

GLOWA-VOLTA PROJECT (GVP)

*WORKSHOP
ON*

IRRIGATION OPTIONS IN THE CHANGING ENVIRONMENT OF THE WHITE VOLTA BASIN

ORGANIZED BY

**GLOWA VOLTA PROJECT, CENTRE FOR
DEVELOPMENT RESEARCH (ZEF), UNIVERSITY
OF BONN**

IN COLLABORATION WITH

**UNITED NATIONS UNIVERSITY-
INSTITUTE FOR NATURAL RESOURCES IN
AFRICA (UNU-INRA),
WATER RESOURCES COMMISSION &
MINISTRY OF FOOD AGRICULTURE**

AT

BOLGATANGA

1ST - 2ND APRIL 2008

AGYARE W.A., LAUBE W. & ADUNA A:



LIST OF ACRONYMS

| | |
|------------------|--|
| ACMAD | - African Centre of Meteorological Application for Development |
| CAW | - Center for African Wetlands |
| CEIA | - Centre for Environmental Impact Analysis |
| CoA-KNUST | - College of Agriculture, KNUST |
| COBIDS | - Component-Based Integrated Data Simulation |
| CoE-KNUST | - College of Engineering, KNUST |
| CoES-UGL | - College of Engineering Sciences, University of Ghana, Legon |
| CONIWAS | - Coalition of NGOs in Water and Sanitation |
| CPWF | - Challenge Program on Water and Food |
| CSIR | - Council for Scientific and Industrial Research |
| CSO | - Civil Society Organization |
| CWSA | - Community Water & Sanitation Agency |
| DGRE | - Direction Générale des Ressources en Eau (Burkina Faso) |
| DoBS | - Department of Biological Sciences |
| DoFO | - Department of Fisheries and Oceanography |
| DoG | - Department of Geography |
| DoRNR | - Department of Renewable Natural Resources |
| ECG | - Electricity Company of Ghana |
| ECMWF | - European Center for Medium range Weather Forecasting |
| ECOWAS | - Economic Community of West African States |
| EPA | - Environmental Protection Agency |
| FERB | - Friends of the Earth and River Bodies |
| GAMS | - General Algebraic Modeling System |
| GCWP | - Ghana Country Water Partnership |
| GHG | - Green House Gases |
| GVP | - GLOWA-Volta Project |
| GMA | - Ghana Meteorological Agency |
| GWCL | - Ghana Water Company Ltd. |
| HSD | - Hydrological Services Department |
| HYCOS | - Hydrological Cycle Observing Systems |
| IDA | - Irrigation Development Authority |
| IMF | - International Monetary Fund |
| IMS | - Institute of Mathematical Sciences |
| ISODEC | - Integrated Social Development Centre |
| ISSER | - Institute of Statistical, Social and Economic Research |
| IWMI | - International Water Management Institute |
| IWRM | - Integrated Water Resources Management |
| JTC | - Joint Technical Committee |
| KACE | - Kofi Annan Centre of Excellence in ICT |
| KNUST | - Kwame Nkrumah University of Science and Technology |
| LAS | - Large Aperture Scintillometer |
| LUDAS | - Land-Use Dynamic Simulator |
| MMDA | - Metropolitan/Municipal/District Assembly |
| NADMO | - National Disaster Management Organization |
| NAVRAT | - National Association of (52) VRA (Resettled) Towns |
| NGO | - Non-Governmental Organization |
| PAGEV | - Project for Improving Water Governance in the Volta River |

| | |
|-----------------|--|
| | Basin |
| PURC | - Public Utilities Regulatory Commission |
| SARI | - Savanna Agricultural Research Institute |
| SAP | - Structural Adjustment Programme |
| SR | - Small Reservoir |
| SRI | - Soil Research Institute |
| SWAT | - Soil and Water Assessment Tools |
| TL | - Trade Liberalisation |
| TREND | - Training, Research and Network for Development |
| UDS | - University for Development Studies |
| UoG | - University of Ghana |
| UNU-INRA | - United Nations University- Institute of Natural Resources in Africa |
| USAID | - United States Agency for International Development |
| USEPA | - United States Environmental Protection Agency |
| USGS | - United States Geological Survey |
| VBA | - Volta Basin Authority |
| VBDF | - Volta Basin Research Foundation |
| VBDR | - Volta Basin Research Project |
| VRA | - Volta River Authority |
| WACAM | - Wassa Communities Against Mining |
| WA-net | - West Africa Capacity Building Network |
| WB | - World Bank |
| WEAP | - Water Evaluation and Planning System |
| WRC | - Water Resources Commission |
| WRI | - Water Research Institute |
| ZEF | - Center for Development Research |

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SUMMARY REPORT

“IRRIGATION OPTIONS IN THE CHANGING ENVIRONMENT OF THE WHITE VOLTA BASIN”

The meeting started with a call for opening prayer. Hon Roy Ayariga of MoFA was introduced as the chairman. In his acceptance he thanked all for coming and acknowledged the confidence reposed in him to chair the function. He said if water is not managed well, future wars would be centered on it and not oil, gold, silver nor diamonds and therefore he craves the indulgence of the participants to give water management the needed attention it deserves.

Dr. Wilson Agyare and Dr. Wolfram Laube of GVP introduced the workshop. They emphasized the importance of irrigation to the food security in the region. They indicated that the focus of the workshop was to share ideas with stakeholders in water resources and irrigation management on irrigation options in the changing White Volta Basin environment.

Hon. Alhassan Samari, the Upper East Regional Minister gave the keynote address. He stated that the workshop was a step in the right direction because the region experiences erratic rainfall pattern. He added that the collaboration of the Water Resources Commission and GLOWA Volta Project to support the efficient management of the White Volta Basin is noteworthy. He concluded by indicating that the region depends heavily on agriculture and it is therefore crucial that participants take the workshop seriously.

The technical session was put into three sessions and a plenary. Session one focused on environmental issues. It began with an overview of the past and present irrigation practices in the region. The session looked at the onset of the rains and dry spells, taking into account different approaches to attain this result. The onset was found to be dependent on the position of the ITCZ, movement of wind, circulation pattern, low pressure system moving across the region, and temperature range of 12°C or lower. The length of dry spell was shown to increase from north to south in the region. A presentation on evaporation and local water cycle in West Africa as influence by climate change was made. The characteristics, suitability and capability of soils in the region for crop production and the potential impact of climate change on rain-fed food production were also presented. The soils are under poor continues use predisposing them to degradation. Cultivation practices such as contour ploughing, strip cropping and crop rotation that can limit soil erosion was recommended. Management practices that makes more use of organic matter is important to increase soil organic carbon as it is the primary limitation to soil fertility. Also the use of irrigation and water harvesting techniques were recommended. The characteristics of shallow groundwater in the region were presented to establish the relationship between the surface water and the underlying aquifer.

In the second session, presentation on the environment was continued, then followed by topics on different irrigation options. A presentation on geophysical exploitation of groundwater and pollution in the region indicated the groundwater to be very shallow with average recovery and high vulnerability to pollution in the Kasena-Nankana District. The recent flooding in the region as an effect of ecological change and the impact on livelihood was assessed. This recent phenomenon calls for adaptation of existing risk-management or

production-enhancement activities, apply water conserving technologies, and promote agrobiodiversity for increased resilience of the agricultural systems. The hydrological aspects and sediment input to small reservoirs was highlighted. This indicated the existence of regional area-volume relationship. As a result of siltation most reservoirs have lost their dead storage capacity which is design to store sediment until their anticipated design life. Decreasing storage capacity by siltation affect the livelihoods of local inhabitants since reservoirs can not serve all their intended purposes. The actual and potential spatial spread of pump irrigation practices along the riverine areas in the Upper East was also presented. The amount of water used for irrigation and the water productivity of the system was estimated. It was estimated that by 2020, 8.4 % of the total water available in the region will be utilized as compared to 9.8 % taking into account climate change. Overview of water harvesting techniques that highlight the fact that rain water can reduce the strain on municipal water supply and help meet domestic, industrial and agricultural water needs. It raised the need to legislate water harvesting into building code and make use of extensive road network for harvesting rainfall for agriculture and fishing

The second days' presentation started with the third session. The session focused on institutional and socio-economic aspects of different irrigation options. This gave the advantages and disadvantages of the different irrigation options. The challenges in terms of trade and agricultural policies of marketing tomatoes an important cash crop cultivated under irrigation in Upper East Region of Ghana were evaluated. This presentation raised more questions than answers in the contest of importance of the tomato factory, importation of tomatoes from Burkina Faso, and linkage between the small scale farmer and the tomato market Queens. It had been relised that riverine small-scale irrigation has positive impact - exclusively purely economic - on seasonal peasant migration from Northern Ghana as it is for almost reasons. Family labour, farm capital stock, farm credit and cultivated area were identified as important determinants of household farm production and investment decisions. It is thus recommended that policies should target these variables to ensure agriculture development. The importance of fish as a commodity is reflected by a growing number of traders in the sector as well as consumers. However, analysis shows a lack of technological knowledge by extension workers which is necessary for building and supervising fishermen associations, that is essential for the resources management. Finally, a presentation was made on transboundary cooperation through improved water governance. This was noted to have led to the formation of Joint Technical Committee (JTC) on IWRM and establishment of bilateral agreement between Burkina Faso and Ghana.

The plenary session focused discussion on irrigation in the Upper East Region. Discussions were on sprinkler irrigation, cloud seeding, attitude of the people to adopting innovations. However mush of the discussion was on drip irrigation and its potential for using small amount of water for large acreages. It was suggested that MoFA takes up a training and demonstration programme on drip irrigation to supplement the other well known irrigation options.

KEYNOTE ADDRESS

DELIVERED BY THE UPPER EAST REGIONAL MINISTER, HON. ALHASSAN SAMARI ON THE OCCASION OF THE FORMAL OPENING OF A TWO-DAY WORKSHOP ON “IRRIGATION OPTIONS IN THE CHANGING ENVIRONMENT OF THE WHITE VOLTA BASIN” FROM 1ST – 2ND APRIL 2008, BOLGATANGA

Mr. Chairman;

The Scientific Co-ordinator of the GLOWA Volta Project-White Volta Basin, (WVB-GVP); The Representative of the United Nations University; The Acting Executive Secretary of Water Resources Commission (WRC); The Regional Director of Food and Agriculture; Heads of Departments; The Press; Distinguished Invited Guests; Ladies and Gentlemen; I am extremely glad and greatly honoured to be invited for the opening ceremony of this important workshop. It is really gratifying to note that the workshop has been organized by our development partners who feel equally concerned about the socio-economic impact of the fast changing environment and our water bodies like the White Volta Basin. I am very grateful to them and other stakeholders and welcome them whole-heartedly to the Upper East Region.

Mr. Chairman, I have been reliably informed that the workshop is aimed at not only presenting an opportunity for stakeholders to discuss irrigation options in the changing environment but also to afford participants the opportunity to prepare action plans that will lead to poverty alleviation and also meet the Millennium Development Goals (MDGs) for the people in the White Volta Basin. I must say this is a laudable idea and deserves every commendation and support.

Mr. Chairman, the entire Upper East Region is within the White Volta River Basin with over 65% of the population having Agriculture as their main occupation. The region also experiences highly variable rainfall leading to extreme events like drought and floods.

These extreme events adversely affect the socio-economic development of our people. With just five months of erratic rainfall in the Region, 65 percent of the population will be without work for seven months in a year if there were no form of irrigation. This workshop could not therefore have come at a more opportune time and I wish to express my appreciation to the organizers and sponsors.

Mr. Chairman, the government of Ghana recognizing the fact that the water and agricultural sectors interact with all other sectors of the economy, recently launched a national water policy document through its Ministry of Water Resources, Works and Housing. Through the Ministry of Food and Agriculture, a national irrigation policy is being prepared.

Distinguished Ladies and Gentlemen, it is my understanding that the GLOWA-Volta Project has been in collaboration with the Water Resources Commission to develop a Decision Support System for the efficient management of the water resources in the White Volta Basin. I welcome this collaboration and urge other research institutions to enter into similar collaborations with their counterparts in the development sector. Without collaboration between research and implementing agencies, there can be no sustainable development.

Mr. Chairman, we all know the positive contribution that the White Volta River has on the socio-economic development on the people of the Region. With the support of the Regional Co-ordinating Council, the Water Resource Commission and the Regional Directorate of MoFA, a programme is in place, in partnership with our sister region in Burkina-Faso that ensures that farmers are engaged in an all-year food production along the White Volta basin. At the same time, the programme takes cognisance of environmental management practices to conserve the sanity of the Basin. The Basin however, was badly affected due to the havoc caused by the drought and subsequent floods that hit the three (3) Regions of the North last year. I am therefore overwhelmed with joy to have this intervention at this particular moment in time to assist our regional efforts at addressing the situation.

Mr. Chairman, the workshop also has the component of exploring alternative means of harvesting rain water for optimum dry season irrigation farming to maximize crop and animal production for the people of the region. Our Region no doubt, is an agrarian economy with almost 65 percent of the population engaged in the Agricultural sector. I therefore, wish to implore all participants to take the workshop seriously and to also apply the knowledge and skills acquired at the end of the session to turn the fortunes of the region around.

Finally, I wish, once again, to commend the United Nations University – Institute for Natural Resources in Africa; the German Government through its Ministry of Education, Science and Technology (BMBF) for its financial support to the GLOWA Volta Project; the Water Resources Commission, the Ministry of food and Agriculture and indeed, all collaborators for the realization of this dream in the Region.

On this note, I formally declare this workshop opened.

Thank you.

SESSION ONE PRESENTATIONS

PAPER ONE

Irrigation Development in the Upper East Region: Past, Present and the Future

Roy Ayariga

Introduction

- Crop failures and associated food shortages resulting from drought and floods, both of which can occur in a single rainy season has further demonstrated the importance of irrigation.
- It is the sale of such high value irrigated crops such as tomatoes, onions, pepper and water melons that has cushioned the effects of the 2007 drought and floods more than food aid due to the multiplier effect of income derived from irrigated agriculture.
- It is also known that families with access to an irrigated plot are the better-off in rural areas.

Background

Some definitions for the sake of clarity

- **Formal Irrigation** as used by Carter et al (1983) refers to “the development and management of irrigated agriculture in a structured formal way’ usually by government or an external agency.
- **Informal or indigenous irrigation** is defined as those schemes which are under local responsibility, controlled and operated by the local people in response to their felt need.
- **Small dam** refers to the conventional clay earthfill dam connecting two sides of a valley and thus retaining rainfall run-off. Their reservoir capacities range from 1.0million down to 50,000 m³. Usually has inlet-outlet structure for water delivery from the reservoir.
- **Dugouts are** usually constructed by borrowing earth material from the adjacent relatively flat terrain to form an embankment for the purpose of harvesting rainfall run-off mainly for livestock watering than for irrigation and do not have inlet-outlet structures.

Historical perspective

- **Formal irrigation:** was introduced to the Upper East Region in the early 1950s when small dams were built for livestock watering, vegetable production in the dry season and for soil conservation. The government agency GIDA built and operated these schemes on behalf of government.
- **Informal Irrigation:** Historically and even today, traditional methods include fencing off small plots with thorn bushes or stalks along valley bottoms, seasonal rivers and other water bodies for the purpose of producing vegetables at the end of the rains.

Irrigation water is obtained from shallow wells dug within the fenced area or fetched with buckets, gourds or calabashes directly from the water body.

