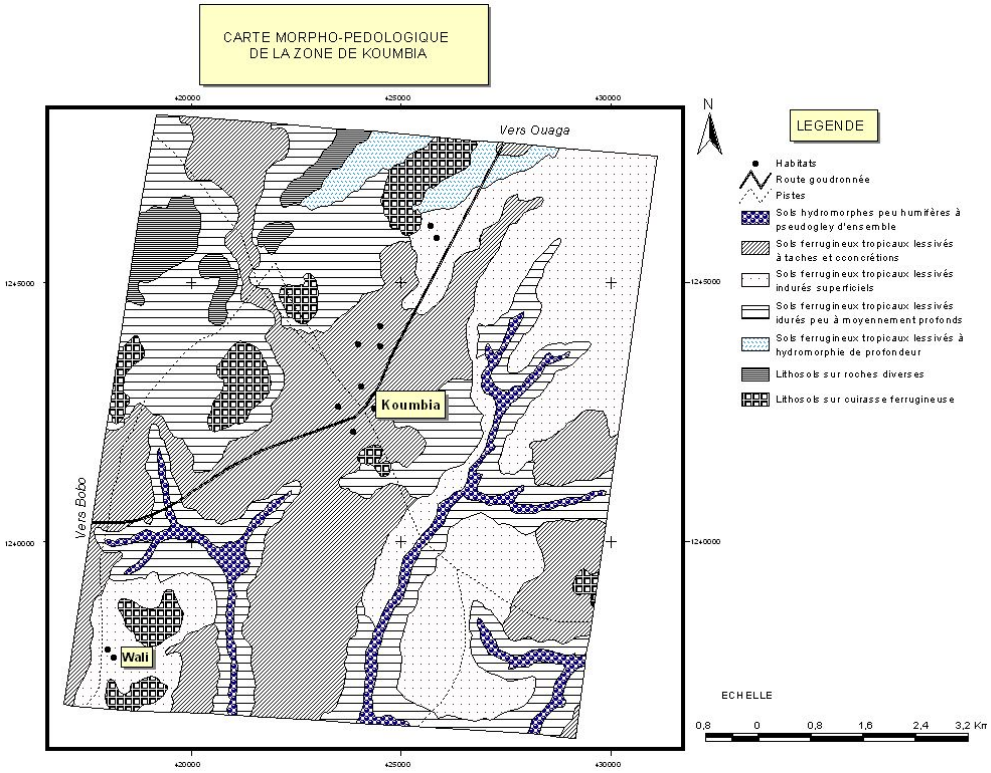
– deux périodes générées à partir de 2 bases de données existantes 1992 et 2002





