GLOWA-VOLTA PROJECT (GVP)

REPORT

ON

PARTNERS' CAPACITY NEEDS ASSESSMENT WORKSHOP

ORGANISED BY

UNITED NATIONS UNIVERSITY (UNU)-INSTITUTE FOR NATURAL RESOURCES IN AFRICA (INRA) & CENTRE FOR DEVELOPMENT RESEARCH (ZEF), UNI-BONN

AT

THE NOGOUCHI CENTRE FOR MEDICAL RESEARCH, LEGON

FROM

31st MAY – 1st JUNE 2007

GROUP PHOTOGRAPH OF PARTICIPANTS

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**
CSIR	**- Counsel 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**
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**
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**
KACE	**- Ghana-India 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**
SRI	**- Soil Research Institute**
SWAT	**- Soil and Water Assessment Tools**
TREND	**- Training, Research and Network for Development**
UDS	**- University of 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	**- Unites 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**
WEAP	**- Water Evaluation and Planning System**
WRC	**- Water Resources Commission**
WRI	**- Water Research Institute**
ZEF	**- Center for Development Research**

TABLE OF CONTENTS

1.0 INTRODUCTION

The GVP intends to transfer a comprehensive array of scientific outputs and tools in the form of information, data, models and various Decision Support Systems for the Volta Basin which have been generated throughout its 3 phases of implementation.

To ensure that these products are used for the greater and sustained benefit of the entire Volta Basin (the 6 riparian countries that make up the basin), GVP has identified the relevant stakeholders in the Ghana region who play or are expected to play vital roles in the water resources management decision making process in the basin.

Most of these relevant collaborators are government agencies, quasi-government agencies and civil society organizations which have policy and decision making, data and information gathering, research and advocacy roles in water resource management.

Among the government and quasi-government institutions are GMA, WRC, HSD, CSIR-WRI, CWSA, VRA, EPA, GWCL, KNUST- Department of Civil Engineering, CONIWAS, VBDF, TREND, CEIA, and Universities.

To determine the extent of collaboration with these stakeholders and their capacity needs and readiness for handling the GVP products to be transferred, the UNU-INRA and GVP organized a 2-day Stakeholders Capacity Needs Assessment Workshop at Noguchi Center, Legon. The following is a presentation of the report of proceedings of the 2 day workshop.

1.1 Workshop Brochure/Handbook

A brochure/handbook on the workshop was made available to all participants upon registration. This brochure summarized information on the GVP. This included in summary:

- GVP overview and history
- Organization and objectives of GVP Phase III
- Research and Implementation Partners
- Project organization and linkages
- Research Clusters of the GVP Phase III
- External collaborators, and
- Post-GVP technology transfer and opportunities for continuing ongoing collaboration
- Summarized abstracts of completed PhD theses under GVP

The full content of the workshop brochure has been attached as appendix to the workshop report.

1.2 General Objectives and Expectations of the Workshop

The workshop was intended to achieve the following objectives:

- To present **GVP** outputs, scientific tools and models to stakeholders of the water sector within the Volta Basin
- To identify Ghanaian institutions and actors and their interests and capacity for knowledge sharing
- To assess the capacity building needs of stakeholders to effectively utilize the **GVP** products in the water resources research and management in the basin

The expected outputs were:

- **GVP** output and other products introduced to the stakeholders
- Relevant Ghanaian institutions and actors for knowledge sharing and capacity building identified
- Training needs of the various stakeholder groups in the use of **GVP** tools and models for sustainable use of the water resources of the basin identified
- The necessary research support for the maintenance and further development of **GVP** tools and models for use in the basin ascertained

A. OPENING

A1. Official Opening

The workshop started at about 9.24 am with an introductory speech/welcome by Prof. Dr. Karl Harmsen, Director of UN University, Legon. Highlights of his speech are:

- that GVP is in its 3rd phase of implementation
- emphasis on Technology transfer to relevant organizations in the Volta Basin
- what needs to be done with the outcome of the GLOWA Volta Project
- briefly outlining the nature of presentations and objectives of the meeting
- that GVP is basically a knowledge-sharing project

He wished all participants a nice and memorable workshop.

A2. Chairman's Opening Remarks

Chairman for Day 1, Dr. Konadu Acheampong (UNU-INRA), entreated participants to cooperate to help achieve the day's objectives, and emphasized the need for presenters to stick to times allotted to them.

A3. Workshop Expectations and Overview

Dr. W. Laube restated the objective and expectations of the workshop which was summarized in the workshop brochure, and gave an overview of how the workshop would be conducted. He emphasized that it would be held in an open manner with more of participatory discussions than presentations. There was therefore the need for participants to make useful contributions. He followed his contribution with a presentation.

A4. Presentation 1 (by Dr. Wolfram Laube (GVP/ZEF))
Topic: **Setting the Stage for the GVP Workshop.**

Gave :

1) an overview of the GLOWA Volta Project and its integrated approach
2) an outline of the objectives of the workshop

1) GLOWA Volta Project:

- **Objectives:**
  - **Integrated analysis** of the physical and social determinants of the hydrological cycle in the Volta Basin (Climate, Land use, Hydrology, Economics, Institutions and Stakeholders analysis)
  - Scientifically sound **Decision Support** for the assessment, sustainable use and development of the water resources of the Volta Basin (Integration of Models and Data (Component-based Integration – COBIDS)
  - **Capacity Building** via advanced education and training, co-operative research, knowledge sharing and stakeholder participation
  - create a basis for capacity building program that meets the needs of these collaborators

- **GLOWA Volta Project Data Management**
  - A central hosted database giving access to the **GVP** data stock
  - A central hosted meta database giving
    - answers about data needed
    - references about data providers
  - A geo portal informing
    - about projects related to water management in the Volta-Basin, and
    - their data: in a spatial visualization

- **Levels of Scientific Analysis and Cooperation**
  - International/Basin-Wide:
    - Impact of Climate Change on Basin Hydrology
    - Surface-Atmosphere Interaction; Surface-Energy-Balance

  - Analysis of onset of the Rainy Season
  - Analysis of Transboundary Flows
  - Development of Data Management System
  - Cooperation with VBA

- Regional/Local (Ghana):
  - White Volta Basin Pilot Project
  - Land Use Change Modeling (LUDAS)
  - Analysis of Alternative Irrigation Practices
  - Cooperation with WRC, MoFA, Interaction with water users
- Focus of this Workshop
  National (Ghana):
  - Hydro-Economic Analysis of Agricultural Sector (MATA)
  - Hydro-Economic Analysis of the Energy Sector
  - River-Discharge Reconstruction
  - Cooperation with WRC, MSD, GMA, VRA, HSD, CSIR, Universities and various CSOs

- **Integrated Analysis: Model Use Cases (temporal scale versus spatial scale)**
  - Impact of changes in onset of rainy season on rain-fed farmers
  - Impact on volumetric charges on livelihoods of small scale farmers
  - Impact of Global climatic change on Volta basin hydrology
  - Management of trans-boundary flows on increasing demand
  - Economic/hydrologic impact of the construction of the Bui dam
  - Economic/hydrologic impact of continued expansion of riverine pump irrigation
  - Economic/hydrologic impact of continued expansion of small reservoirs
  - Impact of West African Gas Pipeline on water conflict
  - Optimal conjunctive use of surface and groundwater – small reservoirs
  - Impact of expansion of small credit on irrigated agriculture

- **Decision Making in the Water Sector**
  - Water Bureaucracy has been successfully established, i.e., VBA
  - Reform processes and IWRM are slowly taking root
    However:
  - Decisions are de-facto taken by different actors at different levels.
  - Non-state actors and stakeholders are effectively involved in the decision-making.

- **Decision and Knowledge Exchange**
  - Decision support and knowledge exchange needs **to** involve **water administrators, scientists,** as well as other **stakeholders and CSOs** involved in the decision making over water resources.
- **Objectives of Participatory Decision Support:**
  - Exchange of knowledge and data
  - Capacity building
  - Definition of likely scenarios

- Discussion of data and modeling outputs

2) Outline of the objectives of the workshop

- Short presentation of GVP approaches and outputs
- Assess the interests and needs of partners vis a vis the GVP
- Assess the capacities for knowledge exchange and model application
- Identify the capacity needs of GVP-partners
- Create the basis for capacity building program
- Contribute to the ongoing stakeholder dialogue in the water sector

also mentioned briefly are some of these relevant organization who have been invited: WRC, GMA, HSD, VRA, IDA, GWCL, CWSA, CoE, KNUST, WRI, SRI, SARI, TREND, VBDF, CEIA

A.5 Presentation 2 (by Dr. Dilnesaw Alamirew – GVP/UNU-INRA)
Topic: **Overview about GVP's Product's and Possible Capacity Building Activities**

I. Overview of GVP's Products

- Some selected PhD Theses topics
- Tools to Generate Data
- Existing Prediction and Simulation tools and Models used by GVP
  - Regional Climate Model
  - Distributed Hydrological model
  - Coupled optimization model
  - Community level land use prediction model

a. Some selected PhD Theses topics

- Regional Climate Change and Hydrologic modeling
- Data driven modeling and filling gaps in stream flow data
- Impact of savannah vegetation on the spatial and temporal variation of the actual evapo-transpiration (SAP flow analysis and SEBAL)
- Multi-scale analysis of landscape data sets (Wavelets and pattern metrics)
- Estimation of groundwater recharge in a semi-arid climate
- Surface energy balance
- Pedo-transfer functions for soil hydraulic properties estimation
- Geo-statistical application for modeling land use change.
- Up-scaling of land surface parameters
- Allocation Water Resources for Agricultural and Economic Development
- Household Water Security and Water Demand

b. Tools to Generate Data

- Surface climate monitoring stations
  - 8 permanent climate monitoring stations in Ghana, Burkina Faso (with BIOTA