Past Policies on Irrigation management

- Government owned and managed the schemes. Still partially the case for some large schemes.
- Farmers were seen as beneficiaries and did not have a voice in the operations and management of the schemes.
- Crops grown by farmers were even dictated by the irrigation staff
- Government voted money for maintenance and payment of the staff and farmers paid little or nothing
- Irrigation staff were responsible for land and water allocation

This management system certainly has had its own problems.

What are the lessons from the past?

- With increasing number of schemes, government can no longer afford the associated budgets
- Farmers were not assured of plots each year.
- Rapid deterioration of the schemes
- Profitability of schemes was not a priority

All these led to collapse of most schemes.

The present policy direction

- **Large schemes:** The present irrigation policy is for government to construct and/or rehabilitate the scheme and for the District Assemblies (DA) and farmers to manage and maintain them.
- **Small schemes:** the policy is for total farmer-management via their Water Users Associations (WUA) with DA providing public interest regulatory functions.
- The WUA must also be democratically run.

Options for the future? Some thoughts/proposals

- The options should not be to choose either dams (large or small), underground water abstraction or river pumping but must be based on location specific criteria combining physical, social and economic factors
- The key factor should be profitability, efficiency and sustainable use of the schemes.
- Whether the choice is for dams, underground abstraction or river pumping the choice has to be made on the system (flooding (basin), furrow, sprinkler and drip)

Each of these has its pros and cons but the most efficient system is the drip system and I am an advocate of the drip system.

Some advantages with the drip system

- Most efficient use of irrigation water
- Savings in labour for water application and weeding
- Fertigation is possible with reduction in cost of labour
- Crop water requirements can be adequately computed and delivered leading to improvement in quality and quantity of crop output
- Pumping cost is reduced for pump irrigation

The choice of multi-functional schemes

- Irrigation schemes should be multi-functional in design and operation to serve for the following:
- Irrigated crop production (vegetable, cereals, legumes and tree crops)
- Livestock watering
- Fisheries
- Environmental restoration

The crop-livestock- fishery initiative of MOFA under pump irrigation

- MOFA is currently demonstrating at Pwalugu the use of the Water Pump for
 - Vegetable production
 - Tree crop production to protect the river banks
 - Fish production using fish ponds
 - Livestock watering to solve the problem of crop-livestock conflict.
 - Poultry and pig production around the fish ponds.
- This is to maximise the use of the pump for multiple profit.
- We invite researchers and other interest groups to visit the site and provide suggestions for improvement.

Conclusion

- Ghana and Northern Ghana in particular has a huge potential for irrigation development. The rate of irrigation development in the north can equate to the rate at which poverty is reduced as irrigation is the key.
- Choice of an irrigation option should consider how multi-functional the scheme can be.

Discussion

Question (Aaron Aduna): Can the energy component be added to our irrigation schemes?

Answer: Yes, in Burkina Faso agriculture and energy planning is coordinated. In Sri Lanka there are series of dams for both power generation and agriculture. At the Bui project there will be both power and agriculture. At Akosombo the agricultural component was neglected.

Question (Asaah S. Mohammed): What is happening to the wind mechanized pumping machine in Mognori in the Bawku Municipality?

Answer: The people are not using it because a lot of sensitization was not done. Also sometimes the wind power was not enough to pump the water. When it was enough the tanks were always full.

Predicting the Onset of the Rainy Season over the Volta Basin in Ghana using Maximum and Minimum Temperatures over the Land Surface

D. S. Pokperlaar and A. A. Juati

Introduction

- Ghana, Burkina Faso, Togo and Mali are countries that lie within the Volta Basin in West Africa. These countries share several critical societal vulnerabilities; large populations of subsistence agriculturalists and pastoralists; scarcity of water supply, strained infrastructure for water resources and agriculture, social, political and economic instability
- Further more, the area's major rivers flow through several countries and the inhabitants migrate across borders in response to drought conditions.
- The Volta, is the most important river basin; with Ghana and Burkina Faso as the predominant riparian states in the region that benefits from its waters
- From this view point the German government and its development partner countries within the Volta Basin (Ghana & Burkina Faso) set up a multidisciplinary research project called GLOWA Volta
- The main objective of the project is to conduct a comprehensive, integrated analysis of the physical and socio-economic determinants of the hydrologic cycle within the Volta Basin, focusing on the impacts of changes in land use and climate
- During the implementation of phase I of the GLOWA Volta project, it became clear that, a topic of prime importance for sustainable agriculture and water management in the Volta basin is the unresolved question of the determination of the onset of the rainy season.

Problem

- Farmers face a crucial dilemma with respect to the onset of the rainy season.
- When the first rainfall events start after the dry season, the farmer must decide whether or not they should start sowing.
- If they start sowing but no major rainfall comes within the following one to two weeks, all of their efforts are lost.
- If farmers do not sow, but the first rains are already part of the rainy season, valuable time for agriculture production is lost.

Objectives

- The task of the research therefore is to investigate the problem, namely: "Predicting the onset of the rainy season over the Volta Basin in Ghana".
- If a station's daily maximum and minimum temperatures are plotted for a period of several weeks, two controls usually stand out.
- First, the periodic or diurnal control determined by the sun, induces a regular rise of temperature by day and a fall at night.
- But superimposed upon this sun-controlled pattern is a non-periodic one controlled largely by the passage of atmospheric disturbances and their associated air masses.

- The method adopted is to detect this non-periodic pattern and then find the behaviour of the meteorological elements (maximum & minimum temperatures) during those periods.
- It is not being claimed that the onset of the rainy season would depend solely on the maximum and minimum temperatures.
- On the contrary, our experience indicates that the onset over the Volta Basin is greatly controlled by many synoptic factors, namely:
 - The movement of the Inter-Tropical Convergence Zone (ITCZ).
 - The wind circulation over the coast of West Africa
 - Upper level disturbances
 - Tropical plumes, geography of the area etc.
- The effects of the maximum and minimum temperatures would of necessity be coloured by these synoptic conditions.
- The main objective of this research therefore is to find any direct and/or reliable indicators that can be used together with these synoptic conditions by the Ghana Meteorological Agency to decide on whether or not the first rains after the long dry season are already the onset of the rainy season.
- In particular, we shall use statistical analysis approach in detecting the behaviour of the maximum and minimum temperatures prior to and up to the onset of the rainy season.
- Some regions in Ghana have the dry period lasting as long as six months.

Specific Objectives

- To investigate and determine the onset dates for the past fifteen or more years of the rainy season over the Volta Basin in Ghana.
- To partition the country into climatic zones based on the onset dates.
- To investigate the behaviour of the maximum and minimum temperatures prior to the onset dates in each climatic zone.
- To find any direct and / or reliable indicators that can be used to decide on the date of onset

Data set and Analysis

- The study area covers nearly the whole of Ghana.
- The republic of Ghana is situated in the middle of West Africa, between latitudes 4.8°N and 11°N. It extends on both sides of the Greenwich meridian to 3°W and 1°E with a total land area of 238,540km².

Results and Discussion

- The onset date is: Any day such that the ten-day cumulative rainfall amount beginning from that day is greater than or equal to 10mm. This definition is taken in order to maximize agriculture use.
- The consecutive dry days for the next three weeks (21days) beginning from the day as above does not exceed seven days.
- The data set for the study was taken from twenty two (22) stations in Ghana
- The twenty two stations were chosen based on the following criteria:
 - The station had confirmed continuous daily rainfall amounts for at least fifteen years or more (special consideration Abetifi)
 - To give a fair and even distribution of the stations in the region or area.
 - The stations were grouped into three blocks, namely:
 - Coastal Belt – Latitude 4.5°N to 6.5°N

- Middle Belt – Latitude 6.5°N to 8.0°N
- Northern Belt – Latitude 8.0°N to 11.0°N
- From the rainfall graphs, the onset dates for each year of the stations were computed.
- The country was partitioned into climatic zones, based on the onset dates
- Based on the partitioning of the study area into climatic zones, the variability of the maximum and minimum temperatures were further investigated.
- These temperature-graphs together with the rainfall-graphs over the three Northern Regions in particular were further investigated.
- The rainfall and temperature graphs showed that the rains started when the temperature dropped to 15°C or lower.
- A critical examination further revealed that when the temperature falls to 12°C or lower for seven consecutive days, it coincided with the onset dates for the three Northern regions.

Summary

- The general objective was to obtain the indicators for finding the onset of the rainy season over the Volta Basin in Ghana.
- To this end a statistical approach as well as the prevailing synoptic conditions during the period of onset was used to realize the objective.
- In the preceding sections we have seen in detail the different periods for the onset of the rainy season in each climatic zone.
- Perceptible changes on account of the onset of the rainy season are:
 - The position of the ITCZ.
 - The period of onset for each climatic zone
 - The temperature range
 - Wind circulation pattern
 - Low pressure systems moving across the West African region.
- All these systems may not always be present simultaneously.
- The reorganization of the wind circulation pattern during the rainy season over the Volta Basin extends over an interval, ranging from a few days to one or two weeks.
- From the forecasting view point therefore, the following may be taken as the main indicators for the imminent onset of the rainy season.

Conclusion

- The position of the ITCZ over the Volta Basin should be at Latitude 8°N or more for about two weeks.
- Winds from south west should be consistent.
- The easterlies should be reasonably strong.
- Low pressure systems moving across the West African region.
- Then within the period for each climatic zone and a combination of three or more of (1) to (5) above, synchronous with a temperature range of 12°C or lower for seven consecutive days ushers in the rainy season over the three northern regions.

Frequency of dry spells within the rainy season over some stations at the white Volta basin.

Charles K.A.Yorke.

Introduction

- Extremely dry years, highly variable onset dates and long dry spells within the rainy season in recent decades have led to unstable and unsustainable agricultural practices; a long dry spell between rain events could be disastrous for crops and may lead to outright crop failure
- Inefficient water resource management resulting in famine and food insecurity.
- Hence any study of rainfall variability is not complete without an investigation of dry spells.
- The most critical period for seed germination and crop establishment is the first 4-6 weeks.
- A semi-arid region as the White Volta basin, with high evaporation rate, even 10 days of a dry spell between two successive rainfall events at the early stages of the rainy season could be disastrous for seed germination and crop survival.
- Analysis of dry spells between consecutive rain days at some stations in the White Volta basin was done based on a threshold of 1.0 mm of daily rainfall event.

Objective

Objective of the research is to analyze daily rainfall data and investigate the extent of dry spell occurrences during the rainy season from one year to another.

This is to enhance the understanding of the variable climatic conditions so as to provide improved climate information products that can be used to reduce or mitigate the vulnerability of climatic events at the White Volta basin.

Data and Methodology

- Eight years of daily rainfall data (2000-2007)
 - Manga Bawku(11° 01'), Navrongo (10° 53'), Tamale(09°30'N) and Yendi (9° 27') all in the White Volta Basin used in this work were all sourced from the archives of Ghana Meteorological Agency.
- The daily rainfall data were used to determine the onset and cessation dates of the rainy season for each year at all the stations.
- dry spells for each month after the onset of the rainy season till the cessation during the period of study for all the stations.
- Definition of Onset and Cessation.
- The onset of the rainy season was defined as the beginning of the first 7-day period with at least 15mm of total rainfall with one of the days having at least 10mm rainfall with no dry spell of 10 days or more within the next 3 weeks.
- Cessation is defined as any day from the peak of the rainfall after which there are 14 or more consecutive days of rainfall less than 1.0mm.
- A threshold of 1.0mm of daily rainfall event is considered a rainy day.

Results and discussions

- The years with the highest monthly total dry spell during the first 4-6 weeks from the onset of the rainy season at Manga Bawku were 2001, 2002 and 2007. All these occurred in May
- There was a significant reduction of the dry spell values in 2007 as the rainy season progressed.
- However, 2001 and 2007 were the years with the longest run of dry spell of 18 and 13 days respectively, occurring in May.
- Continuous dry spell for the above number of days may result in outright crop failure.
- At Navrongo, May 2002 and 2007 recorded the highest monthly total and the longest run of dry spell of 10 days or more during the first 4-6 weeks of the onset
- These long dry spell runs occurred once in 2002 and twice in 2007.
- Here also as the rainy season progressed to the peak in 2007, the monthly total values of the dry spell reduced significantly.
- Tamale, a more southerly station has more monthly total and long dry spell run. Significant amongst them being 2001, 2003 and 2005.
- 2002, 2005, 2006 and 2007 were years with the longest run of dry spell of 10 days or more during the first 4-6 weeks of the onset of the rainy season occurring mostly in April-May. Interestingly, in 2007, there were two occurrences of the dry spell in May and also in June/July.
- Yendi, a station on almost the same latitude as Tamale has a similar number of years of highest monthly total dry spell during the first 4-6 weeks from the onset of the rainy season, occurring in 2003, 2004, 2005 and 2007, These years also had the longest run of dry spell of 10 days or more in addition to 2000.
- The occurrences were from April to May. Again there were two separate events of long run of dry spell in 2007
- The lowest monthly total dry spell occurred in August 2007 at all the stations except Yendi which had it in September 2003 and 2007.

Conclusion

- This study has shown that in order to ensure maximum and sustainable agricultural productivity, as well as efficient water resource management practices knowledge of the frequency of dry spell occurrence is vital. Appropriate decisions with regard to irrigation needs and their timings as well as water conservation strategies for dams could be made effectively.
- The results of this study showed that from the onset to about the 8th week:
 - Frequency of occurrence of dry spell was highest in the month of May at all the four stations.
 - The longest dry spell run of 10 days or more mostly occurred in May and it increases from the north to the south of the White Volta basin.
 - The highest frequency of occurrence of continuous dry spell of 10 or more days was in 2007.

Recommendation

This study is extended to cover the rest of the river basins in Ghana for improved agricultural practices and water resource management.

Discussions (for Presentations 2, 3 and 4)

Question (M. Fosu): Is it possible to harmonize the definition of on-set of rainy season so as to have a convergence of determination of on-set date? Your on-set periods cover 1 – 2 months. How useful is this to a farmer who needs specific date of planting?

Answer: The onset date given was with respect to agriculture. Hence three of us were talking about agriculture that is why we emphasized on 7 – 10 day dry spell. On your second question, you should answer the question yourself and advice farmers accordingly. Maybe use of drought resistant varieties can help.

Contribution (M. Fosu): Farmers like to know when to plant with wide varieties so it will be difficult to advice them.

Question (A.R.Z. Salifu): We have an indigenous knowledge that the Lunar movement within the 1st 2nd, 3rd or 4th quarters, have a bearing on influence on rainfall. Is there any scientific study to establish or confirm this relations? If not can there be any study on human movements for 1st to 4th quarters (weekly) in relation to rainfall distribution especially drought or dry spells during the season. Please use Catholic calendar as reference to Lunar movements. This can help us forecast rainfall distribution ahead, if we know the lunar movement.

Answer: A lot of other factors influence weather besides lunar movement. For example sun storm. Lunar movement affects tides. If high tides combine with strong winds there is likely to be a rainfall. But no study has been conducted yet on the effect of lunar movement on rainfall onset.

Question (Gordana Kanjac): On comparing rainfall onset situation now with historical records of the 1960s are changes noticeable, though rainfall pattern is changing?

Answer: Historical records are used, especially with indicators of flood. In the 1960s we experienced early onset and late cessation. The data is available.