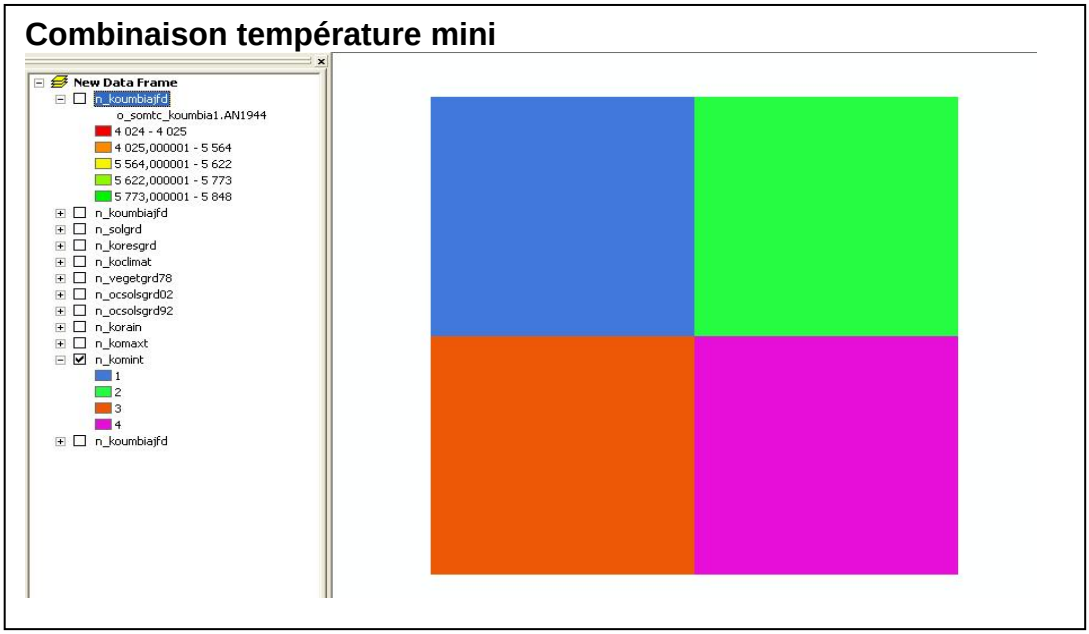


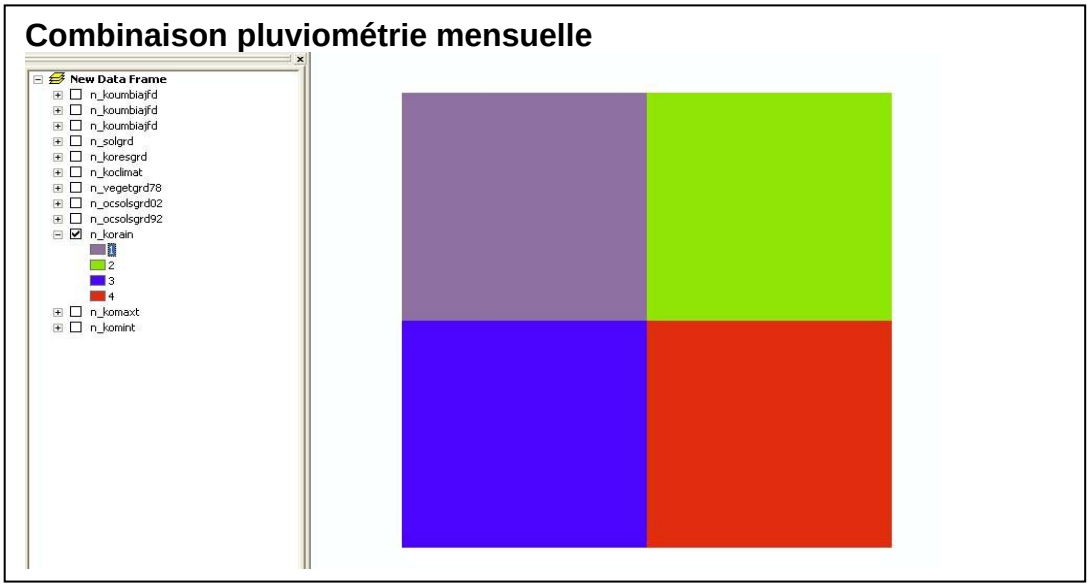
6.1.3. Cartes des sols de la zone

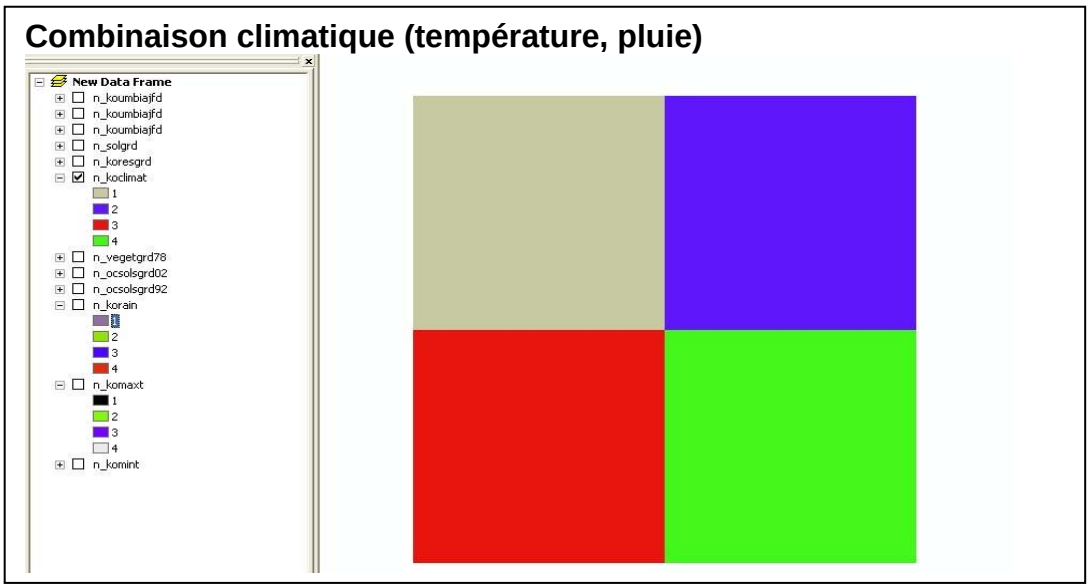


L'établissement de la carte des sols de la zone de Koumbia s'est effectué comme suit :
- une photo-interprétation détaillée des prises de vue aérienne qui a permis de dresser une carte des unités géomorphologiques ;
- une vérification de terrain de cette carte géomorphologiques ;
- une mesure des points GPS sur le terrain en vue d'une géoréferentiation ;
- une prospection pédologique de type toposequentiel qui a permis de déterminer pour chaque unité géomorphologique le type de sol correspondant.

6.1.4. Cartes climatiques de la zone







Combinaison climatique (température, pluie)

6.1.5. Données socio-économiques

Les spéculations les plus significatives de la zone de Koumbia sont les suivantes :

1	**Coton**	**Cotton**
2	**Sorgho**	**Sorghum**
3	**Maïs**	**Maize**