W. Africa)
- Surface discharge stations
- Weirs
- Runoff plots
- Flux instrumentation (LAS, Eddy covariance)

c. Existing Prediction and Simulation tools and Models used by GVP

i) Hydrologic Prediction

- Surface hydrology
  - Data-driven modeling
    - Modeling river flow
    - Stochastically hydrological simulations
  - Distributed modeling (Hydrologic modeling)
    - WASiM-ETH (Water balance Simulation Model ETH), (Schula, 1997**)**
- public domain
- physically based hydrological model,
  - Soil and Water Assessment Tools (SWAT) (Arnold et al., 1998)
- Public domain
  - Groundwater hydrology
  - MODFLOW (Modular Three-Dimensional Finite-Difference Groundwater Flow Model) (USGS)
- public domain
  - HYDRUS-1

ii) Climate and Meteorology

- Heat and moisture flux
  - LAS and eddy co-variance (local measurements)
  - SEBAL(Surface Energy Balance Algorithm for Land) modeling (Bastiaanssen, et al,1998).(regional scale)
  - Makkink -Vegetative Fraction (basin scale)
  - SVAT (Soil-Vegetation-Atmosphere-Transfer) modeling
- MM5 (Mesoscale Meteorology Model 5) (Chen and Dudhia 1999)
  - Public domain
  - is a medium scale computer model for creating atmospheric simulations, weather forecasts
  - Operational short-term forecasting
  - Climate change scenarios modeling
  - Climate simulation
- Forecasting of Onset of the rainy season

iii. Prediction of Land use dynamics

- Cellular Automata
- LUDAS (Land-use Dynamics Simulator)

iv. Crop Growth Modeling

v. Economic Optimization

- GAMS (General Algebraic Modeling System)
  - Commercial
- MATA (Multi-Level Analysis Tool for the Agricultural Sector)
  - integrated agricultural sector modeling

vi. Modeling tool for integrated river basin planning and management

- MIKE BASIN (http://www.dhisoftware.com/mikebasin/)
  - Water allocation
  - Conjuctive water use
  - Reservoir operations
  - Water quality issues
  - Commercial
- WEAP ("Water Evaluation And Planning" system)
  Public domain

II. Possible Capacity Building Activities

- **Strategy**
  - the capacity building activities both in Anglophone and Francophone countries
  - it is proposed that in the first phase of the GVP capacity building activities to concentrate on transferring tools and models for researchers in the water sector
  - it is planned by GVP to have a workshop called Stakeholders Workshop in 2008 in Ouagadougou after this workshop the capacity building program will concentrate on transferring of scenario results from GVP DSS.
  - the capacity building activities will include stakeholders from water research area , data gatherings, water resources managers and civil societies

- **Proposed training topics**
  - Stakeholders Capacity Needs Assessment
  - Training in Hydrologic Modeling
  - Training on Spatial Data Generation, Management Technology, Allocation and Optimization tools
  - MM5 scenarios and modeling onset of the rainy season
  - Water use management scenarios relevant to VBA stakeholders
  - Stakeholders Exit Scenarios

B. QUESTIONS AND COMMENTS ARISING FROM THE 2 PRESENTATIONS

1. There may be doubts about the impact on the end-user as a result of disconnect between research and end-user.

Resp: Apart from knowledge exchange and decision support on the national and transboundary level the GVP also interacts with local stakeholders and decision makers. Eexamples are the GVP activities in the White Volta Basin

2. Has any survey been conducted at the end-user scale?

Resp: Throughout the implementation of the Project, GVP has continued to identify various end-user groups. Most of the participants are considered to be from organizations that will eventually use the products of GVP

3. Which crop growth models have been used in GVP?

*Resp: Under GVP there is one PhD student who used **APSIM** (**A**gricultural **P**roduction **S**ystems s**IM**ulator) for crop growth modeling.*

4. Need for convergence of science and end-user

Resp: GVP has tried to address this problem through its extensive consultation with its partners in the basin and also through many of the PhD research activities.

5. Need for end-user involvement in building research questions, that is collaborative, participatory and demand-driven approach to research

Resp: These concerns have been addressed through collaborations and consultations with partners in the basin since the project formulation and inception to implementation.

6. Need for GVP to build in M. Phil component in order to ensure the issue of sustainability of the project.

Resp:The project has trained and continues to train students at M.Phil level. Additionally, a number of employees of partner organization (e.g. HSD, GMA) have been supported in their M.Phil and M.Sc studies and GVP is also currently funding the research activities of 5 M Phil. Students at the Sociology Department of the University of Ghana, Legon.

7. How will the end product of GVP be used and perceived.

Resp: The various GVP products will be used by the partners in the basin, such as VBA, WRC, GMA, HSD, CSIR, VRA, research institutes and Universities. This workshop will assess the capacities of these organizations and the nature of capacity-building in order to support them in the use of these products.

8. There was the necessity to have training programs for lower level users

Resp: This issue is part of the objectives of workshop.

9. Need for forecasting at different temporal scales to meet the requirements of different users or activities in the basin.

   Resp: The climate model used in the project, MM5 can provide both short and long range forecast.

B1. General Observation of Presentations

Generally, most participants were of the view that the efforts of GVP, in providing models and a database for the management of the Volta Basin, have so far been quite commendable. It is up to the users and agencies in the 6 riparian countries of the basin to take full advantage of these products to enhance the sustainable water resources management of the Basin.

C. PLENARY & PARALLEL SESSIONS

C1. Introduction of Plenary

Dr. Wilson Agyare introduced the topics for the plenary session and parallel sessions. After the plenary participants were split up to discuses the topics in more detail in four parallel sessions.

Topics for both sessions were;

- **Climate and Meteorology**
  Moderated by Mr. Zinedeme Minia (Ag Director General, GMA) and Dr. Barnabas Amisigo (GVP/WRI/UNU-INRA)
- **Hydrology, Water Supply (later changed to Water Use)/Water availability**
  Moderated by Mr J. Wellens-Mensah (Director, HSD) and Dr. Boubacar Barry (GVP/IWMI)
- **Water Demand/Allocation and Trans-boundary Issues**
  Moderated by Mr. Ben Ampomah (Ag Executive Secretary, WRC) and Dr. Victor Afari-Sefa (GVP/ZEF)
- **Water Politics and Participation of Scientists and Civil Society in decision-making in the water sector**
  Moderated by Mr. Ben Ampomah (Ag Executive Secretary, WRC) and Dr. Wolfram Laube (GVP/ZEF)

Discussions were to address the topics under the following considerations:

- **What are the pressing issues** (what are the current concerns and priorities of your

organization in the water resources sector?)
- What types of strategies and approaches (models and tools, e.g. procedures) are available for dealing with or mitigating these stresses?
- What are the areas of application of these models?
- What are their capabilities, limitations and data requirement
- Some results obtained from application of these models or tools
- Cost of acquisition and use of these models and tools
- What is lacking inn their effective use (both human and material capacity)
- Who are the important/principal actors (agencies, organizations, groups)
- What has been the present approaches used by the different actors in solving the issues
- What are the existing structures for inclusion (for the fourth topic)

C2. SUMMARIZED OUTPUT OF PLENARY AND PARALLEL SESSIONS

Participants made critical, frank and fruitful analysis and discussions of the topics during the plenary session. In some instances, the topics were altered to give clearer meaning and appreciation to the issue at sake. For example, Water Supply was changed to Water Use, whilst Water Politics was altered to Water Governance. The parallel session that treated **Water Demand/Allocation and Trans-boundary issues** found it necessary to treat **Trans-boundary Issues** under **Water Politics and Participation of Scientists and Civil Society in decision-making in the water sector.** These alterations ere all made to make the discussion more focused so as to meet the demands and objectives of the workshop.

The following is a summary of decisions arising after the plenary and group discussions.

C2a. CLIMATE AND METEOROLOGY

Mr. Minia of GMA gave brief information on the activities of GMA.