Question (Asaah S. Mohammed): What has been the position of the ITCZ over the past 5 years in the northern belt at the time of this first rains? What causes the intermittent rains and how can farmers determine the onset rains?

Answer: The ITCZ is not fixed, but always oscillates. It comes with movement of sun across the equator. It is controlled by two wind regimes. The North-East wind is stronger during hammattan and pushes it to the coast. During the rainy season it is pushed to the north. It can be anywhere in May. There is a lot of dynamics in the position. Rainfall depends more on whether there is moisture in the atmosphere. Other conditions also determine whether there will be rain or not.

Question (Wolfham Laube): Is the onset of the rainy season becoming later?

Answer: Precipitation pattern is moving north wards from the equator. In southern Ghana June, which used to be the month of maximum rainfall, is now turning to October. Hence farmers down south are confused.

Comment (Paul Nkegbe): Is it possible to synchronize the data from the various stations for comparison? For example 1984 – 1994 for all stations if we have only 11 years data. One presenter used a 26 year data, another 15 year data.

Answer: Comment well taken

PAPER FIVE

Evapotranspiration and local water cycle in West-Africa

Ulrike Falk

Introduction

- BIOTA West project
- Biophysical Observation Network
- Surface Energy Processes and Water Cycle
- „*Ongoing deforestation will cause a substantial reduction in precipitation over tropical Africa*“

Motivation and Objectives

- Environmental Change is manifest, and will continue to occur within the Volta Basin
- *Exogenous*: radiative forcing (“global warming”) and associated impacts on global and regional climate systems
- *Endogenous*: broadscale alterations in land cover, land use, water use and management
- *Interactions* between the two
- Many of the impacts of environmental change can be identified and simulated through application of rigorous scientific methodologies

Results:

- Time series analysis and climate variability
- Burkina Faso: Mean annual precipitation for the decades:

Bowen ratio and comparison to undisturbed rainforests

- Unexpectedly high Bowen ratio measured above Agroforestry System (AFS)
- Indication of potential shift in heat partitioning and enhancement of the sensible heat conductance and reduced evaporation in the AFS
- Likely feedback to local climate: heating effect of the convective boundary-layer
- Higher air temperatures, reduced water vapor saturation, and increased run-off / groundwater recharge rates.
- Potential impact of AFS on regional climate might be expected lower than that of other land-use types growing annual crops in shifting cultivation, because of permanent soil cover and transpiration the perennial cacao trees.
- Historical climate data show that isohyets are being shifted south for the period of 1950 to 2000 enhancing the risk of droughts
- The extreme climatological difference between wet and dry season lead to an average Bowen ratio of $\beta=3.9$ in the dry season and $\beta=0.29$ in the wet season, and an albedo of $\alpha=14.7\%$ in the wet season and $\alpha=19.2\%$ in the dry season.

- Energy balance closure amounts to 88% but the residual shows a pronounced daily cycle indicating advection or erroneous measurements of the soil heat flux.
- Comparison of Bowen ratio from rainforest sites give indication that conversion of rainforest to managed land has a heating effect on local climate.
- The CO₂ fluxes showed clear diurnal patterns with the highest uptake rates at noon and up to 1 mg m⁻² s⁻¹ in July and August

Local to regional fluxes:

- Surface energy balance capacity building at ZEF: Modelling and Scintillometry:
- EC measurements, micrometeorological stations and biophysical measurements
- Scintillometry (natural savanna, „hot“ and „dry“ pixel)
- Remote sensing (Landsat and/or MODIS) and DEM
- Thermographic overflight missions

Discussion

Question (A. A. Juati): Do you have data on Normalized Difference Vegetations Index (NDVI), Leaf Area Index (LAI), Fraction of Photosynthetically Active Radiation (FPAR) and can this data be accessed to validate same type of data available on satellite facilities?

What is your comment on the effect of cloud seeding that is being practiced in Burkina Faso on these Biophysical parameters?

Answer 1: I measured those parameters and willing to share the data.

Answer 2: I know some project related to cloud seeding, but I am not connected to it. I can send you contact details though I have used it I cannot tell of its effectiveness.

Question (Wolfham Laube): Impact of irrigation on evapotranspiration? Where is water that is evaporating turned into rainfall?

Answer 3: Irrigation definitely has effect on evapotranspiration. Hence irrigation has effect on local climate. Clouds from irrigation sites are carried further away and any rain elsewhere far from the site.

Question (A.R.Z. Salifu): Irrigation site in Navrongo: How is this affecting the local climate and your data on climatology compared to other sites without such conditions?

Answer: The basic idea was not to measure conditions at the natural sites as we used managed sites and analysed results with respect to others (managed sites e.g. game reserves, etc)

Question (Sabastian Bagina): Planting trees along the lake shore is thought to keep the environment cool and reduce surface evaporation. However, we know that trees by the lake will increase evapotranspiration. So in sum, will planting trees along the lake lead to minimizing water loss from it.

Answer: It depends on how close the trees are to the lake and the topoccale. Vegetation serves as a buffer zone and slows down evapotranspiration. Thick vegetation layer provide shelter for a lake and may slow down evapotranspiration.

Characteristics of Soils in the Upper East Region and their Potential for Agriculture

E. Boateng and W. A. Agyare

Introduction

- Upper East region lies within the sudan savanna zone – a semi arid-tropic
- Environmental factors such as temperature, R.H., rainfall have influenced the cropping system of the region
- Average annual rainfall is around 1,000 mm, characterized by short duration rains usually preceded by violent storms that sometimes cause erosion
- Most soils are very fragile with less organic matter (OM) accumulation owing to high temps which causes rapid rate of decomposition
- Adverse climatic condition coupled with human activities e.g. bush burning, overgrazing, intensive cultivation have led to all forms of land degradation including erosion and iron pan formation
- Soils are therefore poor in nutrients and also shallow in some areas
- Common savanna tress and grasses which are able to withstand this enviromental.conditions include *Butyrspernum paradoxum*, *Accacia species*, *Andropogon gayanus* and *Imperata cylindrica*

Geology

- Voltaian rocks mostly sandstones and shales confined to the southern part. They are further classified into upper, middle and lower voltaian rocks
- Birrimiam rocks – metamorphosed sediments of volcanic rocks. They are also sub divided into arenaceous, argillaceous and volcanic rocks
- Granitic rocks- These are also divided into biotitic, hornblende complex, muscovite and Bongo rocks.

Soils from granite - Biotite and hornblende granite:

- **Varampere association:** (*Wenchi, Hilum, Varampere, Tafali, Gulo, Pusiga, Pu, Berenyasi, Kupela*)
- **Tanchera association:** (*Tanchera, Puga, Kologu, Pusiga, Gulo, Berenyasi, Kupela*)
- **Chuchuliga association** (*Chuchuliga, Kologu, Pu, Tanchera, Pusiga*)
- **Wenchi consociation:** (*Wenchi*)

Soils over Bongo granites

- **Wenchi association:** (*Wenchi, Babile, tanchera, Pusiga, Pu, Kupela, Berenyasi*)
- **Bongo association:** (*Bongo, Vea, Yorogo, Yaratanga, Akurubu, Zoko, Tongo*)
- **Tongo association:** (*Tongo, Bongo*)

Soils from Birrimian rocks

Soils from volcanic rocks - Heavy clay piedmont slope from mixed volcanic rocks, Sandy clay soils from greywackes and quartz sericite rocks

- **Mogo consociation:** (*Mogo*)
- **Nagodi association:** (*Nagodi, Dorimon, Yagha, Kalini*)
- **Yagha association:** (*Yagha, Sapeliga, Kalini, Nagodi*)
- **Bianya Association:** (*Bianya, Nangodi, Pale*)

Upper and lower Voltaian rocks

Mimi association: (*Mimi, Murugu, Kintampo, Techiman, Wenchi, Nalerigu, yaroyiri, Bombi Kunkwa*)

Kintampo association: (*Kintampo, Techiman, Wenchi, Mimi, Yaroyiri, Bombi*)

Bombi-Yaroyiri association: (*Bombi, Yaroyiri, Kunkwa*)

Wenchi association: (*Wenchi*)

Soils from Voltaian shales (ground water laterites)

- **Kpelesawgu association :** (*Kpelesawgu, Sambu, Changnalili, Volta, Lima*)
- **Volta-Lima association:** (*Volta, Lima*)
- **Kpea association:** (*Kpea*)- *talus, mainly large boulders*
- **Klopu association:** (*Klopu*) – *mixed colluvium of clay and rock boulders*

Soils derived from alluvial materials

Can be from alluvial levees (recent), floodplain alluvial (old levees), mixed (recent and old) and terrace soils

- **Dagare association:** (*Dagare, Kunkwa, Sirru*)
- **Siare association:** (*Siare, Pani*)
- **Siare-Dagare complex:** (*Siare, Pani, Dagare, Kunkwa, Sirru*)
- **Nterso-Zaw association:** (*Nterso, Zaw*)
- **Sirru-Lapliki:** (*Sirru, Lapliki*)

Soil quality groupings

Based on soil characteristics

- Depth to impenetrable layer, Drainage, Texture, Slope, Permeability, Water holding capacity, OM levels, Nutrient content
- Several sub-classes depending on limiting factors
- The sub-classes indicates the kind of limiting factors – (topographic, wetness, salinity and or sodicity, soil fertility, soil physical limitation)

Suitability ratings of soils according to their limitations - Summary of suitability ratings

- Highly suitable soils with very little or no limitation and can support a wide range of arable crops is about 2%
- Moderately suitable soils which requires some kind of improvement is about 63.5%
- Marginally suitable soils which requires proper tillage practice and Land Utilization Type is about 27.5%
- Soils without agricultural value is about 6.0

Detailed land suitability assessment

The FAO framework indicates that it is necessary to land and not just soil

A complete suitability rating is assessed and classified with specific kind of Land Utilization Type (LUT) e.g. rice production. Under irrigated agriculture or tobacco-maize rotation Matching soil qualities/characteristics with the growth requirements for millet, sorghum, rice and groundnuts under rainfed conditions near Pwalugu

Conclusion

- Soil degradation continues to be a yearly phenomenon in the Upper East region. This is due to the fact that the same piece of land continues to be subjected to the same poor management practices every year without fallowing.

- Most of the soils which are considered to be moderately good agricultural soils are characterized by sandy top horizons and low organic matter over an impervious clay C horizon. These are properties that induce erosion if appropriate conservation measures are not taken. For this reason, attempts at soil rehabilitation should aim at increasing and conserving large amounts of organic matter in the soil to increase nitrogen content, and improve the structure of the A horizon. Also protection against erosion by contour ploughing, strip cropping, crop rotation should be advocated
- Marginal lands especially those with shallow depths < 30 cm to the bedrock should be developed for control pasture grazing and forestry.
- Attention should also be focused on the heavy textured clay soils (Vertisols) of Yagha and Bianya series which forms about 6% of the total land area for possible development for intensive mechanized irrigation farming
- Efforts should be made to put alluvial soils around the White Volta and other major rivers into productive use i.e. dry season irrigation farming.

Discussion

Question (Wolfram Laube): Is your presentation based on a reclassification of old data? Has a comparison with new data been done?

Answer: We considered new classification done by Agyare and me. They fall on the same category. There is, however, no fund to carry out further work. This work was done in the Bawku area. Obviously further degradation has occurred since Adu's report, shown by work done since then.

Question: (Jens Liebe): Any measures taken to advise farmer to increase organic matter in soils.

Answer: Yes, the Soil Research Institute has done a lot of work on soil fertility, especially using green manure or poultry manure to improve on soil fertility.

Contribution (Roy Ayariga): Soil fertility measures have been carried out in the UER: The problem is vines are carried away by livestock keepers soon after harvesting. But we cannot advice farmers to devote arable lands to pasture due to land shortage and land tenure system.

Question (John Apatinga): What steps could you take to make your observations on soil degradation due to bush fires brought to bear on policy making in this country to combat them? There is a serious need to promote composting. This is a matter for MoFA to consider practically.

Answer and Contribution (Roy): I wish to propose a different name for bush fires in UER; because what is burnt is crop residue. Hence we should call it farm fires. The AEAs should advice farmers to desist from that practice.

Bush fire laws exist, but prosecution rarely takes place because those involved are either local opinion leaders or politicians.

Composting is a traditional process hence people are aware of it. But I will not propose what is taught at school: Leaving crop residue on farms alone will attract animals to it, which will eventually leave their droppings behind.

PAPER SEVEN

Potential Impact of Climate Change on Food Production in Semi-Arid Region of Ghana: The Case of Sorghum in Upper East region

Kpongor, D.S., W. Agyare, M. Fosu and R. Kanton

Introduction

Climate change and its potential long-term impact on crop production is a topical issue world wide.

Variability in weather patterns is likely to be more devastating in Sub-Saharan Africa characterised by:

- Subsistent agriculture
- Rainfed agriculture
- low use of external inputs.
- Nutrient export/mining and high spatial variation in soil fertility.
- poverty (high cost)
- Variable yield response due to variable soil fertility and erratic seasonal rainfall amounts and distributions.
- Evaluating interactive effect of soil-atmosphere on crop yield: use of crop simulation models-CSM
 - APSIM –(Agricultural Production systems SIMulator)
 - Routine to simulate soil P impact on yield
 - Simulating long term soil dynamics in response to management practice and weather
 - It is a suite of simulation model that can make a valuable contribution to the understanding of the processes that determine crop responses and also predict crop performance, resource use and environmental impacts for different environments and management scenarios used with generated weather data

Objectives

- Assess the potential impacts of projected climate change on food production
- Suggest innovations that could potentially reduce impact of CC in the region

Methodology

- Simulated weather data (GLOWA Volta Project)
- Two time slices used, 1991-2000 and 2030-2039.
- Based on the 2030-2039 data, LARS-WG- Weather generator was used to project data over 40 years period.
- Weather data fed into APSIM-CSM
- APSIM already calibrated and evaluated (Kpongor, 2007).
- Data (crop, soil, weather) collected from Navrongo (2005-2006)
- Statistical analysis

$$SN = \frac{|X_{fut} - X_{pres}|}{stdev}$$

where SN = signal to noise ratio

X_{fut} and X_{pres} are mean future and present values, respectively.

SN > 1 indicates a detected change in the variable in question over present values

Results

Rainfall

- Signal to noise ratio generally below threshold values that indicate change for most of the months except for August and Oct.
- Crop growth is more sensitive to rainfall distribution over cropping cycle than absolute values.
- On set of rains delayed in future rainfall scenario

Temperature

- Significant increases in Monthly mean temps higher for almost all of the months over the two time slices as indicated by SN values of above 1
- Retaining crop residue from previous season resulted in higher yields, particularly in scenario with no fertilization
- A clear trend of decreasing grain yield with continuous cropping with no fertilization.
- Rate of decrease is lower with use of crop residue
- Use of fertilizer increases grain yield but also increases variability of grain yield
- Need to provide means of irrigation to reduce uncertainty with grain yield and to encourage farmers to use mineral fertilizers
- With no fertilization, retaining crop residue from preceding crop resulted in decrease in seasonal grain yield variation
- Depleting soil organic carbon (SOC) as result of removal of crop residue is evident in both time slices
- Reduction in the long-term grain yield can also be attributed to reduction in SOC
- Buffering capacity of the soil, particularly when no fertilizer was applied
- Rainfall is the most variable weather parameter, hence more attributable to fluctuations in yield, particularly under fertilization

Conclusion and recommendations

- Variability in weather pattern poses threat to food security
- Use of mineral fertilizers increases crop yield but also increases variability in yield probably due to variability in rainfall
- Need to encourage farm management practices that improves SOC
- Need to harvest rain water
- Need for increased irrigation to encourage farmers to use mineral fertilizers

Discussion

Question (A. A. Juati): Is Drip irrigation feasible? Can it be practiced in the Upper East Region?