4	**Mil**	**Millet**
5	**Arachide**	**Groundnut**

Le fichier a le format ci-dessous

Distr.	**Beg.**	**End**	**Groundnut**	**Cotton**	**Sorghum**	**Maize**	**Millet**
0	**1950**	**1978**	**0.02**	**0.04**	**0.52**	**0.60**	**1.00**
0	**1979**	**1992**	**0.11**	**0.56**	**0.63**	**0.68**	**1.00**
0	**1993**	**2002**	**0.05**	**0.33**	**0.65**	**0.90**	**1.00**

Rotation des cultures

Spéculations	Code
Groundnut	840
Cotton	830
Sorghum	820
Maize	850
Millet	810
Fallow	300

Fichiers Rotation des cultures

From.	**To**	**Cumulative Probability**
300	300	0.35
300	810	0.45
300	820	0.55
300	830	0.80
300	840	0.90
300	850	1.00
810	300	0.30
810	810	0.65
810	820	0.72
810	830	0.74
810	840	0.95
810	850	1.00
820	300	0.03
820	810	0.23
820	820	0.63
820	830	0.93

6.2. Résultats de la modélisation

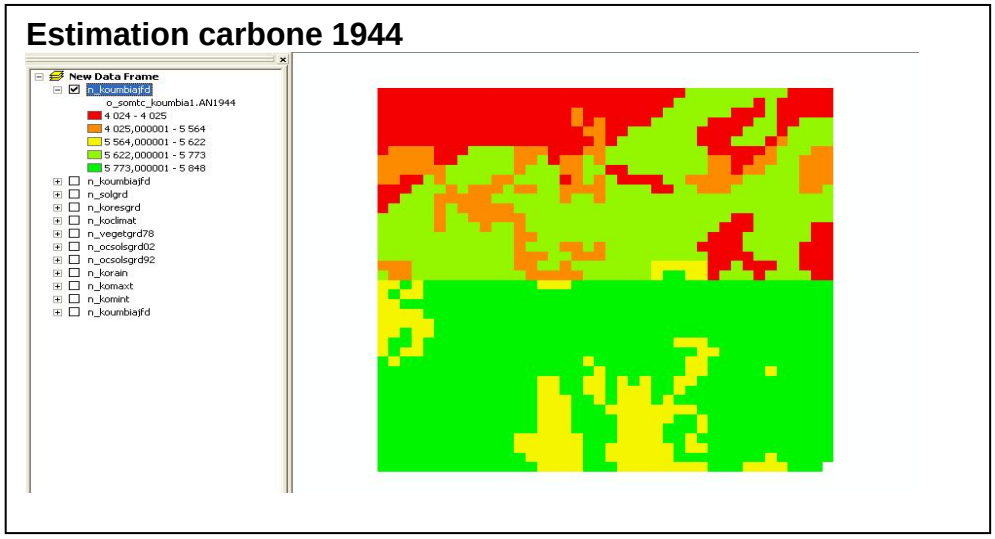
Le résultat obtenu ci-après est la combinaison de toutes les données ci-dessus dans le logiciel GEMS.