In summary, GMA:

- Provides the public with data on the weather through forecasting
- Provides information on wind, rainfall, temperature, etc
- Provides specialized services to other sectors of the economy such as agriculture, hydro, pollution control, marine and air transport
- Provides information that supports national development

i. Main concerns of the GMA

- Lack of adequate human resources
- Lack of training opportunities for staff
- Lack of any comprehensive plan drawn for the training of staff
- Lack of modern communication and data collection equipment

ii. Pressing issues facing the Agency include:

- The urgent need for modern equipment and tools (e.g. numerical weather prediction models) to enhance accurate forecasting
- The necessary capacity and ability to provide precise seasonal weather forecasts, particularly on the onset of the rainy season.
- The need to increase and support data collections stations
- The need to improve the ability to accurately transmit data from stations to head office – provision of better communication equipment

a. Discussion of Presentation

Participants raised concerns about the difficulty in getting information from GMA stations. After detailed discussion of the GMA presentation, the following consensus was reached.

i. Main Concerns

- Poor networking of rain gauge stations/decline in the number of properly functioning stations
- Need for understanding that data sharing from other operators is important
- Issue of adaptation to climate change – what has so far been done
- Problem of data quality – rather inconsistent, unreliable and discontinuous/inadequate
- Difficulty in getting data from the Agency
- Difficulty in using data received from the Agency
- Quality of people who gather raw data/low level of training given to recorders
- Use of volunteers in recording data
- meager allowance given to volunteers leading to lack of motivation
- Lack of data monitoring and quality assurance
- Lack of collaboration with other agencies
- Use of the outmoded SSB radio in transmitting information from stations

ii. Present Approach

GMA

- uses simple statistical models to forecast the weather
- makes short and medium term forecasts,
- uses SSB Radio communication to transmit data and information
- makes short to medium term forecasts using:
    i. modeled products from

1. ECMWF
2. Meteo France
3. UK Met Service
4. ACMAD

ii. plotted surface charts using Observed Data for surface wind profiles, pressure fields and thermal fields

iii. plotted tephigrams (entropy versus temperature) from ascents made at radiosonce at Tamale and Cotonou

iii. Important Actors in Climate and Meteorology are:

- Research Institutes
- GMA
- CoE, KNUST
- CoA, KNUST
- Department of Soil Science, UoG
- CoES, UoG
- DoG, UoG
- VRA
- MoFA
- GIDA
- Ghana Committee on Climate Change
- NADMO
- EPA

iv. Needs and Recommended Interventions

There is the need

- to have or use dynamic models
- for GMA to organize fora with DAs for rain gauge network support
- include or use DAs to support data collection efforts
- for GMA to validate 3-day Weather forecast by GVP from Climate Institute in Garmisch (Germany)
- GVP to assist in training and capacity building in weather and climate modeling.
- KACE to provide Clusters and super-computing facilities for running climate models.

C2b. HYDROLOGY AND WATER USE/WATER AVAILABILITY

Mr J. Wellens-Mensah of HSD gave a brief description of its activities.

i. Current Approaches

- HSD - undertakes catchment using statistical models
  - venturing into the use of new technologies such as Divers, Satellite, Remote

sensing (remote-based data gathering and monitoring) etc.
- Uses GIS in scenario generation

- GWCL - development of urban water supply systems.
- CWSA - supervision and coordination of community water supply and sanitation activities in rural areas
- WRC - Development of Basin Management Structure
  - Integrated Water Resources management (IWRM)
- VRA - use of models to forecast inflows and simulate the hydro-power generation system.
- GIDA -crop water requirement estimate using water use per head ; however would we need appropriate models for the estimates.
- EPA -does water quality assessment.
- WRI -does water resources assessment using different hydrological modeling techniques
  -does erosion and sediment yield modeling
- SRI - does erosion and sediment yield modeling

ii. Major concerns include:

- Doubts over the quality of data (and perhaps adequacy), especially of ground water
- Data on water quality is scanty and disjointed
- data on abstractions not available
- difficulty in modeling and using/applying models and tools

iii. Pressing issues include:

- need for an institution to coordinate activities in water quality tests, analysis and data management.
- Collecting information on groundwater (borehole logs), maps for geophysical investigations for the future
- Need for an institution to coordinate activities in groundwater data collection and management on a sustained basis
- Need for methodology for filling missing both surface and groundwater data
- Need for determining environmental flows.
- Harnessing seasonal flows should also be critically examined.

iv. Important Actors

- HSD (for surface water data)
- WRC (for ground water data)
- CWSA (for borehole data generation in rural communities)
- GWCL for domestic/industrial water supply
- GIDA
- Geological Services Department

- VRA
- EPA (as regulators)
- Relevant Department/Colleges of Universities
- Research Institutes
- Forestry Commission
- Department of Wildlife
- NADMO
- MMDAs
- NGOs/CSOs – CONIWAS, TREND, CEIA, VBDF

iv. Needs and Expected Interventions

There is the need for

- standardization of water quality analysis methods
- quality assurance of data
- for standardization of drilling data
- standardization of water quality analysis
- the identification of an organization responsible for coordinating data on water availability and water quality
- identification of an organization responsible for collecting effluent samples from factories – presently it is the factories themselves that produce samples
- water use policy
- matching water availability against water accessibility and affordability
- ensuring that gaps in the original data/records (after making any artificial filling) are left blank to give indication that the figures are missing. Theoretically filled gaps should be flagged.
- crop water modeling
- GVP to assist in training and capacity building in
    - Data generation and management in hydrology
    - Surface and groundwater hydrologic modeling
    - Water quality modeling
    - Developing methods for data gaps infilling
    - Determination of Environmental flows
- KACE to provide Clusters and super-computing facilities for running hydrologic models.

C2c. WATER DEMAND/ALLOCATION AND TRANS-BOUNDARY ISSUES

C2c1. Trans-boundary:

i. Pressing issues

- Harmonization of flow measurement methodologies in trans-boundary issues
- Need for reliable good data and good data collection
- Harmonization of water policies of different riparian countries – regional water policy
- Water quality
- Harmonization of development plans on particular rivers
- The level of perceptions of different countries

C2c2. Water Demand:

ii. Pressing Issues

- Need for the estimation of environmental flows
- Disparities in the level of regional development
- Lack of an integrated water resources management plan
- Allocation between different sectors of the economy

iii. Forms of demand:

In the field of water demand, agricultural water use in the basin has to be distinguished from non-agricultural demand. Non-agricultural water demand consists of consumptive uses, such as industrial (in Ghana mainly: mining), domestic (rural and urban), and environmental flows. Furthermore, there are non-consumptive uses such as hydropower and water demand for transportation and recreation.

- Agricultural demand
- Non-agricultural:
  - Industrial (mining, etc.)
  - Domestic (rural/urban)
  - Environmental flows
  - Hydropower (non-consumptive)
  - Transportation and recreation (Non-consumptive)

C2d. Existing planning methodologies:

Different planning methodologies are already in place.

- For the agricultural demand, there is the WRC's Water Resources Information Box as well as its IWRM for the Densu-Basin project.
- The WRC also estimates the industrial demand, calculated on the basis of data provided by the companies by setting minimum consumption levels.
- GWCL also calculates the domestic demand, on the basis of the following average numbers: 60 liters per day/person in rural areas, 90 liters in urban areas; while 25 liters is the absolute minimum.
- In the discussion it was mentioned that these numbers are of limited validity, since many household uses go far beyond these average numbers, especially if flush toilets are available. Nevertheless, the actual supply of domestic water can be estimated satisfactorily as a function of GWCL's treatment capacities.

ii. Current Approaches

Water Demand:

- Use of WEAP software modeling approach (especially in Ghana)
- Use of the Mike Basin software modeling approach (especially in Burkina Faso)

C2e. Environmental flows:

- The estimation of the demand for environmental flows is a considerable problem, because there are no standard estimation approaches in use.
- Environmental flows basically constitute floodplains, riparian forests, wetlands, aquatic life, and mangrove forests.
- GVP is in the process of estimating environmental flows for the Volta basin, using proprietary software. GVP has contracted Ms. Luna Bharati and Mr. Smakhtin of the

IWMI Headquarters in Sri Lanka to estimate the environmental flow requirements in the Volta basin.

i. **Stakeholders for the field of environmental flows were identified**:

- EPA
- WRI
- DoFO, UoG.
- FRWB
- CEIA
- CAW
- TREND
- CoE, KNUST
- DoRNR, KNUST
- DoBS (of all Universities)

C2f. Water quality

In the field of water quality, there has been some work done.

- PURC is responsible for measuring the quality of urban household water and industrial water use.
- The CEIA calculates health risks of water contamination.
- The United States Environmental Protection Agency (USEPA) is also active in this field in Ghana. However, there is no comprehensive water quality assessment tool that is currently in use in the country as a whole.
- In the discussion it was suggested that a single agency, e.g. the WRI, be given the mandate for measuring water quality in Ghana.

The following stakeholders were identified for the field of water quality:

- WRI
- PURC
- CEIA
- USEPA
- KNUST: Environmental Quality Lab
- GWCL

C2g. Hydropower

i. Main Actors (Service Providers) identified:

- VRA
- ECG
- Energy Foundation
- PURC
- Ghana Energy Commission

ii. Important Actors

Interested Collaborators

- WRC
- VBA
- GLOWA Volta
- GWCL
- CWSA
- HSD
- GIDA
- VRA
- TREND
- VBDF
- Research Institutes
- Relevant Departments/Colleges of Universities
- Polluters

C2i. General Conclusion

- GVP estimates agricultural water demand using MATA.
- Optimization tools (GAMS, MIKE BASIN) are being used to estimate the demand and the optimal allocation of water for the various sectors.
- It is a hybrid which links the macroeconomic with the microeconomic behavior of farm households via the mesoscale . In this approach, the whole basin is categorized into representative farm types by means of identifiable homogenous typologies in the various sub-basins.
- The model has already been specified for Burkina Faso and modifications are on-going for application to Ghana part of the Volta basin.
- The idea is to optimize the net benefits of water allocation (use) for the various water use actors within the basin.

Furthermore,

- non-agricultural water demand is represented by an energy sector model known as West African Power Pool (WAPP) developed by Purdue/USAID and is being applied to the riparian countries of the basin.
- this model was originally developed to estimate low cost electricity production in the 16 countries of the ECOWAS region.
- the Volta basin countries all fall in zone A of the original model comprising zones A and B, so that they could be separate analytically for the model to be representative of the part of Volta River basin being investigated by GVP.