Answer: The picture you see in this slide is drip irrigation. Currently we have drip irrigation projects at Binduri, Navrongo and Golinga near Tamale. The price for a unit that

covers 500m² is \$200 US. The scheme needs only 1.0m head of water. We now connect drip lines to existing irrigation project. Hence no lift pump is required.

Question (John Apatinga): Rain harvesting: How is it to be done on the farm? Can the drip irrigation systems mounted at the Tono irrigation site be relocated somewhere else like Kandiga, Pungu, etc where they are most needed?

Answer 1: On-farm rain water harvesting is done by using tied ridges. Rain water is confined within the ridges and prevent erosion.

Answer 2. The drip irrigation project at Tono is worse performing not due to cheap water but the management of water. Water is not managed well because farmers there are used to large farm sizes. Also distance from farm to house is quite far hence they open the drip and go home. By the time they return a lot of water has been wasted. We would have to move it to other places where irrigation schemes are scarce.

Question (Wolfram Laube): Do yield variability under fertilizer affecting the economic viability of using fertilizer in rainfall agriculture?

Answer: Farmers are not getting value for fertilizer use, especially when rainfall is low. Hence there is a threat to fertilizer use under rainfall agriculture.

Question (Jens Liebe): Are there any advances regarding faster growing crop varieties that farmers can chose when expecting short rainy season?

Answer: There are a number of crop improvement programmes going on under CP6 project to come up with early maturing crop varieties.

Contribution (Vitus Ayingayure): I want to comment on the drip system at Golinga. The first system installed takes water directly from the main canal. However the second system that is about to be installed makes use of an overhead tank which will require the use of a pump. How can farmers beat the cost of pumping?

Question (Alhaji ARZ Salifu): How can a farmer can practically harvest water on the field.

Answer: Bonding of rice fields or flooded fields can bond water to enhance crop utilization of rainfall.

PAPER EIGHT

Characterization of Shallow Groundwater in the White Volta Basin, Ghana

Benjamin Kofi Nyarko

Introduction

White Volta River catchment is experiencing climatic, hydrologic and vegetation changes.

Anthropogenic and natural causes

- Farmers along the White Volta River cultivate on the floodplain to make use of residual moisture
- Ministry of Food and Agriculture, Ghana is encouraging dry season floodplain cultivation, (shallow dug wells and pumped river water)
- Environmental changes, causes uncertain impacts, on agriculture and water flow
- Evolving adaptive strategy seems a necessary condition for sustainable water resource management. To ensure efficient management and sustainable level of water resource usage for floodplain agriculture.
- Shallow groundwater storage and capacity for flow should be understood.

Methods

Hydraulic gradient method: Horizontal and vertical hydraulic gradient

Water table monitoring

- The vertical hydraulic gradient (VHG) was calculated as the difference between hydraulic head divided by the depth to the piezometer screen. A positive VHG indicates upwelling, a negative indicates draw down
- The horizontal hydraulic gradient is the change in hydraulic head per unit of distance of the groundwater flow in a given direction.

HYDRUS-1D model (Pwalugu wetland site)

- The HYDRUS-1D is a finite element model for simulating one dimensional movement of water in a porous media.
- The HYDRUS program numerically solves the Richards equation for saturated-unsaturated water flow
- A depth of 1.0 m was modelled (4 layers)
- Unsaturated soil hydraulic properties (K_s and soil texture), residual soil water content, saturated soil water content, soil retention function
- Water flow boundaries conditions:
- Surface: Atmospheric boundary condition with surface layer
- Bottom: Free drainage
- Time varying conditions:
- Precipitation and evapotranspiration (September 2004- December 2005: 487 days)

Isotope technique

- Isotope species- Oxygen-18 (^{18}O) and deuterium (^2H)
- Sampling:
 - White Volta River at Pwalugu gauging site,
 - Sub-surface water in Pwalugu Wetland-B

Samples were analyzed at the IAEA Isotope Laboratory, Vienna (GC mass spectrometer).

PM-WIN (MODFLOW)

- Three-dimensional finite-difference ground-water model
- Aquifer system is divided into grids (rows, columns and layers)

Results

- Contribution of unsaturated zone to groundwater recharge in the Pwalugu floodplain site shows spatial and temporal variation
- Model calibration-steady state and transient mode
- To obtain a tolerable distribution of the initial hydraulic head

Conclusion

- The relationship of surface water to an underlying aquifer is an important component of groundwater system characterization.
- Shallow groundwater is a strictly a renewable resource.
- Uncertainty about shallow groundwater recharge mechanisms and rates, is as a result of hydrogeological complexity and inadequate field data.
- Exploitation of shallow groundwater resources thus requires systematic evaluation.

Discussion

Question (Thomas Atta-Darkwa): What wetland type did you work on? Can you show us on the map the direction of flow? Is the wetland a discharge or recharge one?

Answer 1: The wetland worked on was close to Pwalugu – a riverine wetland. Within the area i studied there are many flow systems. I could not determine the flow system, but it looked like it is within. Having an idea about the flow system will help in advising farmers.

Question (G. K. Anormu): How would the removal of water from the shallow ground water affect your results? Are your results going to be used to advice only farmers at your study area?

Answer: I did not perform that test. The study was to enable me get a degree. The technique could be applied to other basins as well.

Question (Asaah S. Mohammed): How do farmers especially in Mognori and Sapeliga determine the recharge of ground water in the White Volta?

Answer: GLOWA is currently undertaking a study in that area. Recharge can be regional or local. It can come from the river bed. The flow direction should be known in order to make available the resource.

Question (M Fosu): Did you determine rate of recharge and did you find any soil parameters influencing the rate of recharge?

Answer: No, I tried doing pump test, but resources were limited. Pwalugu do pump irrigation. The area is voltaic sandstone and hard rock. Only shallow wells would be dug there.

SESSION TWO PRESENTATIONS

PAPER ONE

Geophysical Studies in Groundwater Exploitation and Pollution in the Kassena-Nankana District of Ghana

Bayor Jude Simons

Introduction

- The Kassena-Nankana District (KND) has a huge potential for agricultural development. Associated with most scientific methods in agricultural activities is the increased use of pesticides and chemical fertilizers. These chemicals thus have a chance to intercept the groundwater regime, thus causing pollution.
- One can make a semi-qualitative assessment of the groundwater vulnerability by making use of geophysical and drilling data from the area concerned. With the hydraulic properties of the materials known, it is possible to make a conclusion on how susceptible groundwater is to pollution from any main source.
- The aim of this paper is to outline the physical properties of the earth materials and the hydraulic properties of the aquifers from geophysical measurements, drill and test pumping results carried out by the Community Water and Sanitation Agency in the Kassena-Nankana District (KND).
- The study then compared these attributes of the District to the following suggested factors: the depth to groundwater (i.e. thickness of the unsaturated zone), degree of weathering and groundwater fortunes in the weathered zone, presence and thickness of a clay cap, and recharge or recovery rate.

Location of the study area

- KND is located in the Northwest of the Upper East Region and it is one of the Districts in the region.
- It lies within latitudes 11°10' N and 10°30' N and longitude 1°01' W and 1°30' W.
- It is bounded to the North by Burkina Faso, to the East by Bolga and Bongo Districts, to the south by the Builsa District and to the west by the Upper West Region. It covers an area of 1,674 square kilometers

Climate

- Falls under the Tropical Continental or interior wooded Savanna climatic region.
- Characterized by a single rainy season from May to October followed by a prolonged dry season. The mean annual rainfall is between 100 and 115 cm.
- The highest mean annual monthly temperature is about 36°C occurs in March and the lowest of about 27°C in August. High relative humidities of 70 to 90% are recorded in the rainy season while in the dry season, the lowest value of 20% is observed

Relief and drainage

- Low-lying with an average height of 110m above sea level. However a few isolated areas, where topography appears undulating, have been found rising to about 300 m above sea level

- Drainage is enhanced in the district mainly by tributaries of Sissili river. These include Asibelica and Afumbeli.

Geology and hydrogeology

- Kassena-Nankana is underlain to a large extent by granitic rocks (forming about 90% of the area). The southern Upper Birimian rocks make up about 10% of the districts total area in the south.
- Generally aquifer zones are located in
- Decomposed rocks
- Fracture quartz and aplite veins occurring in a dense massive decomposed rocks
- Fractured poor decomposed or fresh rock (Wardrop and Associates, 1980)

Geophysical Survey

- Geophysical survey investigations were carried out after field reconnaissance survey.
- The Schlumberger electrode configuration, which is an electrical resistivity survey method, was used for profiling. Electrode separations ($L/2$, $a/2$) of (19.0m, 0.5m) and (40.0m, 5.0m) was chosen and employed to carry out the resistivity profiling along selected traverse lines. These electrode separations were chosen with regard to the local water table depths, essentially to coincide with the weathered zone and bedrock resistivities.
- Anomalous low points observed from the resistivity profiling curves were marked for further investigations by Vertical Electrical Sounding (VES) using the dipole-dipole method. Measurements were taken to depths of 60-70m.
- Borehole drilling was carried out from the overburden, through various weathered layers and into the fresh bedrock with bits of varying diameter.
- Sampling and logging of drill cuttings was also done during drilling at 1m interval and at every change of rock type or colour of weathered material.
- Test pumping of boreholes comprised a 6-hour constant discharge test carried out with a suitable submersible pump, followed by a 3-hour recovery test.

Results and data analysis

- The resistivity values of the aquifer material indicates that groundwater occurs both in weathered zones and in fractured poorly weathered or fresh rock layers underlying the study area.
- The electrical survey showed generally that apparent resistivity values in the study area were found to range from 10.2 Ω -m to 629.0 Ω -m and 26.7 Ω -m to 955.5 Ω -m for profile depths of 19.0 m and 40.0 m respectively. The wide variations in these ranges depict the varying degrees of weathering which also accounts for the non-uniform groundwater occurrence within the area.
- From a total of 62 boreholes drilled in the project, 32 were successful and 30 were dry. This results in a success ratio of 51.6%
- Borehole depths ranged from 25.0 to 61.0 m with a mean value of 43.0 m. The total drill depths of the successful boreholes made up 46.9% of the overall total drilled depths of 2622.0 m for the Kassena-Nankana District.
- The successful boreholes have a mean borehole yield of 66.751 lpm.
- Water bearing zones, generally, encountered at somewhat shallow depths, having a mean of 20.69 m. In some cases these coincided with the moderately weathered layers, while in others, fractures of poorly weathered layers or fresh rocks formed the main aquifers.

- All the 32 boreholes were successfully test pumped over a 6-hour period. Discharge rates ranged from 10.5 to 200.0 lpm with a maximum drawdown of 11.88 m.
- A satisfactory mean recovery of 96.8% was obtained for the tested boreholes.
- Static water levels ranged from 4.69 to 25.38 m with a mean value of 10.04 m.

Discussion and conclusion

- The migration of fertilizers and agrochemicals through the unsaturated zone to the groundwater is a complicated process depending on various factors. These factors can be classified under the following:
 - Subsurface factors: the application method, uptake by wind, photochemical reaction, and uptake by plants and soil
 - Unsaturated zone factors: persistence of agrochemicals, travel time, soil characteristics, and microbiological activity
 - Saturated zone factors: physico-chemical characteristics and soil characteristics.
- However the vulnerability of groundwater to pollution depends on:
 - the depth to groundwater (thickness of unsaturated zone)
 - presence and thickness of clay cap
 - recovery rate
 - degree of weathering of aquifer material.
- Groundwater is said to have high vulnerability if the groundwater properties are strongly affirmative with the factors listed above.
- In perspective therefore, the geophysical surveys, drilling and the test pumping results for the Kassena-Nankana District shows that on the whole, groundwater depths are very shallow. It is observed that water bearing zones are generally encountered at somewhat shallow depths, having a mean of 20.69 m. The geological formation here does not show the presence of an impervious clay cap or a lateritic hard pan. Also, the recovery rate of the aquifers in the district is observed to be very high, having an average recovery of 96.8%. Finally, groundwater wells were obtained in the completely weathered to the moderately weathered rock.
- It can thus be concluded that the Kassena-Nankana District can be regarded as a homogenous pollution unit, and based on the groundwater vulnerability factors, described as highly vulnerable to pollution.

Recommendation

- The groundwater resources of the Kassena-Nankana District have high vulnerability to pollution. Increasing use of agrochemicals and fertilizers for farming has the chance of increasing the pollution sources. It is therefore recommended that studies be carried out to study the transport rate, agents of transport and mode of transport of these chemicals from the soil to the unsaturated zone to interact with groundwater. A final consideration is that periodic water quality assessment be carried out on samples from the boreholes in the district to check for common ions from agrochemicals.

Discussion

Question (Benjamin Kofi Nyarko): At what depth should one dig to be considered as shallow groundwater?

Answer: Wells as deep as 200m has been dug so a well depth of 20.93 cannot be considered as deep well. Shallow wells can be anything from 5m to 30m.

Question (G. Kranjac): Was there any information about water quality of boreholes?

Answer: Yes information on water quality of hand dug wells exist.

Comment (M. Fosu): The way shallow ground water irrigation will affect ground water quality will be studied within the Shallow Ground Water Project of the CPWF

PAPER TWO

Recent Floods in Northern Ghana: Ecological Change and Effect on Livelihood and Development in Upper East Region

G. Kranjac-Berisavljevic

Agriculture and climate

- The relationship between climate change and agriculture (crops, livestock and forestry) is very complex.
- Agriculture contributes to climate change in several major ways:
 - Land conversion and plowing releases large amounts of stored carbon as CO₂ from vegetation and soils. About 50% of the world's surface land area has been converted to land for grazing and crop cultivation resulting in a loss of more than half of the world's forests.
 - Carbon dioxide (CO₂) and particulate matter are emitted from fossil fuels used to power farm machinery, irrigation pumps etc.
 - Nitrogen fertilizer applications and manure applications as well as decomposition of agricultural wastes results in emissions of nitrous oxide (N₂O)
 - Methane (CH₄) is released through livestock digestive processes and rice production
 - Altered radiative fluxes and evaporation from newly bare soils.
- The highest emissions of greenhouse gases from agriculture are generally associated with the most intensive farming systems.
- Sub-Saharan Africa, on rain-fed agriculture, contributes the least in terms of GHG emissions and yet it is among the most vulnerable region to the impacts of climate change due to multiple stresses, including the heavy reliance on rainfed agriculture, poverty, weak institutional structures and low adaptive capacity

Relationships between agriculture and climate

- Threat of climate change encompasses the potential for irreversible damage to the natural resource base on which agriculture depends.
- In addition, climate changes are taking place simultaneously with increasing demands for food, feed, fiber and fuel by growing population.
- Another significant challenge is the rapidity of the changes in the climate that have occurred or will occur, as was the case with 2007 flood event in Northern Ghana.

Water scarcity and floods –some expectations

- Extreme climate events are expected to increase in frequency and severity and all regions will likely be affected by the increase in floods, droughts, heat waves, tropical

cyclones and other extreme events with significant consequences for food and forestry production and food insecurity.