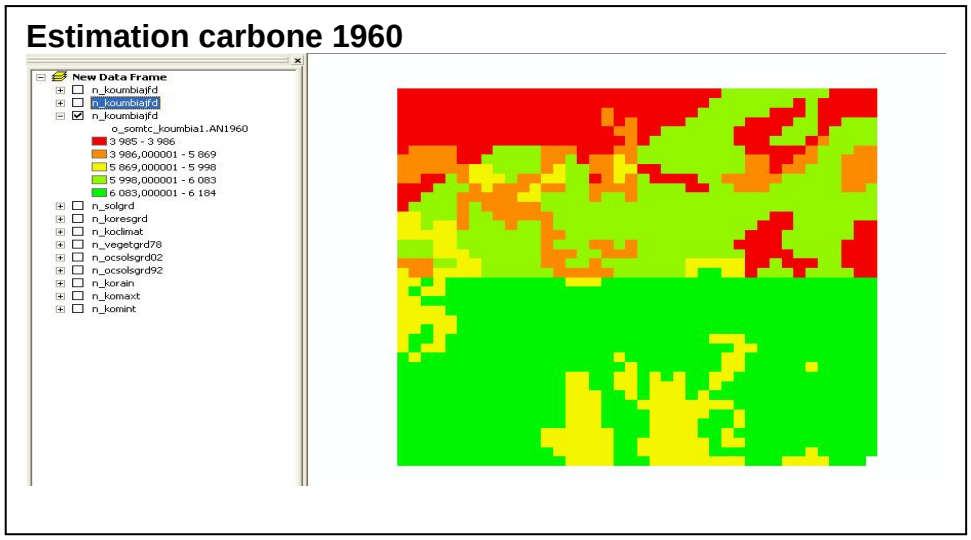
Extrait des résultats finaux sous forme de chiffres

AN011	AN1900	AN1904	AN1908	AN1912	AN1916	AN1920	AN1924	AN1928
1	1954	2885	3800	4061	4180	4175	4139	4105
2	1954	2885	3800	4061	4180	4175	4139	4105
3	1954	2885	3800	4061	4180	4175	4139	4105
4	1954	2885	3800	4061	4180	4175	4139	4105
5	1954	2885	3800	4061	4180	4175	4139	4105
6	1954	2885	3800	4061	4180	4175	4139	4105
7	1954	2884	3799	4061	4180	4175	4138	4104
8	1954	2884	3799	4061	4180	4175	4138	4104

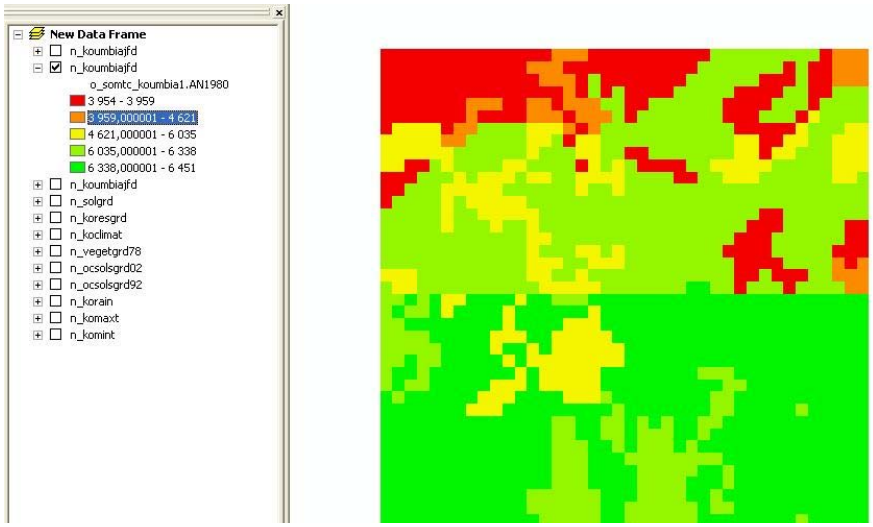
9	1954	2884	3799	4061	4180	4175	4138	4104
10	1954	3388	3757	4107	4418	4703	4930	5138
11	1954	3388	3757	4107	4418	4703	4930	5138
12	1954	2884	3799	4061	4180	4175	4138	4104
13	1954	2885	3800	4061	4180	4175	4139	4105
14	1954	2885	3800	4061	4180	4175	4139	4105
15	1954	3360	3562	3907	4219	4497	4727	4931
16	1954	2885	3800	4061	4180	4175	4139	4105
17	1954	3388	3757	4107	4418	4703	4930	5138
18	1954	2885	3800	4061	4180	4175	4139	4105
19	1954	3342	3555	3900	4211	4488	4708	4917
20	1954	3342	3555	3900	4211	4488	4708	4917
21	1954	3388	3757	4107	4418	4703	4930	5138
22	1954	3342	3555	3900	4211	4488	4708	4917
23	1954	3342	3555	3900	4211	4488	4708	4917