The following organizations already have expertise in GAMS (Generalized Algebraic Modeling System), which is the basis for the optimization the models used by GVP:

- WRC
- CoE, KNUST
- CoAS, KNUST

- MoFA is potentially interested in the results of the modeling activities.
- The most challenging task is the estimation of the overall demand for water at the basin scale. GVP is currently in the process of estimating the demand for water in the agricultural sector (via the MATA model) and non-agricultural sector (via the WAPP model). The goal is to integrate.

Publication:

- Ghana Water basin Vision 2025 (this is a book that has been published regarding projected policies for sustainable management of water resources in the basin.)

C3. WATER GOVERNANCE, PARTICIPATION OF SCIENTISTS AND CIVIL SOCIETY ORGANIZATIONS

i. Pressing issues

- Harvesting local knowledge
- Lack of policy briefing
- Applicability and usability of research finding by scientists
- Capacity building of NGOs on water governance
- Applicability and usability of scientific publications
- Funding extensions of research finding as part of scientific publication
- Funding of research
- Building of collaboration among different actors
- Conflict and conflict resolution between different water users
- The allocation of water resources
- Disparities between water users
- Poverty and equity of water use
- The inclusion of indigenous knowledge

Discussion focused on conflict resolution and negotiation processes, especially trans-boundary conflicts and, on a national level, conflicts around mining (the biggest user within the industrial sector) and dams.

C3a. Trans-boundary conflicts

Pressing issues in trans-boundary water management are:

- Allocation and water sharing: there are no quotas in place, and no modeling is carried out up to date.
- Knowledge sharing mechanisms concerning extreme events like floods are needed: e.g., water released in Burkina Faso has caused floods in the Upper East region of Ghana.
- Infrastructure development (e.g. dams) is also a potential source of conflict, not only between Ghana and Burkina Faso, but also Ghana/Togo and Ghana/Cote D'ivoire. Agreements are needed in this area.
- Trans-human movements: people moving across the border (Fulani) are also affecting water issues and should be addressed.

- Finally, the pollution of water by riparian countries needs to be addressed.

i. Data sharing already in place:

- HYCOS: involved countries that share data, basin based (Niger- HYCOS, Volta-HYCOS).
- Data-sharing versus Meteosat.
- Data can be accessed directly.
- Burkina informs Ghana (Information on large-scale development of hydraulic infrastructure is given to the MWRWH through the Foreign Affairs Department).
- WRC then informs the district assemblies.
- There is also information sharing between VRA and their Burkinabe counterparts (Sonabel).
- Mechanism for cooperation: "Joint Technical Committee on Integrated Water Resources" between Ghana and Burkina

ii. Actors in trans-boundary water management:

- WRC (main)
- DGRE (main)
- VRC (starting)
- PAGEV (initiating dialogue, mitigating conflict)
- MWRWH (very important)
- Ministry of Foreign Affairs of both Ghana and Burkina Faso
- HSD (can model extreme event)
- VBA
- GVP
- GWCL
- CWSA
- HSD
- IDA
- VRA
- University and Research Institutes: Hydrological Services, CoE-KNUST, SRI

iii. Actors interested in modeling:

- WRC
- DGRE
- VRA

iv Various interested parties/Information dissemination target groups:

- NGOs: CONIWAS, TREND, VBDF, CEIA
- Policy makers: MWRWH, WRC, GWCL,
- Regulators: EPA
- Users, water companies
- MoFA

- Major water users: mining companies, GIDA,

C3b Mining:

- The actors in the field of mining are mining companies/polluters, and the affected communities.
- There are conflicts between mining companies and communities concerning the extraction and the pollution of water.
- In the discussion it was mentioned that it might be a problem that there are many small-scale/informal mining companies, but since they are difficult to identify, their impact is very difficult to measure.

i. Actors:

- WRC: *extraction monitoring, which water users, require environmental reports and data on used quantity by mining companies*
- EPA: *carries out environmental impact assessments, based on the data provided by the developer, no modeling, active in conflict resolution*
- Mining companies: *extract water, pollute water resources, affect communities. Some carry out Environmental Management Plans.*
- Chamber of Mines
- affected communities
- WACAM
- Basin Boards
- CEIA(Carries out alternative environmental impact assessment and environmental monitoring according to US-EPA standards)
- ISODEC
- TREND (*carries out environmental and social impact assessment, and also Resettlement Action Plans of mining activities on livelihoods in affected communities*)

- Problem of institutional competition between different agencies in the country regarding water quality/pollution.
- No sound water quality assessment.

Interest in GVP tools:

WRC
EPA
CEIA

Interest in information:

All actors

C3c. Dams

i. Main Issues:

- Impact of dams on aquatic weed
- Impact of dams on downstream water availability
- Hydropower

ii. Actors:

- VRA
- WRC
- GWCL
- NAVRAT
- Ghana Dams Forum
- IDA
- VRA has inflow models.
- EPA -> EIA
- MMDAs should be involved
- TREND
- VBDF
- WRI

- **ACTORS interested in GVP models:**

  VRA, WRC, GWCL, TREND, VBDF, EPA, WRI

- **All actors are interested in information**

  Models involved:
  - WASIM/MM5
  - MIKE BASIN? (Good, interesting, but too expensive. if monetary and license issues could be resolved the interest in Mike Basin would be large)
  - GAMS, MATA

iii. Current Approaches

- Dialogue between actors
- Risks and rights approach by VBDF and the Ghana Dam Forum
- Social impact assessment (possibly IMWI with GVP)

TABULATED SUMMARY OF GROUP DISCUSSIONS (should include a section with proposed capacity building activities and the actors that should be involved.)

S/N	Topic/Issue	Current Approach	Main Concerns	Main Actors	Pressing Issues	Needs/Intervention
1.	**Climate & Meteorology**	GMA • use of simple statistical models to forecast the weather • use models for climate change • makes short and medium term forecasts, • uses SSB Radio communication to transmit information • modeled products from - ECMWF - Meteo France - UK Met Service - ACMAD • plots surface charts using Observed Data • uses plotted tephigram (entropy versus temperature) from ascents made at radiosonce at Tamale and Cotonou	• Poor networking of stations/decline in the number of properly functioning stations • Need for understanding that data sharing from other operators is important • Issue of adaptation to climate change – what has so far been done • Problem of data quality – rather inconsistent, unreliable and discontinuous/ inadequate • Difficulty in getting data from the Agency • Difficulty in using data received from the Agency •	• Research Institutions • GMA • CoE, KNUST • CoA, KNUST • Department of Soil Science, UoG • CoES (UoG) • DoG (UoG) • VRA • MoFA • IDA • Ghana Committee on Climate Change • NADMO	• Quality of people who gather raw data/low level of training given to recorders • Use of volunteers in recording data • meager allowance given to volunteers leading to lack of motivation • Lack of data monitoring and quality assurance • Lack of collaboration with other agencies • Use of outmoded SSB radio in transmitting information from stations	• to have or use dynamic models • for GMA to organize fora with DAs for rain gauge network support • include or use DAs to support data collection efforts • for GMA to validate 3-day Weather forecast by GVP from Climate Institute in Garmisch (Germany) • GVP to assist in training and capacity building in weather forecast, climate and onset of the rainy season modeling • KACE to provide Clusters and super-computing facilities for running climate models.

S/N	Topic/Issue	Current Approach	Main Concern	Main Actors	Pressing Issues	Needs/Intervention
2.	**Hydrology and Water Use**	• HSD - uses statistical methods - does catchment modeling - venturing into new technologies such as Divers, Satellite, etc. - Remote Sensing (remote-based data gathering and monitoring) - GIS and scenario generation • GWCL - urban water supply • CWSA - Community participation in rural water supply • WRC - Basin Management Structure - Integrated Water Resources management (IWRM) • VRA - use of models to forecast inflows and simulate the system. - However, the basic issue is the rapid increase n energy demand vis-à-vis the reduction in inflow needed for power generation • GIDA - crop water requirement ; estimation using water used per head; • EPA - does water quality assessment.	• Doubts over the quality of data (and perhaps adequacy), especially of ground water • Data on water quality is scanty and disjointed • data on abstraction not available • inadequate capacity in modeling and using/applying models and tools in surface and groundwater hydrology and water quality	• HSD (for surface water data) • WRC for ground water data • CWSA (for data generation) • GWCL for domestic/industrial water supply • GIDA • Geological Services Department • VRA • EPA (as regulators) • Relevant Department/Colleges of Universities • Research Institutions • Forestry Commission • Department of Wildlife • NADMO • District Assemblies NGOs/CSOs – CONIWAS, TREND, CEIA, VBDF	• carrying out water quality tests, analysis and data • gathering information on groundwater (boreholes logs), maps for geophysical investigations for the future • need an institution for collecting ground water data on a sustained basis • need for groundwater mapping • methodology for filling missing flow data • Need for HSD to take control of data quality control • Water allocation for environmental flows should be considered • Harnessing seasonal flows should also be critically examined	• standardization of methods • quality assurance of data • for standardization of drilling data • standardization of water quality analysis • the identification of an organization responsible for coordinating data on water availability and water quality • identification of an organization responsible for collecting effluent samples from factories • water use policy • GVP to assist in training and capacity building in 1) Data generation and management in hydrology 2) Surface and groundwater hydrologic modeling 3) Water quality modeling 4) Developing methods for data gaps infilling 5) Determination of Environmental flows • KACE to provide Clusters and super-computing facilities for running hydrologic models.