- There is likely to be an increase in incidence and severity of forest fires in next decades, partly as a result of climate change.

Human factors affecting water scarcity

- Large part of current system's inability to meet water demands stems from conflicting requirements or concerns over land and water use.
- Common problems among these are:
 - growing urbanization, resulting in the development of additional water supplies,
 - the need to meet increased water requirements for dry season irrigation, and
 - conflicts over private property and public rights regarding water allocations.
 - other issues can involve trans-basin water sharing, and demands by various groups, such as pastoralists, farmers, etc

Floods: human influence

- Damage due to flooding events is also becoming increasingly common and this comes as a direct result of development of floodplains for agriculture: an environment that is vulnerable to floods.
- The increased economic value of the development on floodplains is evaluated against increased expenditure on flood damage reduction measures.
- When a flood exceeding the capacity of existing flood protection works occurs, damaging results emerge.
- This cycle of increasing flood damage and cost of protection is a result of the increasing floodplain development.

Main environmental problems of Upper East Region of Ghana

- With poor soils, erratic rainfall and one of the highest population densities in the country, the Upper East Region is the country's most impoverished area.
- One solution, to achieve greater food security and allow farmers to earn a living from their land during the dry season was to use low-lying lands as reservoirs by building dykes and dams- a solution which is considerably reduced by expected increase in frequency of catastrophic events.
- Climatic changes have partly contributed to the loss of crop species that are less resistant to drought.
- Frequent droughts and high food insecurity forced many residents, especially male, to migrate south seeking work as seasonal labourers.
- From 1980 to 1994, the region experienced prolonged drought with 30% drop in rainfall
- Assessment of the region's vulnerability to climate change on the basis of temperature rise and decrease in precipitation indicates potential severe effects on the household economy due to
 - lack of water resources and
 - Inability of considerable number of crops, large percentage of region's tree population and even livestock to survive under such harsh weather conditions.

The loss of biodiversity and biological productivity

- The persistent bush fire and over-exploitation of the rich and extensive savannah vegetation found in the northern Ghana, especially the UER has been highly degraded with the resultant loss of vegetation cover, fertile top soil and wild faunal species.
- The present depleted nature of vegetation comes as a result of prolonged grazing, burning, intensive cropping and climatic changes.
- Animal wildlife populations are severely depleted due to hunting. Animal habitats in unprotected forests and savannas continue to be threatened by hunting, agricultural expansion, fires, mining, and road construction.
- Intensive cropping and large numbers of cattle, sheep and goats have affected the biodiversity and has degraded the life supporting system.
- Land clearing through the use of bushfires has resulted in low agricultural output, which in turn put more pressure on the land to be used for agriculture
- Bush burning is the common practice for the people of the region and this greatly influences the land degradation process. The purpose of the bush burning is to hunt for bush meat and as a tool for land preparation, but fires are rampant and often burn out of control

Other anthropogenic factors influencing environmental degradation in the UER

- The population density in the UER is relatively high and this fact, together with traditional inheritance system which gives every child share of the parents' land, has led to the land fragmentation and the associated excessive cultivation
- In recent times, there has been an unprecedented upsurge of small-scale gold mining in the Upper East Region, especially in the Bawku West and Bolgatanga Districts. Periodically, even the forest reserves in these districts (Tankwidi and Tili) are encroached upon by illegal gold miners and trees cleared in the process of gold exploration.
- The population density of cattle in the region is the highest in the entire country, reaching the figure of 103/km² and 77 /km² in Navrongo and Bawku districts, respectively.
- This situation has a very negative influence on the land, as livestock grazing reduces already sparse vegetative cover, especially in the dry season.
- Furthermore, the cattle weight destroys soil structure, while the constant movement has impact on the management of the range lands.

Climate observations in the UER

- Harsh climatic conditions have a negative impact on the soil's physical, biological and chemical properties, which results in the lowering of its supporting powers for land use.
- There is evidence of climatic trends and changes in the UER, where most (80%) are farmers and depend mainly on rain fed agriculture.
- The Navrongo area in the Kasena Nankana District shows an increase in the average daily temperature over the last thirty years, as compared to data recorded from 1931 – 1960.
- Results collected in 1999 show a decline in annual rainfall for the same synoptic station.
- The increasing temperature records indicate higher evapotranspiration for agricultural crops, while declining and unreliable rainfall means unreliable water supply for the activities of subsistence farmers.

Options for action: Expected changes

- Climate change is expected to threaten livestock holders in numerous ways: animals are very sensitive to heat stress; they require a reliable resource of water and pasture; is very sensitive to drought. In addition, infectious and vector-borne animal diseases will continue to become increasingly frequent.
- Pests and diseases are strongly influenced by seasonal weather patterns and changes in climate. Established pests will become more prevalent due to favourable conditions that include higher temperatures and more rainfall/floods. Changing weather patterns also increase crop vulnerability to pests, weeds and invasive plants, thus decreasing yields and increasing pesticide applications. Increased temperatures are likely to facilitate range expansion of highly damaging weeds.
- Climate models also indicate substantial increases in soil erosion. Tropical soils with low organic matter are expected to experience the greatest impact of erosion on crop productivity.
- Desertification will be exacerbated by reductions in average annual rainfall and increased evapotranspiration especially in soils that have low levels of biological activity, organic matter and aggregate stability.
- In addition, continued migration to urban areas of younger segments of the population can lead to agricultural land degradation thus exacerbating the effects of climate change, as those left on the land are mostly old and the vulnerable.
- The extent to which agricultural production will be affected by climate change depends on how well communities are able to cope with current climate change and variability, as well as to other stresses such as land degradation, poverty, lack of economic diversification, institutional stability and conflict.

Responses

Many adaptation options are largely extensions or intensifications of existing risk-management or production-enhancement activities. These include:

- changing varieties/species to fit more appropriately to the changing thermal and/or hydrological conditions;
- changing timing of irrigation and adjusting nutrient management;
- applying water-conserving technologies and promoting agro-biodiversity for increased resilience of the agricultural systems;
- altering timing or location of cropping activities and the diversification of agriculture

Conclusions

Appropriate management of the vulnerable environment of UER should recognize the limitations of current knowledge and experience gathered so far.

- This realisation helps us to move toward meeting our changing goals over time in the face of this incomplete knowledge and uncertainty.
- There is a continual need to review and revise management approaches because of the changing, as well as uncertain, nature of our socio-economic and natural environments.
- Changing the social and institutional components of water resources management is often the most challenging task, because it involves changing the way individuals think and act. Any process involving change will require that we change our institutional structure as well as the rules under which we function accordingly.
- Sustainability requires that public and private institutions also change over time in ways that are responsive to the needs of individuals and society in order to cope with

the unknown and as yet incompletely understood climatic and environmental situations.

Discussion

Question (Vitus Ayingayure): I want to find out how the construction of dams will result in more floods

Answer: I did not say that building dams will cause flooding. I said the high variability of rainfall will mean higher dam walls and wider spill ways leading to higher cost. Also I said that dam building will alter the natural regimes of the rivers.

Contribution (Winston Andah): That the gentleman was saying that if there was plan to build a dam in Accra to regulate flood, why do you say if dams are built in UER will cause flood?

Answer: Floods in Accra is due to water from the Akuapim Range. The engineers are proposing to build interceptor drains to divert the water from Accra.

Question (A. A. Juati): With increasing use of fuel oil in expanding economies threats of the effects of climate change and Global warming. Due to this some people think of diversifying away from fossil fuel use into the production of Biofuels. What is your comment on this?

Answer: It is very controversial. There are two schools of taught. One think biofuel is fuel for the future. The opinion of the other schools is alternative fuel source like nuclear, solar, etc. Investors in biofuel are acquiring land to cultivate Jetropher. I don't think it is the best thing to do because these land are fertile ones. Biofuel is definitely not for UER where there is fight for food security.

PAPER THREE

Hydrology of Small Reservoirs in Semi-Arid Northern Ghana

Jens Liebe

What we need to know for strategic Water Resources Management?

- Small Reservoirs Inventory
- Storage volumes
- What are the filling processes
- How is the storage efficiency
- How is the use efficiency
- What is the downstream impact
- Satellite images useful for reservoir inventories. Regional Area-Volume Relations exist. Hydrological models can be calibrated by monitoring Small Reservoirs (SR) with Satellite Images. Impact of SR can be approximated
- Monitoring small reservoirs' extents and volumes with ENVISAT ASAR
- $V = 0.00857 \times A^{1.4367} \text{ [m}^3\text{]}$

Field surveys

- Very time consuming,

- Expensive
- Repeated region wide surveys hardly possible

Optical remote sensing

- Excellent land-water separation
- Does not work under cloudy conditions

Radar remote sensing:

- Cloud penetrating
- Frequent image acquisition
- Difficult processing

Concluding Remarks

- Satellite images useful for reservoir inventories
- Regional Area-Volume Relations exist
- Hydrological models can be calibrated by monitoring SR with Satellite Images
- Impact of SR can be approximated

Discussion

Question (Asaah S. Mohammed): How does the Upper East Region increase small reservoir for irrigation at the same time maintain sufficient flow into the Akosombo for hydro electricity?

Answer: (Roy Ayariga): There should be no worry that increasing the number of small reservoirs will deny the White Volta of water. This is because the rivers and streams that feed the White Volta are silted up and small reservoirs help prevent flooding.

Question: (Ulrike Falk): Small reservoirs are located in areas where you have most fertile soils. What are numbers here for the ratio of surface area of water body to area of irrigated land, especially with regard to actual water surface area to water content of small reservoirs.

Answer: The study is still on-going to measure these parameters.

Contribution (Gordana Kranjac): Ratio of reservoir size to irrigable area varies considerably. It varies between 3 ha to 15 ha per hectare of reservoir size, and may average between 6 ha and 7 ha. Also water use efficiency is quite high the smaller the reservoir.

PAPER FOUR

Assessment of Sediment Inputs to Small Reservoirs in the Upper East Region of Ghana through Bathymetric Survey

B. Amegashie, A. Adwubi and W. A. Agyare

Background

- Upper East region: North-easternmost part of Ghana's ten regions with a gross area of 8842km² and a population of 920,089.
- 80% of population live in rural areas with rainfed agriculture being the major economic activity
- Dry season: most of the streams reduce to a series of ponds or dry up completely
- The region experiences low and erratic rainfall with an average annual rainfall of about 1100mm. This brings about the problem of water scarcity in the region for agriculture and other useful activities.
- Over 200 dams and dugouts have been constructed by the Government of Ghana and other agencies.
- Many of the reservoirs dry up in the dry season and this is attributed to siltation.

Objectives

- Quantify annual rate of siltation using bathymetric survey
- Assess the relation between sediment yield and catchment area

Methodology

Criteria for site selection 18 dams out of 200

- Omitted dugouts
- Rehabilitated dams not later than 1990-1998 with design maps
- Size of reservoirs (small, medium, big)

Reconnaissance survey

- Visited 18 sites
- Selected 4 reservoir sites
- Different sizes
- Omitted desilted reservoirs
- Spread across the region

Field survey

- Benchmark identification
- Level taking
- Reservoir peripheral mapping
- Bathymetric survey
- Soil sampling

Results and discussions

- Comparing original and current capacity curves
- Sediment deposition and sediment yield
- Current and projected storage capacity lost

Factors influencing sediment yield estimation

- Dislocation of benchmarks and error in leveling
- Changes in original design during construction
- Dry bulk density
- Trap efficiency
- Excavation of reservoir bed material for construction and other purposes
- Method of interpolation

Conclusions

- The rate of siltation for reservoirs are 1272, 3518, 2764 and 6135 t y⁻¹ for Doba, Dua, Zebilla and Kumpalgogo reservoirs, respectively
- Drying up of reservoirs is due to combination of factors such as siltation and evapotranspiration, seepage and high dependency on reservoirs for which siltation is key
- Sediment yield has a negative relationship with catchment area
- A simple empirical model has been developed for predicting area specific yield from catchment.

Recommendations

- Catchment area protection measures
- Grow grass around reservoirs and areas in the catchment where there are traces of erosion
- Control grazing by delineating specific areas for grazing which will not contribute to soil loss to reservoirs
- Delineate a buffer zone around reservoirs to prevent farming activities very close to the reservoirs
- Resurvey reservoirs after construction
- Desilt reservoirs
- As siltation is only one of the factors leading to drying up of reservoirs, integrated assessment of all factors is required

Discussion

Question (Vitus Ayingayare): What factors other than catchment area influence sediment yield?

Answer: Other factors may include soil type, vegetation cover, land use, channel conditions etc.

Question (Sabastian Bagina): If a reservoir is constructed for irrigation purposes and its dead storage is taken up by silt can you say a reservoir still has a live?

Answer (W. Agyare): We considered both dead storage and life storage in the study. Dams could still be used when left with dead storage is taken up but it is recommended that the irrigated area should be reduced from the recommended capacity.

Contribution (Roy Ayariga): The presenter recommends desilting but desilting is expensive and contributes more to dead storage than life storage. So what has informed this recommendation is that engineers do not recommend desilting but raising dam wall.

Question (Osman Gyasi): Which dams did you consider in your sample? Those constructed between 1990 – 1998 or those rehabilitated between that period? Did you have background on the Dua dam. There were already heaped gravel that was not carried away that could have affected the result.

Answer: We selected dams constructed in the 1950s and 1960s. We could not get the design maps for the older dams. We did not see any uncollected materials in the Dua dam. We used the original map as the bench mark.

PAPER FIVE

Potential of Riverine Pump Irrigation for Dry Season Farming in Northern Ghana

Agyare W.A., Gyasi K.O, Aduna A. and Ayariga Roy

Introduction

- Dry season farming along the White Volta
- improve on household food security and to provide off-season employment
- Multiple-cropping system: cultivation of traditional crops during the rainy season; production of high value crops during the dry season; and maize during the transition period from dry to wet season
- Growing concern about water availability for alternative uses

Objectives

- To identify the actual and potential spatial spread of pump irrigation practices along the riverine areas
- To quantify the amount of water used for irrigation
- To evaluate the agro-economic features of this production system
- To determine its socio-economic impacts

Materials and methods

Field experimentation

- Trial involve 3 farmers: close (CF), mid-way (MF), and farther away (FF) from the stream)
- Treatments (T1:30-15-15 kg/ha NPK, T2:60-30-30 kg/ha NPK, T3:120-45-45 kg/ha NPK and T4: farmer application rate)
- Irrigation application dates and duration

Data

- Irrigation application dates and duration enable estimation of water application. The water applied per unit time was estimated per farmer by measuring the rate at which a calibrated empty drum is filled
- Socioeconomic survey
 - Individual interviews
 - Sample of 186 individuals across the basin using semi-structured questionnaire
- Focus group discussions
 - Pump irrigation groups in 5 communities

Key livelihood strategies

- Agricultural production is the only source of livelihood
- Yields from main growing season barely guarantee a household's livelihood

Coping strategies:

- Reliance on livestock and poultry
- Migration of young men and women
- Dry season farming using different forms of irrigation

Technical Performance of the pump irrigation system

- Daily water application (m³) on the three farms at Pwalugu
- Farm size, water use per ha and water delivery system
- Tomatoes yield, number of fruit, biomass at harvest and weight per fruit
- Selected economic performance parameters
- Production performance by gender and generation
- Socioeconomic impact

Conclusions

- Dry season farming is major livelihood strategy
- Rapid spread of pump irrigation along the volta river
- Informal sources of knowledge sharing is a key diffusion pathway
- Pumps with different discharge requiring different regimes: water use per unit land depends on the delivery system
- Productivity of factor employed in the irrigation are generally low: Low yields and high input use
- Significant socioeconomic impact as households are more able to purchase more food, educate children, seek health care for their members
- Key constraint to pump farmers is the high cost of pumping machine and pipes
- Issues of fuel and input cost as well as pest and diseases are equally bothering.