Transformation du fichier ci-dessus en données spatiales de carbone

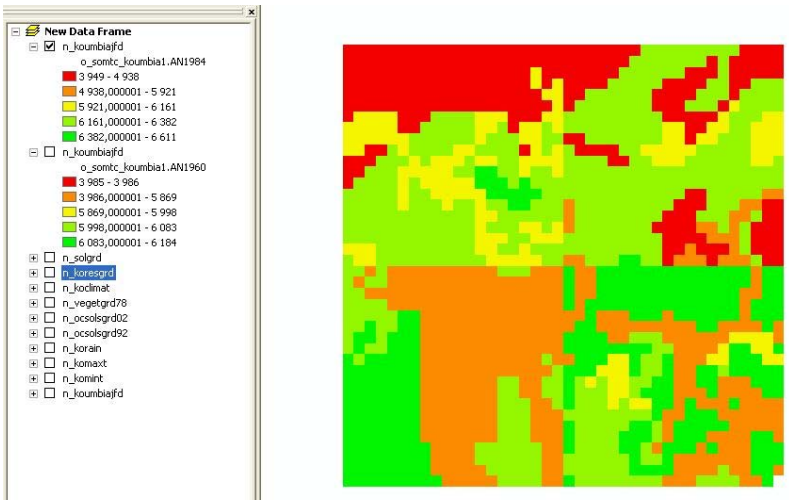




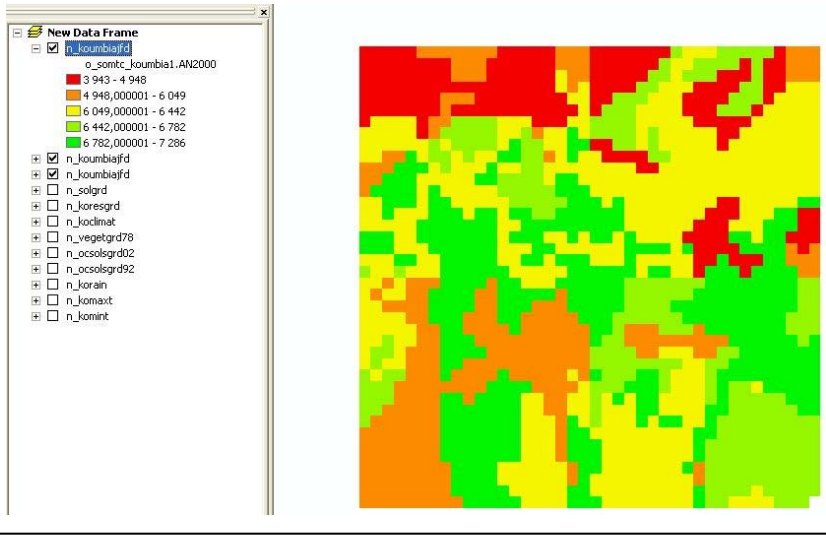
Estimation carbone 1980



Estimation carbone 1984



Estimation carbone 2000



Estimation carbone année 2000 et plus

Elles s'effectueront par la modification des variables climatiques et relance du modèle

7. Conclusion

La modélisation du carbone est une tache de longue haleine qui demande de la disponibilité de temps et des données de qualité.
L'exercice de modélisation effectué sur un carre de 10kmx10km, bien que très concluant reste à être généré au niveau de toute la province entière. Des données complémentaires portant sur les sols, la végétation et aussi socio-économiques doivent être collectées à cet effet. Cette problématique demeure valable pour les deux autres provinces, la méthodologie étant parfaitement maîtrisé.