S/N	Topic/Issue	Current Approach	Main Concern	Main Actors	Pressing Issues	Needs/Intervention
3.	**Water Demand/ Allocation And Trans-boundary Issues** **a. Water Demand**	• For the agricultural demand, there is the WRC's Water Resources Information Box as well as the Integrated Water Resources Management for the Densu-Basin • The WRC also estimates the industrial demand, calculated on the basis of data provided by the companies by setting minimum consumption levels. • GWCL calculates domestic demand, on the basis of the ff average numbers: 60l/p/d in rural areas, 90 l/p/d in urban areas; 25 l/p/d is the absolute minimum. • these numbers are of limited validity, since many households use go far beyond these average numbers, esp. if flush toilets are available. • actual supply of domestic water can be estimated as a function of GWCL's treatment capacities **General Approach** ▪ Use of WEAP modeling (esp. in Ghana) ▪ Use of the Mike BASINS (esp. in Burkina Faso)	• Lack of data on aquifer recharge; • Lack of data on groundwater abstraction • Lack of data on groundwater quality	• WRC • GWCL • WRI • HSD	• Disparities in the level of development • Problem of estimation of quantity to be allowed for environmental flows • Lack of integrated water resources plan • Development of a sound integrated water resources management • Allocation between different sectors of the economy	• Need for the estimation of environmental flows • Model for determining environmental flows • GVP to assist in capacity building in water demand and allocation modeling for main actors

S/N	Topic/Issue	Current Approach	Main Concern	Main Actors	Pressing Issues	Needs/Intervention
3b	**b. Trans-boundary Issues**	• HYCOS: involved countries that share data, basin based (Niger-HYCOS, Volta-HYCOS). • Data-sharing versus Meteosat. • Data can be accessed directly. • Burkina informs Ghana (whom exactly? WRC?). • WRC then informs the district assemblies. • There is also information sharing between VRA and their Burkinabe counterparts. • Mechanism for cooperation: "Joint Technical Committee on Integrated Water Resources" between Ghana and Burkina	• Allocation and water sharing: there are no quotas in place, and no modeling is carried out up to date. • Knowledge sharing mechanisms concerning extreme events like floods are needed: e.g., water released in Burkina Faso has caused floods in the Upper East region of Ghana. • Infrastructure development (e.g. dams) is also a potential source of conflict, not only between Ghana and Burkina Faso, but also Ghana/Togo and Ghana/Cote d'ivoire. Agreements are needed in this area. • Trans-human movements: people moving across the border (Fulani) are also affecting water issues and should be addressed. Finally, the pollution of water by riparian countries needs to be addressed.	• WRC (main) • DGRE (main) • VRC (starting) • PAGEV (initiating dialogue, mitigating conflict) • Ministry of Works and Housing (very important) • Ministries of Foreign Affairs of both Ghana and Burkina Faso • Hydrological Service Department (can model extreme event) • VBC • GLOWA • GWCL • CWSA • HSD • IDA • VRA University and Research Institutes: Hydrological Services, College of Engineering -KNUST, SRI	• Lack of harmonization of flow measurement methodologies in trans-boundary issues • Lack of harmonization of water policies of different riparian countries – regional water policy • Poor data on water quality • Lack of harmonization of development plans on a particular river • The level of perceptions of different countries	• Need for good data and good data collection • Models and tools for handling trans-boundary issues • Harmonization of flow measurement methodologies in trans-boundary issues • Harmonization of water policies of different riparian countries – regional water policy • Water quality analysis standardization • Harmonization of development plans on particular rivers • The level of perceptions of different countries on water resources management

S/N	Topic/Issue	Current Approach	Main Concern	Main Actors	Pressing Issues	Needs/Intervention
	c. Environmental Flows	• The estimation of the demand for environmental flows is a considerable problem, because there are no such estimating systems in place. • Environmental flows consist of floodplains, riparian forests, wetlands, aquatic life, mangroves. • GVP is working on an estimation for this field, using a proprietary software. GLOWA has contracted Ms. Luna Bharati and Mr. Smakhtin of the IWMI Headquarters in Sri Lanka to estimate the water required for environmental flows in the Volta basin.		• EPA • FRWB • CAW • NGOs/CSOs	• Difficulty of EPA in estimating amount of flow required	• Model that includes environmental flow • Need for guidelines estimating environmental flows • Policy on environmental flows
	d. Water Quality	• PURC -responsible for measuring water quality for urban domestic and industrial uses. • CEIA calculates health risks of water contamination. • The United States Environmental Protection Agency (USEPA) also active in this field.. • In the discussion it was suggested that a single agency, e.g. the WRI, be given the mandate for measuring water quality in Ghana.	•	• WRI • PURC • CEIA • USEPA • KNUST: Environmental Quality Lab	• Inadequacy of data on ground water quality • Lack of equipment and accessories for testing ground water • Disjointed data • Proponents collecting their own water sample for testing and analysis.	• Models and tools for water quality analysis • Standardization of data and analysis • Identification of an organization to handle water quality testing analysis and data.

S/N	Topic/Issue	Current Approach	Main Concern	Main Actors	Pressing Issues	Needs/Intervention
4.	**WATER GOVERNANCE, PARTICIPATION OF SCIENTISTS AND CIVIL SOCIETY ORGANIZATIONS**	• Allocation and water sharing: there are no quotas in place, and no modeling is carried out up to date. • Knowledge sharing mechanisms concerning extreme events like floods are needed: e.g., water released in Burkina Faso has caused floods in the Upper East region of Ghana. • Infrastructure development (e.g. dams) is also a potential source of conflict, not only between Ghana and Burkina Faso, but also Ghana/Togo and Ghana/Cote D'ivoire. Agreements are needed in this area. • Trans-human movements: people moving across the border (Fulani) are also affecting water issues and should be addressed.	• Conflict and conflict resolution between different water users • The allocation of water resources • Disparities between water users • Poverty and equity of water use • The inclusion of indigenous knowledge •	• MWRWH • WRC • Research Institutes • GVP • PURC • VRA • WRC • GWCL • NAVRAT • Ghana Dams Forum • IDA • VRA has inflow models. • EPA -> EIA • MMDAs • TREND • VBDF •	▪ Harvesting local knowledge ▪ Lack of policy briefing ▪ Research finding by scientists ▪ Capacity building of NGOs on water governance ▪ Applicability and usability of scientific publications ▪ Fund extensions of research finding as part of scientific publication ▪ Funding of research ▪ Building of collaboration among different actors	• Need to address pollution of water bodies by riparian countries. • Funding of research • Capacity building of NGOs on water governance • Need for water policy for the region • Dialogue between actors • Risks and rights approach by VBDF and the Ghana Dam Forum • Social impact assessment (possibly IMWI with GVP)

S/N	Topic/Issue	Current Approach	Main Concern	Main Actors	Pressing Issues	Needs/Intervention
3b	**Dams**	• Flow measurements • Stream gauging • Basin demarcation • Flow models	• Impact of dams on aquatic weed • Impact of dams on downstream water • availability • Hydropower	• VRA • WRC • GWCL • NAVRAT • Ghana Dams Forum • IDA • VRA has inflow models. • EPA -> EIA • MMDAs • TREND • VBDF	• Impact on downstream flows and downstream users	• Comprehensive Environmental Impact Assessment • Adequate Compensation • Comprehensive Resettlement Action Plans • Sound Mitigation Measures
	Mining	• Conduct environmental Impact assessment • EPA grants permits • Prepare environmental Management Plans	• Conflicts between miners and affected communities • Lack of comprehensive policy on granting of concessions for mining • Pollution of water bodies • Loss of aquatic lives	• mining companies • polluters, • affected communities. • NGOs/CSOs • WRC: • EPA • Chamber of Mines • WACAM • Basin Boards • CEIA • TREND	• problem of institutional competition between different agencies in the country regarding water quality/pollution. • no sound water quality assessment.	• Comprehensive Environmental Impact Assessment • Model for determining water use by mining companies • Protection of water bodies • Comprehensive Resettlement Action Plans • Sound Mitigation Measures

D. PRESENTATION BY ANTONIO ROGMANN

Rogmann made a power-point presentation on the **Establishment of the GVP Geo-portal website and Access to project data**. Highlights of the presentation were:

1. **Overview:**
   - Problem
   - Solution
   - Data Management Definition
   - Data Management in the GVP
   - Project Data
   - Access to Project Data: Meta Database
   - Access to Project Data: GVP Geo-portal

2. **Problem**

   Common questions encountered when searching for data
   - Which data exist to serve my research / decision / information requirements?
   - Where is the data available?
   - How can I get the data without a huge amount of effort?
   - What are the formats? Are they compatible with my applications / models?
   - What are the data characteristics (e.g. time steps, units ...)?
   - Who owns the data? Are there costs?