Discussion

Question (Wolfram Laube): How can poor farmers cover the heavy capital investment necessary to engage in irrigation of large areas?

Answer: Obviously water pump usage leads to high cost of fuel. Some farmers have started using manual pumps.

Question (A. Mutari): What did you consider as closeness in relation to the distance from the stream?

Answer: Distances of river to farm range from 50 m to 200 m. Beyond 40 m they use canals to deliver the water to the farms. Our emphasis was on the delivery system. The longer the distance the more wastage and more fuel needed to pump the water.

Question (John Amegashitsi): Are there any direct relationship or impact between the coping strategies (especially migration) and the irrigation farming.

Answer: A lot of studies have been conducted on this and the outcome is interesting. Migration of men allows women to get a place to farm and acquire their own pump. Also the migration season has changed. Some go early and come back to farm. Migration also helps them to acquire new knowledge on pump irrigation. However, there are negative social effects associated with migration.

Question (John Apatinga): May I suggest that riverine pump irrigation research be extended to areas outside the White Volta to places like the Atankwidi river basin? Could there be recommendations on water lifting techniques other than petrol pumps?

Answer: The project was on the entire White Volta basin. The high fuel cost has also led to the choice of high value crop. The problem with the manual pump is the health of the farmer.

PAPER SIX

Increase Irrigation Water Use Impact on Water Availability in the Upper East Region of Ghana

Aaron Aduna and Wilson A. Agyare

Introduction

The Upper East Region

- Population of over 1.0 Million.
- Population density of 96.5persons/km²
- Entire Region lies within the White Volta
- Climatologically within the semi-arid tropics
- Predominantly agrarian population
- Five months of uni-modal erratic rainfall 7 months of drought. Average annual rainfall, evaporation, temperature and relative humidity of 971mm, 2267mm, 28.6°C and 56% respectively.

Materials and Methods

- Water Demand, water availability and other data from previous studies used and projections made up to the year 2020.
- Consumptive and non-consumptive water demand taken into account
- Focus more on the consumptive water demand
- Non-consumptive water demand consists of
 - Fish and Wildlife
 - Navigation
 - Hydro-power
 - Recreation
 - Waste water assimilation
- Consumptive Water Demand consists of
 - Urban and rural domestic
 - Agricultural
 - Livestock
 - Industrial
 - Extreme Flow Regulation

- Water availability estimated from hydro-meteorological information and storage in reservoirs

Results and discussion

- Population(rural, urban)
- Domestic water demand (rural, urban)
- Livestock water demand (dry & wet seasons)
- Extreme Flow Regulation
- Industrial water demand
- Water demand and availability

Conclusion

- Total water demand by 2020 will be 8.4% of the total available water if climate change effect is neglected.
- Irrigation water demand will be 7.7% of the total available water
- With climate change leading to 15% flow reduction by 2020, total water demand will be 9.8%
- With climate change and 15% flow reduction, irrigation water demand will be 9.05 of the total available water
- Non-Consumptive water demand for fish and wildlife, recreation, hydropower and navigation are expected to be met.
- Waste water assimilation needs to be closely monitored as this leads to pollution

Discussion

Question (Bayor Jude Simons): In your discussion about water availability, you mentioned the estimates of water availability from surface water consideration. Why is ground water not considered?

Answer: We considered only surface water because it is difficult to quantify groundwater.

Question (M. Fosu): Your data shows that water availability exceeds water demand by at least 70%. This is contrary to estimates by FAO indicating that Ghana will experience water stress by 2025. How do you explain the discrepancy?

Answer: We are considering only the Upper East Region. So much water is coming into the region but everything flows away.

PAPER SEVEN

Rainwater Harvesting: A Sustaining Development Resource for Ghana

Frederick K. Amu-Mensah

Introduction

- Water is necessary to all organic life
- It is also a versatile solvent in industry and in the home
- Clean freshwater is becoming scarce due to demand and pollution

- All freshwater comes from rainwater
- It is free of many mineral salts; “soft water”
- Unlike other fresh water sources, it can be found everywhere
- It is a free resource and must not be wasted
- Rainwater harvesting is not new
- Can be used for household, industry and agricultural purposes

Advantages of rainwater harvesting

- Relief of the strain on conventional water supply systems especially expensive ones
- Ability to build or farm in areas with no other water supply
- Cleaner water than river water
- Increased independence and own water security
- Lower water supply cost
- Gentler on equipment and piping because no scaling occurs
- Reduced flood flows especially in urban areas prone to flood
- Reduced topsoil loss due to erosion
- Improved plant growth

Capturing Rainwater

- Before rainwater can be used, it must be captured (Rainwater Harvesting)
- Virtually all surface can be used
- Some capture more than others because
- Some materials absorb water
- Some materials adsorb water
- Net result: not all of the rainwater can be captured
- Thus some materials are more efficient

Some harvesting coefficients (efficiency)

| | |
|--------------------------|--------|
| Plastic & metal sheets - | 80-90% |
| Cement tiles - | 75% |
| Clay tiles - | < 50% |
| Thatch - | <30% |

- Inefficiency due to absorption, adsorption - rough surfaces and low slopes all of which trap some of the rainwater on or within the material.
- This is eventually lost through evaporation
- Apart from loss of water, health hazards are associated with inefficient harvesters
- Dirt and grime in the cracks and crevices become ideal environment for micro-organism proliferation

How much rain can be captured?

- Assume 80% harvesting efficiency, roof area of 100m² and average daily consumption of 20 litres per capita

Ghana’s Experience

- Rainwater harvesting is not new in Ghana
- Rural communities collect rainwater regularly
- The forts and castles depended on rainwater
- The residencies collected rainwater into underground cisterns
- Some mission institutions stored rainwater for use

- Recently, peri-urban communities not connected to pipe borne water harvest rainwater for use
- Generally rainwater harvesting is undertaken as a last resort; when there is serious need

Current Situation

- Ghana's forest cover has been greatly depleted
- This means retention time of rainwater on land is reduced
- Streams and river banks are encroached for housing and for agriculture
- Communities dispose of refuse in streams
- Demand for water is increasing
- Freshwater quality and quantity is reducing
- Treatment costs for potable water are rising because of pollution and transmission
- Stockpiling water in response to poor service

How can Rainwater help?

- Domestic water requirements
- A whole new technology evolving around domestic rainwater harvesting
- Improved filtration and disinfection systems for safer water
- Cheaper polytank storage means reduced capital costs
- Aside direct consumption, laundry, dishwashing, gardening, car wash, cleaning are options that will improve savings

Simple Household Treatment

- Strainer to remove leaves and twigs from roof
- First flush to reduce dirt, bird dropping from roof
- Flocculation and settling using pulverized moringa seed
- Slow sand filtration, sometimes containing activated charcoal to remove colour and odour
- Sophisticated treatment - filter canisters, ozonation and ultraviolet light

How can Rainwater help?

- Agriculture water requirements
- Ghana's agriculture is rainfall dependent – enhance this by improving efficiency of rainfall (conservation methods)
- Store water on-site from overland flow
- Make use of extensive paved road network to harvest rainwater and store in dugouts
- Provide reservoirs by streams/rivers to store floodwaters
- Provide weirs at upstream of bridges and culverts to impound stream flows for irrigation and fishing

Challenges

- Reduce cost of storage systems
- Make cheap yet efficient treatment systems – especially for industry
- Increase awareness on the suitability of rainwater for domestic use
- Incorporate rainwater harvesting in building code at least for public and municipal buildings
- Consciously design road networks/bridges to capture and lead rainwater into reservoirs for irrigation/fishing rather than let them go waste

Conclusions

- Rainwater is virtually free
- It contains very little mineral salts and is “soft”
- If harnessed will reduce strain on municipal water supply
- Cleaner than river water
- Can be used for domestic, industrial and agricultural water needs
- Requires some treatment as a result of coming into contact with catchment and conveyance systems
- Storage constitute the bulk of financial outlay
- System enables control of own water system
- System requires self maintenance and self operation
- Legislate system into the building code
- Make use of extensive road network for harvesting rainfall for agriculture and fishing
- Take care of the ecosystem so it can take care of us

Discussion

Contribution (Zenabu Wasai King): There is the need for us to have an integrated approach to issues on rain water harvesting. There is the need to link up with other sectors for sustainable development.

Contribution (Ben Ampomah): The legislation to harvest water is there in the building code. The problem is enforcement. I rely on rainwater for 9 months every year. You may contact me for details.

Question: What limits you from making use of rainwater for 12 months?

Answer: There is a way to calculate how much water is needed. One can build a huge tank, but will not get enough water in it and that is a waste of funds. You can design a small reservoir but may lose some water. To design the right reservoir you use the mean rainfall in your locality and the size of your roof.

Question: I have seen people harvesting water into drain. How is it done?

Answer: Trenches are constructed across water courses to compound water that is otherwise flowing away. This is practiced in Mali and Burkina Faso.

Question (Bayor Jude Simons): The speaker enumerated various advantages of water harvesting. I want to know how in his own circumstances how far has he adopted this technology?

Answer: I have started building. I have built a reservoir right under the foundation.

SESSION THREE PRESENTATIONS

PAPER ONE

Comparing Different Types of Irrigation in the Ghanaian White Volta Basin: Institutional, Socio-Economic and Agricultural Aspects

Wolfram Laube

Benefits for small-scale farmers

- Institutional set-up
- Risks and problems
- Yield and water productivity of tomato production
- Development trends

Types of irrigation schemes

- Medium-Scale Gravity Irrigation
- Small-Scale Gravity Irrigation
- Shallow Groundwater Irrigation
- Pump Irrigation
- Bucket Irrigation

Benefits of medium-scale irrigation

Reduction of rainfall dependency

Enhanced production security

Additional agricultural income

Crop diversification

Access to extension and credit

Employment

Benefits of small-scale irrigation

- Additional agricultural income
- Crop diversification
- Access to extension services
- Multiple uses of dams

Benefits of shallow groundwater irrigation

- Additional agricultural income
- Crop diversification
- Land availability
- Employment
- Decreasing migration
- Independent farming decisions

Results

- Comparing the benefits of the different irrigation schemes
- Comparing risks and problems

- Resource management in medium, small and shallow groundwater irrigation schemes
- Comparing institutional setup for medium, small and shallow groundwater irrigation schemes
- Tomatoes yield and water productivity

Different types of irrigation have different advantages and disadvantages:

Medium-scale irrigation projects:

- has a large poverty reducing impact
- enhances adaptation to a changing environment
- creates employment
- creates economic dynamic/boosts development
- enhances access to extension and credit

However:

- construction is costly
- institutional flaws that affect the efficient and equitable management of projects
- low production efficiency
- limited number of beneficiaries
- negative health impact

With a changing investment climate, new medium-scale projects should be constructed, if appropriate measures are taken to decrease exorbitant construction costs and to reduce institutional shortcomings.

Small-scale irrigation projects:

- have some poverty reducing impact
- somewhat enhances adaptation to a changing environment
- supports multiple uses
- high production efficiency

However: construction is costly

- construction is often poor
- some institutional flaws affect efficient management
- Limited number of beneficiaries
- Negative health impacts

Construction and rehabilitation of small dams is important and highly demanded for. Focus should be on areas where other water sources for irrigation are unavailable.

Shallow groundwater irrigation:

- large poverty reducing impact
- enhances adaptation to a changing environment
- farmer driven
- no external funding
- highest production efficiency
- availability of land

However: labour intensive

- absence of extension and credit
- sustainability unclear

Farmer-driven expansion of shallow groundwater irrigation is ongoing.

External support, extension services, credit facilities should be made available.

Levels of sustainable groundwater use need to be investigated.

Discussion

Comment (W. Andah): Medium scale should be medium reservoir and small-scale should be small reservoir.

Question (Sebastian Bagina) Comparison on your table on benefits of the various irrigation schemes, how do you explain your findings that medium scale systems afford high employments opportunities but low impact on migration whilst the opposite is the case for small scale irrigation.

Answer: I was concentrating on direct impact of beneficiary households. It is true that medium-scale systems indirectly affect migration rates as they provide wage labour opportunities for non-beneficiaries.

Question (G. Kranjac) What are the gender issues observed in these irrigation projects.

Answer: Gender issues were not the main focus of my study. However, female farmers were included in the survey. At several places many women have acquired lands. At some places you see many ladies and young women, probably helping their brothers or husbands.

Question (Vitus Ayinyayure): How can the number of beneficiaries in medium and small scale irrigation projects where about 0.5 ha plot is allocated to an average family size of 5 persons be smaller than the bucket system?

Answer: Looking at the level of support given by the government, the number of farmers benefiting from small and medium scale irrigation project is small compared to those doing bucket irrigation.

Question (Dominic S. Pokperlaan): Why should construction of dams strictly for irrigation be more costly in sub-Saharan Africa compared to elsewhere specifically India? Is it the nature of the soil, labour cost etc

Contribution (G. Kranjac): The perception that irrigation in Africa is expensive is due to other facilities not related directly to irrigation e.g recreational facilities for expatriate engineers who construct such schemes. I will recommend that policy makers should invest in only what farmers will directly benefit.

PAPER TWO

Tomato marketing in the Upper East Region of Ghana: Difficulties of collective action, problematic trade and agricultural policies

Martha Awo

Introduction

- The study is on Small Scale Tomato farmers (SSTF) who use wells for irrigation

- It looks at marketing problems, local/informal farmer groups and trade policies
- 1960s and 80s, establishment of irrigation projects
- Importance; poverty, environmental degradation and climatic change
- But there is a different story with the SSTF

The problem

Dry season tomato production among small scale farmers has been increasing over the years yet, marketing problems has equally been on the increase in recent times

Main objective

Is to find out if dry season tomato production has the potential for poverty alleviation

Structural Adjustment Programmes (SAPs)

- Marketing
 - Trade Liberalization (TL) as part of SAPs advanced by World Bank and IMF
 - Impact on agriculture e.g. marketing
 - Interest of donors on less comparative advantage crops
 - Flooding of markets with tomatoes paste
 - Low interest in investments
 - Introduction of market queens
- Informal groups/ institutions
 - Banks branches cut down and demand for collaterals
 - Emergence of other banks which encouraged group formation and eventually creation of informal groups
 - Hyden's definition as; Moralistic, network of support, communication Affection and interaction among actors
 - Interest because rural people e.g. farmers have collectively used such informal groups to achieve their goals e.g. 2007 marketing crisis

Methodology

Primary (quantitative & qualitative)

Quantitatively

- Interviews with structured questionnaires
- Communities importance; due to their geographical location
- 20 farmers were selected from various sections in each community

Qualitatively

- Interviews with semi structured questionnaires
- Formal institutions, tomato queens and traders, NGOs and importers

Secondary

From books, journals, reports and internet

Observation

Farmers farms, the Paga border, the factory and the markets

Findings

- A local market chain
- National: problems in marketing

- Queen mothers
 - Strong association
 - Dictate prices,
 - Heaping of crates
 - Buying on credits
 - Control trucks
 - Cause artificial scarcity
 - Problem of coherence
- Farmer groups
 - Lack of coordination
 - Labour
 - Individual investments.
 - 2007 tomato glut incidence
- The factory
 - 2007
 - Problem of electricity
 - inadequate crates
 - Problems of farmer linkage
 - Group leaders
 - 2008
 - New seeds and crates
 - Electricity connection to the national grid
 - Investors interest
 - Level of import
 - Banning of import
- Regional: Tomato Imports from Burkina Faso
- Impact of 2007 crisis on 2008
 - Effects on Traders
 - Difficulty in access to loans
 - Buying on credits
 - No produce

Tomato production in Ghana and Paste imports 2000-2003

For instance, data on the levels of production and consumption needs show that out of a total national consumption of 250 mt only 217 mt is domestically produced, and only 172 mt is available for domestic consumption, implying a deficit of 78 mt.

Conclusion

In the absence of importation of tomatoes, the question of whether the sector has a potential for poverty alleviation still remains unanswered due to the combination of internal factors that pose a serious challenge. Key among others are poor formal and informal institutions resulting in high transaction costs for farmers

Is banning imports and reviving the tomato factory enough to promote rural poverty reduction, considering the number of actors whose livelihoods depends on the sector?
 How can the small scale farmer be integrated into the broader economy?
 What is the way forward for the tomato Industry?

Discussion

Question (W. Andah): Can the factory, the farmer and the market queens meet to have a compromise?

Answer (Factory Manager): I am prepared to meet anybody but would like to know the objectives of the meeting. The existence of the factory is a threat to the market queens. The women want to buy from the farmers and sell to the factory, which will increase our cost. I never shy away from meeting anybody. The factory needs the produce to process to achieve poverty reduction and create employment in the zone.

Contribution: Due to last year disaster there is no need for factory to sit with all stakeholders. Factory should sit with only farmers. Farmers are prepared to produce tomato all year round only if factory will buy.

Question (Aaron Aduna) Has the idea of land acquisition and provision of inputs for farmers to produce tomato been abandoned?

Answer (Factory Manager): We haven't abandoned the idea of acquiring land. We are using existing farmers this year. As a result of lack of control over key ingredient, we are going to have control over those we supply seed. We are looking forward to acquiring our own land and using existing farmers to produce, but that will come at a cost.

Question (Bayor Jude Simons): (i) A situation was raised where you mentioned that one farmer was not getting market for his produce. What stopped the farmer from selling to the factory? (ii) Why the hue and cry about marketing of tomatoes in the region. There are other producing areas in Ghana and yet we never hear about marketing problems.

Answer (Factory Manager): Farmers are not having problems with marketing when the factory was operating. The traders capitalize on the closure.

Contribution: Farmers have problem with marketing. Some tomato traders go to Burkina Faso. Their reason is that quality is higher in Burkina Faso than Ghana. They claim that Ghana tomato is too watery. But quality has improved this year. The shortfall this year is due to reduced production.

Contribution (Roy Ayariga): Annually AEAs and farmers are sent to Burkina Faso on excursion. Actually no one can differentiate between tomato from Navrongo and Burkina Faso unless the traders tell. The traders go to Burkina Faso for various reasons, despite the fact that they are usually harassed, and even raped.

- *The traders maximize their profit by carrying avocado, banana, etc to Burkina.*
- *They smuggle a lot of fuel to Burkina Faso.*

Ghanaian farmers over apply water because water is cheaper here, but can do it as in Burkina Faso. There is need for arbitration between farmers and the factory. When the factory is operational the women buy at higher price to outwit the factory. When factory closes down the women beat down price. I have tested quality of tomato here. It has less water than that from Burkina Faso. Hence women have other interest in going to Burkina Faso.

Question: (Sabastian Bagina): Reports have indicated that tomato yields are low ranging from 4.2 tonnes/ha to 12 tonnes/ha. It is therefore clear that improving tomato production technology to increase yields will be a major area to tackle to enable the factory operates profitably and at the same time the farmer.

Answer (Factory Manager): In order to improve upon yield we have provided hybrid seed to farmers. We also have a resident Agronomist who provides farmers with agronomic practices. We could improve further if there is proper funding and support. Farmers who use our hybrid seed have seen improved yield and quality produce.

Question: (Jacob Afeliga): Farmers sell out healthy tomato to market queens but sell lean (unhealthy) ones to the factory. Farmers claim that the factory officials told them that the factory did not need 'fat' tomatoes My question is: From whom did farmers learn that the factory does not need 'fat' tomatoes?

Answer (Faculty Manager): It is true that the factory can process materials that the market queens had rejected as inferior. Maybe it is too soft to be transported down south. In other words our factory is more forgiven but for example 7kg good quality fresh tomato can yield 1 kg paste while the same quality of poor quality produce will yield only ½ kg paste. So good quality produce is required for processing. We are therefore urging farmers to deal more with the factory. We should disabuse the minds of farmers to give good quality produce to market queens. In fact in some cases we have refused tomato from some farmers due to poor quality.

Contribution (Zenabu Wasai King): A question was posed to one of the market women from Accra in 2007 why they prefer going to Burkina Faso to buy tomatoes. The answer was that tomato produced in the Upper East was of low quality due to the quality of seed used. There has however been an improvement in the quality of tomato produced in 2008. The farmers should therefore be encouraged to sustain production.

Contribution (A.R.Z. Salifu): MoFA Upper East Region is linking up with MoFA Northern Region to work out arrangement such that the raw material base can be increased to cover Northern Ghana. In connection with this about 30 District Directors including the Regional Directors and some regional staff visited the region on a study tour to share experiences on tomato production.

Question (G. Anornu): Does it mean any amount of tomato produced will be purchased by the factory?

Answer (Factory Manager): Factory is prepared to buy all year round if farmers do produce, what we do not want is to get support somewhere and push cost to farmers. Our current financial situation will not allow factory to provide more input beyond the hybrid seed and agronomic services.

Contribution (John Apatinga): There is the need for the factory and farmers to meet to discuss business, but not necessary for a sitting of farmers, market queens and factory management. The factory may be required to support farmers with inputs like the Ghana Cotton Company does with farmers in the Upper East Region can produce tomatoes every month of the year if only there is an accord with the factory.

PAPER THREE

The impact of riverine small-scale irrigation farming on peasant migration patterns in Northern Ghana

John Amegashitsi and Benjamin Schraven

Introduction

Presentation based on PhD research in the Upper East Region as well as Master research in the Migrants reception areas in Southern and Central Ghana

Major objective is to analyze how the diffusion of riverine small-scale irrigation farming has affected the traditional seasonal migration and to describe the current risks of this migration form

Historical development

- Seasonal migration patterns in Ghana began to develop in the 1920s by initially forced labour recruitments
- Until the 1950s/ 1960s the number of seasonal migrants constantly grew and many migrants started to settle permanently in the South
- Especially with the decline of the cocoa industry in the 1970s migration to urban areas became stronger
- The long history of (seasonal) migration created a socio-cultural appreciation of migration (“culture of migration”)

Differences

- 21% of the irrigation and 32% of the non-irrigation households (hh) still have seasonal migrants
- In the group of non-irrigation households, sons (or other hh- members except the head) go more often (28%) than in irrigation households (16%)
- Change of quantity and attitude in irrigation communities towards migration
- Remittances from seasonal migrants to non-irrigation households are higher than those to irrigation households
- The non-farm income of non-irrigation households is significantly higher than the one of irrigation households

Commonalities and general trends

- Rising number of female migrants
- Seasonal migration for the household heads can remain a flexible instrument for food provision, provision for farm inputs (especially for irrigation farmers) or other purposes
- Whereas household heads are interested in the provision of money and or food for their families, young unmarried household members are in general rather “issue workers”
- Traditional values associated with migration can hardly be found
- Non-monetary items as remittances still play an important role

- Autonomous migration decision making
- New temporal staying patterns appear
- Dominant branch is still farming
-

Risks

- Access to jobs
- Low social support and lack of governance/policies
- Labour exploitation
- Prone to disease and infestations (HIV/AIDS)
- Increasing expenditures and high prices for commodities and transport
- Crime
- Decreasing trust for the migrant labourers
- Work-related and road accidents
- Insecurity of return

Conclusion

- Seasonal migration in general has severely changed and has first of all become much more risky
- Although also very risky, irrigation has become the preferred livelihood choice for households that can access irrigation

Discussion

Question (Asaah B. Mohammed): Are local people in Techiman competing with migrants for farm labour jobs? If yes, to what extent has this increased the job serenity of migrants?

Answer (J. Amegashitsi): There are few jobs including farming that locals are competing with migrants. In other jobs, the locals do not compete, example chop bars, fufu pounding and others.

Question (Frederick Amu-Mensah): You indicated that remittances to non-farm households were higher than that to irrigation households. At the same time you indicate that income from non-farm households are higher. Is this because non-farm households take more advantage of their migrant members?

Answer: Household that engage in irrigation has fewer members migrating. The irrigation helps them to stay at home. Few migrate to help them purchase equipment and input.

Question (Fredrick Amu-Mensah): You indicate in your conclusion that irrigation is a preferred choice of employment. Isn't this more of the only option since water security exists?

Answer: No conclusion can be drawn whether if they had not migrated they would have gone into irrigation

Question (Damma Mumuni): Is the crime related to the migrant labourers or is general?. There is the need for clarification

Answer: The crime level increase at the time of peak migration, but the police could not say whether the crime was committed by migrants or locals.

Question (G. K. Anormu): What is the probability that the peasant migrants when at home will take up irrigation farming?

Answer: No conclusion could be drawn as to whether if they had not migrated they would have gone into irrigation.

PAPER FOUR

The Behaviour of Agricultural Households in the Ghanaian Volta Basin of Ghana

Felix A. Asante and Paul K. Nkegbe

Introduction

- The Ghanaian economy is basically agrarian and significant proportion of agricultural activities takes place in the Volta basin
- Ghana's population is also basically rural
- The rural economy is characterised by small scale operators

Problem

- Majority of the small scale operators are located in the Volta basin.
- Their operations are characterised by low level of technology and traditional techniques leading to low levels of income.
- Addressing this situation presents the need to identify and understand factors influencing their production and investment behaviour for effective policy planning and formulation.

Objective

The study examines the behaviour of agricultural households, regarding production and investment, in the Ghanaian Volta basin.

Relevance

- As much as insight into the behaviour of agricultural household will inform policy, no empirical study has been conducted in the Volta basin of Ghana to explain the behaviour of farm households.
- The study provides useful information required for agriculture development as it reveals what factors determine agricultural household investment decision making.

Methodology

Data Collection

Principally, the study makes use of a cross sectional data set.

The data was collected from 512 households located in 20 communities of the Ghanaian part of the Volta basin.

A structured questionnaire was used.

The communities were selected using principal component analysis and cluster analysis – two major data reducing techniques – with GLSS IV dataset as the base.

Kendall's Coefficient of Concordance

$$W = \frac{12 \left[\sum T^2 - (\sum T)^2 / n \right]}{nm^2(n^2 - 1)}$$

Concordance
each factor being ranked
 n is the number of factors being ranked
 m is the number of sets of rankings (i.e household units)

Empirical Model

This study employs the neoclassical agricultural household model to analyse the farm investment decisions of households in the Volta basin of Ghana.

Going through the optimisation process, the empirical model derived is specified using a double-log functional form as:

$$\begin{aligned} LFinvst_t = & \beta_0 + \beta_1 LFlab_{t-1} + \beta_2 LFcap_{t-1} + \beta_3 LRem_t \\ & + \beta_4 LCarea_{t-1} + \beta_5 LRwy_{t-1} + \beta_6 Floan_t + \beta_7 Hhage \\ & + \beta_8 Hhedu + \beta_9 Hhgend + \beta_{10} L + \beta_{11} D + \varepsilon_t \end{aligned}$$

Where:

- $LFinvst$ is log of farm investment
- $LFlab$ is log of farm labour used
- $LFcap$ is log of farm capital stock
- $LCarea$ is log of area cultivated
- $LRwy$ is rural wage income
- $Floan$ is access to farm credit
- $Hhage$ is age of household head
- $Hhedu$ is level of education of household head
- $Hhgend$ is gender of household head
- L is type of land ownership
- D is location dummy

The dependent variable, farm investment ($Finvst$) is the net change in household farm capital stock in the 2004/2005 agricultural year.

Results and discussion

- The coefficient estimate of the variable representing the amount of labour used on the farm in the previous major season (Flab) is positive and significant.
- Coefficient estimates on the variable for the size of land cultivated by the household in the previous major season (Carea) is positive and statistically significant.
- The capital stock held by the household in the previous major season turns out to have positive and statistically significant effect on household farm investment. Remittance is also positive.
- Ownership right to land, L, a proxy variable for household wealth, is not statistically significant.
- The variable representing household access to loan (Fmloan) is positive and statistically significant.

- Other household characteristics like age is not significant, but education and gender of household head are.
- The rural non-agricultural wage income coefficient is negative and significant.
- The location dummies, D, are not statistically significant except D₃ and D₄.

Conclusion

- The results show that labour, farm capital, remittance, access to farm credit, crop area, rural non-agricultural wage income, gender and level of education of household head are cardinal determinants of household farm investment.
- Land ownership rights and to some extent location characteristics are not significant.
- First, the fact that food needs of households is the primary consideration in production and investment decision making means agriculture is subsistent in nature. Policy should thus aim at improving the capacity of subsistent producers. Policies which favour the building of farm capital should be considered.
- It is necessary to consider providing credit to the agricultural sector at affordable and attractive interest rates.
- Extension should be strengthened to improve upon delivery for increased output since education is significant.
- The result on rural wage re-emphasises the need to urgently address the problems (eg. Low prices) confronting the agricultural sector.
- The nature of the variables for land rights brings to the fore the need to study in detail the relation between land rights and investments in low income.

Discussion

Question (Wolfarm Laube): The significance of farm credit for the increase of agricultural investment was very low. How do you explain that fact?

Answer: It is very true that farm credit is positive but low. The reason is that the farmers sampled did not have access to credit. That accounted for the low parameter.

Contribution (Frederick Amu-Mensah): Your subject touches on behaviour of agricultural households implying general behaviour. Your submission however refers to behaviour related to investment and production. I suggest your title reflect his aspect of behaviour.

Question: I understand behaviour is affected by perceptions and attitudes towards the issue at stake. I'm wandering if you considered these two factors in your data collection and analyses.

Answer: Behaviour was used instead of perception. This is explained in the paper. We did not look at perception and attitudes. We did ask of their views.

PAPER FIVE

Fisheries in small reservoirs: incidental benefit or important livelihood strategy?

Jennifer Hauck

Contradicting answers:

Contra

- People in the north don't eat fish, they prefer to take meat!
- People don't have fishing skill in the north. Those who fish in the north are Ewe who migrated from the Volta Region.
- Aquatic resources are under-exploited

Pro

- Although people raise a lot of different animals they are rarely eaten but used as "living cash bank"
- Ghana Statistical Survey: Rising demand for fish in the north
- Traditional fisheries management and enhancement methods
- Department of Fisheries in the region since the 1960s.

Methods:

- Participatory appraisal tools: wealth categories, community mappings, timelines, strategy rankings and social network maps;
- Monitoring of water quality and two fish stock assessments per reservoir;
- Surveys on the demand of fish, the livelihoods derived from fishing and selling fish.