3. **Solution**

   Provision of
   - A central hosted database
     - giving access to the GVP data-stock
   - A central hosted meta database giving
     - answers about data needed
     - references about data providers
   - A geo portal informing
     - about projects related to water management in the Volta-Basin
     - and their data: in a spatial visualization

4. **Definition of Data Management**
   - Data Management is the holistic background in which data access facilities are embedded
   - Data Management in an organization is based on an ensemble of
     - Technology: hardware, software, interfaces ... → data infrastructure
     - Methods for:
       - Data description (meta data)
       - Data quality assurance
       - Data access and distribution
       - Security

- Standards
  - global standards e.g for metadata, formats ...
  - internal standards as concensus inside the organization e.g. database models, file naming, data policy ....
- Workflows / Process Steps / Responsabilities

- providing an easy access to well described data on a high quality level, to be used for
  - Research Activities
  - Decision Making
  - (Public) Information

5. Data management in GVP

GLOWA Volta at ZEF to

- improve its **data infrastructure**
  - webserver (www.glowa-volta.de)
  - data server (file system)
  - web-based meta database, and
- to extend it via
  - central geo-data storage with improved functionalities
  - new search and access facilities within
    - the meta database
    - the GVP Geoportal
  - GVP-Geoportal, providing
    - Map based project information

Data infrastructure is based on:

- global standards for
  - meta-data (data about data): Federal Geographic Data Committee (FGDC)
  - WebMapServices (WMS): Open Geospatial Consortium (OGC)
  - formats: ASCII ..
- GVP-specific standards for
  - file names: encoding the thematic, spatial and time content of the file
  - internal file description in the table headers: means of parameters, data types used (e.g. ddmmyyyy for the datum, decimal degrees for coordinates)
  - data quality controlling: how is the data quality assured
  - data policy: specific owner and access rights on the files

6. Project Data

- Project data: what can GVP provide?
  - Hydrological data: water discharge, groundwater (time series) ...
  - Climatological data: precipitation, temperature, air humidity, evapotranspiration, heat flux (time series and forecasts) ...
  - Water use data: agricultural (irrigation) / domestic / industrial (hydropower) / reservoirs ..

- Land use / land cover data: agriculture, urbanization, soil, geology, vegetation ...
- Topographic / infrastructure / administrative (basic) data: river networks, lakes, elevation roads, settlements, electricity, boundaries ....
- Socio–economic data: demography, census data, economic activities (markets), surveys ...
- in several formats: vector / raster (remote sensing), tables, documents, model specific formats ...

7. Access To Website – Meta database

- First approach: Meta Database (web based), containing
  - meta-data (data about data)
  - search facilities using thematic/spatial keywords, sources, time coverage etc...
  - reference to where a dataset can be obtained
  - download facilities
  - a graduated user access scheme to avoid unauthorized access

8. Access to Project Data – Geo-Portal

- Second approach: Geo Portal
  - Access geo-map data via internet
    - Easy access: display of complete maps
    - Standard internet access technologies, e.g. web browser
  - Visual exploration of maps and data
    - Zoom, re-center, layers on / off, show attributes
    - Spatial visualization of data
  - Search facilities
    - Map selection by topics and/or GVP-use cases
    - Search for data, maps, layers, attributes
  - Download of original geo data for authorized users

9. Next steps in capacity building

GVP/ZEF would like to

- get a first overview for evaluation of basic interests/needs of interested collaborators
- build up a communication structure between GVP data managers and stakeholders for
- planning and organizing further consultations and workshops!

D1. Contributions, Concerns and Questions from Participants

A few questions and concerns raised and contributions made by participants include the ff:

- how long can GVP/ZEF sustain the use of the website?
- the cost of acquiring information and the ability of organizations to afford the cost

- the issue of monitoring and ensuring that reliable data was used in the building of models, etc.
- Will both raw data and meta data be available on the website?
- Has GVP links with other agencies and organizations involved in acquiring and storing database?
- Has the GVP been linked to the Google Search Engine?
- A participant disclosed that UNECA has a project to develop an African meta database, and therefore suggested to GVP to explore the possibility of linking up with the project.

D1a Response to Concerns Raised

Rogmann, in response to the questions and concerns raised by participants, stated that:

- GVP is also involved in the collection of raw data. On the one hand there are persons employed directly by GVP to collect data from our gauge stations, on the other hand GVP receives raw data collected by partner institutions. In the framework of a graduated user access concerning cost and owner rights issues the data should be available by download or other access facilities on the website.
- GVP has 2 sets of data type
  - project generated data
  - data collected from other sources (secondary source data)
- Other secondary data will be referenced
- GVP is yet to be linked to Google

D2. Administration of Questionnaire and Feedback From Participants

A set of questionnaire was given to each participant to fill and submit. This was promptly done by participants.

E. CLOSING REMARKS/OBSERVATIONS

E1. Remarks by Prof. Dr. Karl Harmsen

Prof. Dr Karl Harmsen in his final remarks and recap of GVP's efforts made so far, and the proceedings of the workshop, stated, among other things, that:

1. GVP is a small project; however, efforts have been made to ensure that it fits into the wider domain
2. GVP has made a lot of progress and contributed to scientific research in the Volta Basin. These include:
   - high quality science oriented research

- relevance of its outputs to the Volta Basin
- production of and assistance to about 35 PhD students, most of them from Africa who have returned to their various countries after their training
- development of useful website for interested people to access
- high quality data
- availability of methods of calibrations used in the Volta Basin
- the selection and development of models for various modeling aspects of the water resources of the basin.

3. that not more was discussed about modeling during the workshop
4. GVP is looking at the various training needs for other collaborators for the future in terms of
   - data acquisition
   - data storage
   - data retrieval
   - data quality
   - data availability
   - data monitoring
5. what are the possible effects of climatic change (using MM5 model) in the Volta Basin?
6. what are the policy regulations for adaptation to climate change –, eg use of low energy consuming bulbs, low sanitary kits that enhances the use of less water, short-period yielding plants/crops, etc?
7. participants would be contacted for their comments on the draft report before the final report is produced.

E2. Expression of Gratitude

Dr. Wolfram Laube, expressed sincere thanks to Prof. Dr. Karl Harmsen, Dr. Dilnesaw Alamirew and Dr. Barnabas Amisigo (who contributed in no small way towards the successful hosting of the workshop), the persons who chaired the workshop for each day, the various moderators during the plenary session and group discussions, and last but not least the project partners and workshop participants who so generously shared their expertise and knowledge with the GVP and thus helped to draw up a demand-oriented implementation strategy for the GVP capacity building, knowledge sharing and decision support activities. .

E3. Closing Summary and Departure

The workshop ended with a summary of day 2 activities by the Chairman, Dr. W.E.I. Anda at about 1.50pm.

F. INCLUSIONS/APPENDICES

F1. Workshop Schedule

GLOWA-Volta Project (GVP)-Partners Capacity Needs Assessment Workshop.

Objectives

- To present GVP outputs, scientific tools and models to stakeholders of the water sector within the Volta Basin in Ghana.

- To identify Ghanaian Institutions and actors and their interests and capacity for knowledge sharing.

- To assess the capacity building needs of stakeholders to effectively utilize the GVP products in the water resources research and management in the basin.

Expected outputs

- GVP outputs and other products introduced to the stakeholders

- Relevant Ghanaian institutions and actors for knowledge sharing and capacity building identified

- Training needs of the various stakeholders groups in the use of GVP tools and models for sustainable use of the water resources of the basin determined.

- The necessary research support for the maintenance and further development of GVP tools and models for use in the basin ascertained.

Schedule
GVP-Partners Capacity Needs Assessment Workshop

Dates: Thursday, May 31 – Friday, June 1, 2007
Venue: Noguchi Memorial Institute for Medical Research
University of Ghana
Accra, Ghana
Chairman,
First Day's session: Dr. Konadu Acheampong (Programme Officer, UNU-INRA)
Second Day's session: Dr. W.E.I. Andah (CPWF Volta Basin Coordinator)

Day 1, Thursday, May 31, 2007

09:00 Arrival of Guests, Registration, Distribution of Program Materials

09:20 Formal Opening of Meeting
Prof. Dr. Karl Harmsen (Director, UNU-INRA)

9:30 General Introduction: The GVP, Knowledge Exchange and Stakeholder Dialogue at Different Levels
Dr. Charles Rodgers (GVP/ZEF) and Dr. Wolfram Laube (GVP/ZEF)

10:00 Overview about GVP's Products and possible Capacity Building Activities
Dr. Dilnesaw Alamirew (GVP/UNU-INRA)

10:10 Discussion

10:30 Group Photograph and Coffee Break

10.45 Introduction of the Plenary Sessions:
Dr. Wilson Agyare (GVP/SARI)

11:00 Plenary discussion: ***Climate and Meteorology***
Moderators: i) Ghana Meteorological Services Agency representative
ii) Dr. Barnabas Amisigo (GVP/WRI/UNU-INRA)

1) Pressing Issues
2) Important Actors
3) Current Approaches

11:30 Plenary discussion: ***Hydrology/ Water Supply/Water availability***
Moderators: i) Hydrological Services Department representative
ii) Dr. Charles Rodgers(GVP/ZEF)/Dr. Boubacar Barry(GVP/IWMI)

1) Pressing Issues
2) Important Actors
3) Current Approaches

12:00 Plenary discussion: ***Water Demand/ Allocation and Transboundary Issues***
Moderators: i) Mr. Ben Ampomah (WRC)
ii) Dr Victor Afari-Sefa(GVP/ZEF)

1) Pressing Issues
2) Important Actors
3) Current Approaches

12:30 Plenary Discussion: ***Water Politics and Participation of Scientists and Civil Society in decision making in the water sector***
Moderators:i) Mr. Ben Ampomah (WRC)
ii) Dr. Wolfram Laube (GVP/ZEF)

1) Pressing Issues
2) Important Actors
3) Current Approaches
4) Existing Structures for Inclusion

13.00 Lunch (Buffet at Noguchi Centre)

14:00 Introduction: Breakout Discussion Sections by above-mentioned topics regarding the capacity needs (addressing issues, actors and needs identified before)':
Dr. Wilson Agyare (GVP/SARI)

14:15 First Parallel Session:
Topic 1: Climate and Meteorology
Topic 4: Water Politics and Participation of Scientists and Civil Society in decision making in the water sector

15:25 Coffee Break

15:40 Second Parallel Session:
Topic 2: Hydrology/ Water Supply/ Water availability
Topic 3: Water Demand, Water Allocation and Transboundary Issues

16:50 Introduction of data management questionnaire
Mr. Antonio Rogmann (GVP/ZEF)
16:55 Chairman's closing remarks
17:00 End of Day 1
19:00 Dinner – at University of Ghana Guest Center (Ford Foundation)

Day 2, Friday, June 1, 2007

09:00 Presentation of Group Discussions.
09:05 ***Topic 1) Climate and Meteorology***
09:35 : ***Topic 2) Hydrology/ Water Supply/Water availability***
10:05 ***Topic 3) Water Demand, Water Allocation and Transboundary Issues***
10:35 ***Topic 4) Water Politics and Participation of Scientists and Civil Society in decision making in the water sector***

11:05 Coffee Break, Poster session and presentation of selected GVP research outputs

11:50 Establishment of the GVP Geo-portal website and Access to project data
Mr. Antonio Rogmann (GVP/ZEF)

12:20 Open Discussion

12:50 Closing Remarks: Dr. Charles Rodgers (GVP/ZEF)

12:55 Chairman's Closing Remarks

13:00 Lunch (Buffet at Noguchi Centre) and End of Day-2

Points to be considered in parallel sessions

- What are the current concerns and priorities of your organization in the water resources sector?
- What types of strategies and approaches (models and tools (e.g. procedures)) are available for dealing with or mitigating these stresses?
- Areas of application of these models and tools
- Their capabilities, limitations and data requirement
- Some results obtained from application of these models or tools
- Cost of acquisition and use of these models and tools.
- What is lacking in their effective use (both human and material capacity)

The GLOWA Volta Project

Contents

1. Project Overview and History:

The GLOWA Volta Project (www.glowa-volta.de) is a 9-year study designed and conducted by the Center for Development Research (ZEF), Bonn University and partners, to produce a state-of-the-art analysis of the impacts of Global Environmental Change within a major trans-national river basin in West Africa. *Global Environmental Change* is understood to include not only long-term changes in global and regional climate induced by changes in radiative forcing associated with increasing atmospheric concentrations of "greenhouse" gasses, but also broadscale changes in land surface processes and terrestrial ecology, such as those associated with deforestation. The overall objectives of the GLOWA Volta Project (GVP) are (1) to provide an analysis of the physical and socio-economic determinants of the hydrological cycle within the Volta Basin, and (2) to develop a scientifically sound Decision Support System (DSS) for the assessment, sustainable use and development of the basin's water resources. The GVP is one of five GLOWA (Global Change and the Hydrologic Cycle) river basin projects funded by the German Federal Ministry of Science and Education (BMBf) (www.glowa.de), of which two (Danubia, Elbe) are in Europe; one (Jordan) is in the Middle East and two (IMPETUS, Volta) are in Africa. The GVP is divided into three project phases. During the first project phase (June 2000 – May 2003), priorities included the establishment of research infrastructure and the collection and analysis of climatic, hydrologic, environmental and socioeconomic data, which are scarce within the Volta Basin. A large number of focused studies, many conducted by Ph.D. trainees from the Volta region, attempted to bridge gaps in spatial and temporal scales as solutions to the problems of data scarcity. Phase I also encompassed the establishment of working relationships between European GVP partners and counterparts in Ghana. During Phase II (June 2003 – May 2006), modeling activities predominated. Mesoscale climate models (MM5) were successfully linked with physical hydrology models (WaSIM-ETH) at catchment, tributary and full basin scales. Numerous anthropologic and socioeconomic studies were successfully completed, creating databases from which a range of household models of socioeconomic behavior were identified. Phase II also saw the expansion of GVP research and outreach activities to Burkina Faso. During Phase III (June 2006 – May 2009) activities are focused on integration of Phase I and II outputs, emphasis on aggregate economic analysis, operationalization of DSS components and ***transfer of activities and responsibilities to partner institutions within the Volta Basin.***

The GVP is both inter-disciplinary and trans-disciplinary. It was recognized in the conceptual stages of project development that an understanding of the physical dimensions and determinants of environmental change, albeit essential, is incomplete without a corresponding understanding of how human societies interact with, and act to influence the hydrological cycle. The GVP was correspondingly organized around three broad, cross-cutting themes: (i) Atmosphere, (ii) Land and (iii) Water. Research within the *Atmosphere* theme was largely in the physical science domain, and focused on climate modelling and on land surface – atmosphere interactions. By contrast, research within the *Land* and *Water* themes largely transcended disciplinary boundaries, ranging from hydrology and soil science to anthropology and political science. It is to be emphasized that irrespective of disciplinary emphasis, ***GVP activities were scientifically- rather than developmentally-oriented, although developmentally relevant outputs were clearly valued***. Now, in Phase III, the desire to ensure that GVP scientific outputs are relevant in the search for practical and effective approaches by which human societies pre-empt and adapt to the manifestations of global environmental change is explicit. ***Thus, we are searching for strategies to ensure that GVP outputs and products are not simply consigned to scientific journals, but rather serve as active components of a constantly evolving decision support framework capable of guiding decisions that serve to reduce***

societal vulnerability to the negative consequences of environmental change, thereby improving livelihoods within the Volta Basin.

2. Organization and Objectives of GLOWA Volta Project Phase III

The original GLOWA program concept emphasized three core scientific themes guiding interdisciplinary research:

- Natural variability of precipitation, and variations caused by human activities and their effect on the hydrologic cycle
- Interactions between the hydrologic cycle, the biosphere and land use
- Water availability and conflicting water uses

These themes have guided the GVP since inception, although research priorities (and project resources) have been shifted repeatedly in recognition of the evolving nature of binding constraints to further progress. Analysis of the variation in precipitation and of long-term water availability each require data, therefore the earliest priority was placed on the acquisition and development of infrastructure, methods of analysis and models to enhance the quantity, quality and spatial coverage of data within the basin.

Extensive survey research (the Common Sampling Framework) addressed the corresponding scarcity of data impeding socio-economic enquiry. As the data framework of the GVP became more solid, emphasis and resources shifted to simulation modeling, required to study the interactions and feedbacks between atmospheric, land surface and hydrologic processes. The GLOWA concept also stresses the importance of innovation in the development of early warning- and planning tools to improve decision-making, particularly over long time horizons under conditions of high uncertainty.

With just two years remaining in the project cycle, we now shift our priorities to synthesis activities, in order to address practical water sector problems and challenges within the Volta Basin, and to enhance and enable the modes of co-operation that will be required to ensure that our efforts are translated into ongoing success in meeting these challenges. Accordingly, the primary goals of Phase III are the following:

- Integration of Phase I and II research results, knowledge, data and tools
- Construction of a framework for evaluating and projecting effective demand for water resources at basin scale
- Development of operational versions of research models and tools
- ***Transfer of GVP infrastructure, tools and activities to partners in the basin***

Although essential continuity with Phase I and II research activities is preserved in Phase III, work packages have been re-organized to reflect operational, rather than research requirements. The Atmosphere, Land and Water themes that gave structure to GVP research in Phases I and II are replaced with themes that can be described as

- Water Supply and Distribution
- Analysis of Long-Term Environmental Change
- Water Demand
- Consortium Building for Technology Transfer
- Decision Support System Infrastructure

The new clusters cut across the earlier themes in ways that reflect the requirements of an operational program of integrated water resources management at large basin scale.

3. Research and Implementation Partners

GLOWA Volta Project research activities have been centered in and coordinated from the Center for Development Research (Zentrum fuer Entwicklungsforschung - ZEF), an autonomous, inter-disciplinary research institute affiliated with Bonn University. Research activities requiring specific scientific expertise are performed at partner institutions within Germany and neighboring countries. Important ZEF research partners include:

- Institute for Meteorology and Climate Studies, Research Center Karlsruhe (IMK-IFU), Germany: meso-scale climate modelling; interaction of land surface and atmospheric processes; physical hydrologic modelling
- Faculty of Civil Engineering and Geosciences, Technical University Delft (TU Delft), The Netherlands: surface energy balance; soil-vegetation-atmosphere transfer (SVAT) modelling
- German Institute for Air and Space (DLR), Germany: remote sensing interpretation

- Department of Computer Science and Informatics (III), Bonn University, Germany: technical integration of simulation models and databases; development of visualization tools; grid computing architecture

Close cooperation is also required with a range of partner institutions within the Volta Basin. These partners include scientific research organizations as well as ministries and line agencies involved in policy-making as well as operational activities, including climatic and hydrological forecasting. Important Basin partners in Ghana (GH) ad Burkina Faso (BF) include:

- Centre de Coopération Internationale en Recherche Agronomique pour le Dévelopment (CIRAD), BF
- Consultative Group on International Agricultural Research's Challenge Program on Water for Food GH
- Water Resources Commission, GH
- Council for Scientific and Industrial Research (CSIR), GH
- Water Research Institute, GH
- Savanna Agricultural Research Institute (SARI), GH
- Meteorological Services Department (MSD), GH
- Hydrological Services Department (HSD), GH
- Institute of Statistical, Social and Economic Research (ISSER), University of Ghana, GH
- Institute de l'Environment et de Recherches Agricoles (INERA), BF
- International Water Management Institute (IWMI), a CGIAR Center, West Africa Office GH
- United Nations University (UNU), BF – Germany
- Kofi Annan Centre of Excellence in Information and Communications Technology (KACE), GH
- Volta River Basin Commission, BF

A number of these partners are anticipated to play significant roles in maintaining and expanding scientific and operational activities initiated within GVP. The process of identifying and preparing research partners for post-transitional roles is an important and challenging activity under GVP Phase III.