The demand for fish

- Growing demand because of growing population, health education, high meat prices and a lack of alternatives.
- "Bush meat" as alternative protein source is almost exhausted.

The market for fish

- In the markets of Paga, Akayonga and Binduri fish mongers sell mainly smoke-dried fish.
- An increasing number of fish mongers also sell fried pieces of fish for immediate consumption.
- Number of women selling fish is steadily increasing as a reaction to a growing demand. However, most freshwater fish is not sold on local markets, but "exported" to urban areas.

Livelihoods from fisheries in small reservoirs

Income from fish mongering

- Average income of women selling freshwater fish from local sources:
 - Dry season: ~ 20 Ghana Cedis a month
 - Rainy season: ~ 6.5 Ghana Cedis a month

Income from fishing

- Fishing is the main income source in the

- Dry season: ~ 30 Ghana Cedis per month
- 250 fishermen in the four villages
- More than 15% of the male population in the villages are fishermen

Subsistence fishing

- Every second household is having a fishermen.
- Many of them catch fish for home consumption only.

Issues of reservoir management

Most of the fish resources in the reservoirs are poorly managed, because:

- Traditional leaders have lost integrity; traditional fisheries rules are abandoned.
- DoF failed to establish fishermen association during the 1970th and 1980th.
- Ministry of Fisheries has no capacity to take up the management tasks or train communities to take over.
- Conflicts between different water users and lack of clear responsibilities.
- Mistrust and conflict amongst fishermen.
- Lack of technical knowledge and skepticism against extension agents

Aquaculture

- First aquaculture attempts before independence.
- Massive promotion of aquaculture in the early 1980s.
- Most ponds built during the last 55 years collapsed.

Obstacles to aquaculture for small scale farmers / poverty reduction:

- high primary investment
- expensive maintenance
- time – consuming management
- high risk of loss of production for example due to poaching
- Marketing problems of table-size fish in rural areas

Conclusions

- Fishing provides at least in the dry season the main income source for a substantial number of fishermen and fish mongers.
- Demand is increasing with a growing population and health education.
- Supply of fish from local resources is decreasing.
- Potentials for fish production are under-utilized as a result of poor management.
- The support of aquaculture attempts of individuals should be reduced in favor to realize production potentials.
- Extension services should be modernized to include up-to-date enhancement techniques and to respond to the difficulties of group formation.

Discussion

Question (Wolfram Laube): You indicated that 250 men or 15% of the males of your study villages are fishermen. How do you define a fisherman?

Answer: The people farm during both dry and raining season. My definition for a fisherman is one who fish five days per week, but reduce to 2 to 3 days during farming season. In some cases they fish mainly for household consumption.

Question (Abukari Muntary): Are the fish types available, the preferred ones? And what species would you recommend for aquaculture?

Answer: I will prefer tilapia and catfish or mud fish because of high returns.

Question (G. K. Anormu): Have you identified the types of fishes coming from the small scale reservoirs that you can exactly evaluate the objectives of the topic?

Answer: I was talking of fish in the market. I am not saying that ketaboys come from the reservoir.

Question (Asaah S. Mohamemd): Is your research limited to only reservoir fishing only? Do you think of considering river fishing in the White Volta River?

Answer: I considered only reservoir fishing. I know there is a lot of fish in the Volta. But the people do not know how to fish in deep flowing river. There must be training on how to fish in the White Volta.

Contribution (John Anafo): Fishing in the Volta Basin is going on but there are various methods of fishing but bad methods. Like fishing across the river and using chemical fishing which is not allowed by the fishing laws. Some even used wrong netting mesh below one inch which is not allowed too. In UER the most suitable fish species that is good for aquaculture is the Tilapia species. The MoFA has few extension officers to monitor all fishing activities taking place in the region.

PAPER SIX

Stimulating transboundary cooperation through improved water governance: Lessons from the Volta Basin

Maxwell Boateng-Gyimah and Kwame Odame-Ababio

Key Characteristics of the Volta

- The Volta River Basin ~ 400,000 km² of the sub-humid to semi-arid West-African savannah zone
- The basin countries: Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali & Togo.
- 85% of the total basin area is shared between Burkina Faso and Ghana
- Its water is a key resource for the socio-economic development for both Burkina Faso and Ghana.

Though a key regional integrating factor, it is also a potential source of conflict

- Water resources of the Volta
- Water governance challenges in the Volta Basin
- It is the 9th largest basin in Sub-Sahara Africa – but at the inception of PAGEV, remained one of the few trans-boundary river basins in Africa with no formal institutional arrangements for managing its water resource;

There were no legal provisions for integrated multipurpose development and management of the shared water resources (treaties, code of conduct, etc);

The Volta Water Governance Project - PAGEV

(Projet d'Amélioration de la Gouvernance de l'Eau dans le bassin de la Volta)

PAGEV started as a 3-year project (mid-July 2004-Sept 2007)

PAGEV is part of the Water and Nature Initiative (WANI), a worldwide initiative of the IUCN that seeks to demonstrate how to mainstream the ecosystem approach into river basin planning and management

PAGEV focussed on strengthening the bilateral cooperation between Burkina Faso and Ghana on shared water resources and to implement joint activities towards improved water governance

Donor support:

Directorate General for International Development Cooperation of The Netherlands (DGIS) through WANI - US\$500,000 (~420,000 Euros)

SIDA of Sweden – 8.8 Million SEK (~930,000 Euros)

It also benefits from substantial in-kind contributions from the governments of Ghana and Burkina Faso as well as from the of the Global Water Partnership of West Africa (GWP-WA), IUCN-BRAO, WRC and DGRE

Thematic focus of PAGEV

- Decision-support knowledge base: Key decision-support information base compiled and shared to inform constructive dialogues and collaboration on water management between Burkina Faso and Ghana.
- Pilot IWRM interventions: Burkina Faso and Ghana jointly develop, implement and learn from pilot IWRM interventions in a selected trans-boundary sub-basin
- Policy and institutional change: Existing bi-lateral consultations mechanisms between Burkina Faso and Ghana on water management broadened and strengthened through the adoption and implementation of a code of conduct in the management of shared waters
- Learning and coordination: Project successfully managed and coordinated, structured learning supported and lessons learned made available

Strategic approach of PAGEV

- Linking land and water conservation and livelihood benefits: Nearly 55 nursery attendants trained and supported with seeds and other materials for the production of seedlings and management of the nurseries
- Linking livelihood benefits and water governance: Some of the farmers were supported with seedlings, water pumps and watering cans to enhance farming during the dry season, while at the same time taking care of the trees planted in the buffer strips. Some of the groups reported earning extra income in the region of 90 000 FCFA during the last dry season (January-May 2007). Wells provided for domestic consumption and dry season farming in communities
- Multi-stakeholder forums for IWRM at the community, national and transboundary levels established to promote cooperation

Policy and institutional reforms

- Bilateral Agreement between Burkina Faso and Ghana formalizing the JTC-IWRM signed by Burkina Faso and Ghana Ministers in charge of Water.
- A Code of Conduct on the development and management of the shared water and other natural resources of the basin was prepared by a working group put together by the revitalized JTC-IWRM in June 2006

- Protocol establishing the Volta Basin Authority signed in July 2006. (PAGEV, supported the organization of the 1st meeting of the VBTC held in Ouagadougou in March, 2005)

Reflections on what has been learned from project implementation

- IWRM actions in the White Volta sub-basin demonstrated that planning and implementation of community-based activities can be successfully shared between sectors as well as between communities across boundaries.
- Communities are willing to participate in water and other natural resources conservation interventions when the outcomes of participation are clearly and directly linked to the improvement of their livelihood.
- The trans-boundary meetings brought to the fore the difficulty of working in multilingual environment (French, English and the local languages such as Moré). However, governments and stakeholders' cooperation along with strong institutional supports have made these to be of little effect on the project. The capacity of the local government institutions (District Assemblies in Ghana and Departments in Burkina Faso) need to be strengthened to ensure long-term ownership.

Discussion

Question (Wolfram Laube): Is PAGEV or any other institution addressing the problem of floods after the spilling of the Bagre dam?

Answer: Information concerning the opening of the spillway of the dam was disseminated. But it had to pass through Accra to Bawku. We are trying to resolve that to get regional dissemination network.

Question: What mechanism have you put in place to resolve conflicts between water users?

Answer: We have an alternative livelihood mechanism in place. A lot of people have expressed interest. We bought water pumps for people who were prepared to move and have moved further from river banks for dry season farming. We also gave them credit.

Question (Jacob Apeliga): You planted trees along the Volta River. How did you prevent animals from grazing on the lands?

Answer: We had 3 belts, namely, mango trees and woodlot. However animals still destroyed the mangoes. The trees and mangoes seedlings were given to them for free. If they allowed animals to destroy them they had to purchase grafted mango seedlings to replace them.

Comment (John Apatinga): The farmers of the Kassena-Nankana area shall be grateful to seek co-operation with the Volta Basin authority to grow trees along the Anayere and Atankwidi river banks to stop further siltation.

Question (Asaah S. Mohammed): What local conflict management structures have you put in place to absorb conflict or potential conflicts among competing users along the river basin in the Bawku area?

Answer: In our training we include conflict resolution, we used agents of change to help resolve issues.

PLENARY DISCUSSION ON IRRIGATION IN THE UER

Chairman: Roy Ayariga

Vitus Ayingazure: Most of the presentations have centered on furrow and drip systems. I want to know if any work has been carried out on the sprinkler system.

Gordana Kranjac: There are 2 – 3 places in Ghana where sprinkler irrigation is practiced. I think that few tree crops could be irrigated by sprinkler. The problem is that temperature in the Upper East Region is quite high and evaporation will be high with sprinkler. The second problem is that most of the sprinklers used in Ghana are out-of-date. What are being used now are motorized boom sprinklers, which saves labour.

Roy Ayariga: Any system that will cause unemployment should be discouraged.

Enoch. Boateng: The lands we have in northern Ghana are flat. Therefore wind effect on sprinkler irrigation will be quite high. Strong winds cause non-uniform water distribution, which will adversely affect crop yield. Hence I will not recommend sprinklers.

A.R.Z. Salifu: Sprinkler Irrigation is not common in the UER. It is regarded as a lower option of irrigation. It is however necessary to have some study into smaller forms of sprinkler irrigation to confirm this lower rating.

Samuel Manu Ansah: I will suggest that we involve all interested groups in the discussion of irrigation, especially the youth. We can go into tree planting, especially mango, because the market is good both local and international. We should get the youth involved. If they see the profitability others will follow suit.

John Apatinga: We should see irrigation as rainfall supplementation. Rains improve upon vegetation cover as seen in southern Burkina Faso because of their cloud seeding.

Trees enhance rainfall therefore tree growing must be encourage. Therefore as a nation we have to become more serious with promoting the greening of the environment. The support of policy makers should be sought to help in this venture.

Roy Ayariga: We should always look down, but not up. For instance the government imported 200,000 grafted mango seedlings and distributed to farmers. All the seedlings died as a result of lack of maintenance. So the issue is not awareness from policy makers but attitude of our people.

Sensitisation of the people is required. A lot of farmers allowed their mangoes to be destroyed. But those sensitized took good care of them and are now enjoying the benefits.

Zenabu Wasai King:: I think that if tree planting is incorporated into building code people will adhere to it. Also schools and institutions should be made to plant trees around their buildings. Land tenure system prevent people from planting trees.

Sabastian Bagina: Since trials have shown that the drip system is good in terms of water use efficiency and ease of irrigation. Is there a plan to support our hand dug well vegetable farmers to adopt this system so that they can expand their activities and maximize returns.
Wolfram. Laube: Studies have indicated that the average farm size of our vegetable farmers is 500 m². Since one unit of drip covers 500m², I think it will help these farmers a lot if they acquire the drip system.

Gordana Kranjac: In Italy most of the area where tomato is produced, which is near the coast, is mostly under drip. We can do all tomato production in the UER with drip. One crate of tomato can purchase one unit of drip equipment. One disadvantage with drip is its requirement for clean water. Another is the further you move from the dam a pump will be required to increase the water head, and this increase cost of production. Also drip should be used only in the dry season so as to reduce salinity problems.

Alhassan. Muntari: I'm involved in the African Market Garden Project. Before the drip system, three farmers were cultivating 3 acres. When drip was introduced 20 farmers are using the same 3 acres of land. Hence drip irrigation makes efficient use of land and water for maximum productivity.

Roy Ayariga: We have to encourage farmers to invest instead of always looking up to government. When we introduced the pump everybody benefited. After some time the groups managed to buy more pumps and eventually split.

Aaron Aduna: Multi stakeholder consultation before the development of irrigation scheme. Most irrigation schemes employ surface water. Is it possible to employ groundwater options for irrigation?

Roy Ayariga: MoFA is working towards exploring groundwater for irrigation. Rigs have been purchased purposely for that. They are currently in Accra awaiting transportation to the north.

John Agapi: Where can one get some drip irrigation equipment to buy?

Wilson. Agyei Agyare: One can get drip equipment at Dizengof Ghana Limited.

Gordana. Kranjac: One can make the drip by himself. When you show a sample to any plumber he can duplicate it. It may not be very efficient, but it will serve the purpose.

Wilson Agyei. Agyare: MoFA must be encouraged to take up a training and demonstration workshop on drip irrigation considering the high interest in the system.

Roy Ayariga: The Ministry will take it up together with experts.

Thomas Atta-Darkwa: Can we impound the perennial floods which destroy crops and exacerbate their poverty? Can't we excavate the soil and construct artificial rivers to be used in the dry season?

Samuel Manu Ansah: Options for Irrigation must be solar pumping with drip. Looking at the many problems we have with our dams – high cost, constructional problems, environmental and health problems, it is proposed that solar pumping combined with drip options can be considered for small scale farmers along the rivers and in the valley bottoms.

Gordan. Kranjac: All the French speaking West African countries use solar pumping for both rivers and wells.

Frederick Amu-Mensah: Just as infrastructure development i.e. roads, electricity, water supply are tackled by government because of social development activities, so must irrigation infrastructure i.e., dams, flood detention, reservoirs, dugouts etc should be funded by government because communities on their own cannot fund them.

Roy Ayariga: Funds is the problem. Government funds for agriculture are not enough and keeps on dwindling year after year. It is also important to look at other donor agencies for help. In some cases District Assemblies have helped invest in agriculture. with their share of the common funds. But District Assemblies are under Local Government and their ministry would not be happy seeing that their funds are being used to sponsor agriculture.

A.R.Z. Salifu: Irrigation depends on the availability of water. There are two departments that need to co-ordinate their activities to get water available. GIDA is involved in obstructing waterways. Feeder roads activities allow water to move freely under bridges and culvert. Could these two units co-ordinate their activities such that the objectives will be achieved. Is it possible to do so?

Roy Ayariga: There is hardly any co-ordination in Ghana and this is causing all these problems. GIDA might not even be aware when a particular road is awarded for rehabilitation.

CLOSING REMARKS

The chairman thanked the organizers and all for good work done. He urged all to do well to include what has been discussed into their proposals so that the objectives would be achieved/what has been presented would be implemented.

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IRRIGATION OPTIONS IN THE CHANGING ENVIRONMENT OF THE WHITE VOLTA BASIN

1ST - 2ND APRIL, 2008, SSNIT CONFERENCE ROOM, BOLGATANGA

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