4. Project Organization and Linkages

The current structure of the GVP scientific activities is indicated schematically in Figure 1, as prepared for the 2nd GLOWA Status Conference held in Cologne, May 17-19, 2005. This remains an accurate description of project structure for Phase III, although it will be seen that there is not a precise mapping between icons appearing in Figure 1 (many of which represent specific modeling tools, such as MM5) and Phase III research clusters. Much of the Phase III agenda involves integrative tasks which by definition encompass many or all of the project components depicted in Figure 1. The figure does convey the fundamental organization of Phase III through conceptual separation of research tasks involving the physical distribution of water in space and time (supply), encompassing climate, hydrology and remote sensing; from those that focus on human activities linked to water (demand), including sectoral economic modeling and institutional analysis. The land surface itself lies at the interface between natural and social sciences, as land cover and land use are manifestations of purposive human activities overlaid on the environmental matrix which co-evolve over relatively long timescales. Thus Land Use and Land Cover Change research activities, which fit neither into "supply" nor "demand" categories, are accorded a unique research cluster (long term environmental change). Two proposed research clusters do not fall neatly into Figure 1. The Consortium Building for Technology Transfer cluster is concerned with stakeholder consultation, knowledge transfer and training encompassing all relevant GVP research components, irrespective of discipline. Similarly, tasks associated with the technical integration of DSS components via grid computing infrastructure can be envisioned as an additional layer of project activities that extends over the entire domain of Figure 1.

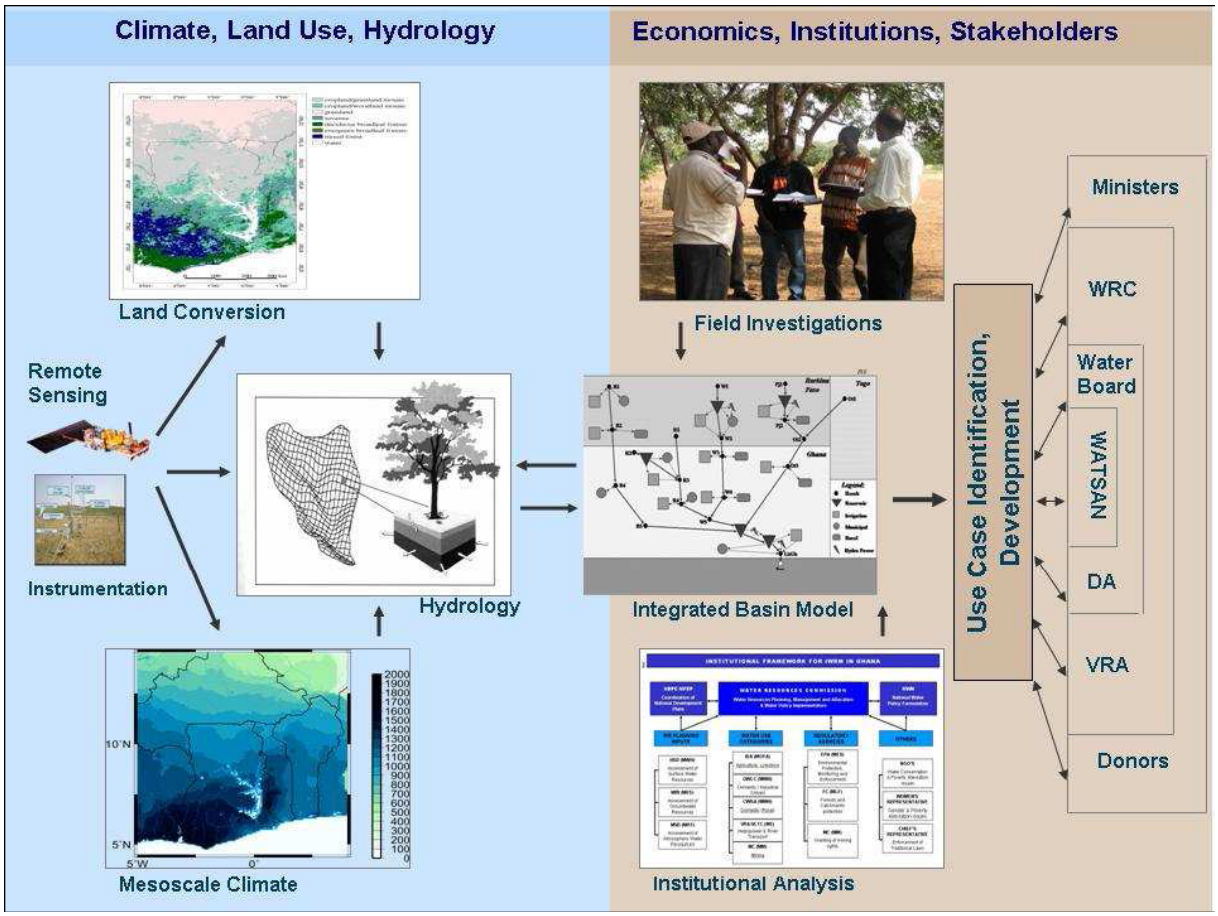

Figure 1: Integration Diagram (from 2nd GLOWA Status Conference, 2005)

5. Brief Summary of Research Clusters of the GVP Phase III

Research Clusters of the GVP Phase III and associated work packages are summarized briefly below and described in detail in the proposal:

The **Water Supply and Distribution** cluster encompasses the analysis of physical water distribution and availability in space and time, inclusive of atmospheric, surface and subsurface hydrologic processes. It contains most of the elements of the original Atmosphere cluster, as well as current work package (Runoff and Hydraulic Routing), extended to include probabilistic analysis of climatic and hydrologic phenomena and investigation of groundwater recharge. This cluster consists of four subprojects: Hydrometeorological Modelling, Hydrometeorological Observatory, Remote sensing and surface energy balance, Surface, Soil and Groundwater monitoring and modeling

The **Analysis of Long-Term Environmental Change** cluster focuses on environmental changes endogenous to the Volta Basin that evolve over decadal time scales. These changes, such as alterations in land cover, soil degradation and loss of wetlands reflect complex interactions and feedbacks between climate, human settlement and economic activities. This research cluster carries forward much of the work originally conducted within the Land Use cluster. Primary objectives are (i) to provide credible future land cover scenarios required by climate and hydrology models, and (ii) to provide decision support tools for proactive land management on the local and basin scales. This cluster consists of five subprojects: Automated Classification of Remotely Sensed Imagery, Cellular Automata, GVP-LUDAS, Land-use Change Predictions and Land-use Policy, Synthesizing this cluster's research to develop credible projections of Land Use and Land Cover Changes.

The **Water Demand and Management** cluster consists largely of integrative activities that build extensively on research conducted within Phase II on operations research modeling of water-demanding economic sectors. It integrates Phase II work packages Water and Livelihood, Institutional Analysis, Household Decision-making and Policy Response, White Volta Policy Pilot, Policy Dialog at Basin Level and some aspects of Technical Integration of Socio-Economic and Environmental Modeling Sub-Systems. The demand cluster has three components: Agricultural Water Demand, Non-Agricultural Water Demand, Integrated Demand Simulation Framework.

The fourth research cluster is **Consortium Building for Technology Transfer:** The success of the GLOWA Volta project will ultimately be measured by the continuity of activities within the region following completion of GVP. GVP has built an effective network of partners in Ghana and Burkina Faso, as well as a consortium of international organizations including KACE, IWMI and UNU. During Phase III these three institutions will progressively assume leadership of project activities, with the ultimate objective of transferring ownership to capable institutional partners within all 6 riparian states. This cluster consists of three subprojects: Knowledge Exchange and Participatory Decision Support, Transboundary Water Management, Consortium building Training and Outreach in use of DSS.

The final cluster, **GLOWA Volta Decision Support System (DSS)** encompasses technical activities required for the implementation of a scientifically sound DSS. DSS encompass a wide range of scientific simulation tools embodying various methodological approaches and technologies. However, there are several reasons why DSS are not often used effectively at the management level, including lack of user-friendly interfaces, insufficient involvement of potential end-users in software development, poor identification of user needs and lack of adequate system infrastructure. The primary goal of this cluster is to facilitate the development of an effective, user-friendly grid-based DSS infrastructure for water management in the Volta Basin. This cluster consists of three subprojects: Requirements Engineering, GVDSS Infrastructure and GVDSS Workbench.

6. External Collaboration

The informal network of projects and organizations affiliated with the GLOWA Volta continues to expand, and several new Phase III collaborative activities are planned or are already underway. The GVP continues to share offices, infrastructure and scientific and managerial staff with the International Water Management Institute (IWMI) through their West Africa regional office in Accra. Past collaboration has included malaria risk mapping within the Volta Basin. New and potential areas of collaborative research include the evaluation of shallow groundwater irrigation in the Upper East region of Ghana, where GVP scientists are collaborating with IWMI efforts to inventory "informal" irrigated area within the region via experimental application of high-

resolution RS imagery; studies of irrigation water productivity, and a pre-construction baseline study of the proposed Bui Gorge Dam.

GVP scientists continue to work closely with the research staff of the Small Reservoirs Project (SRP), a 3-year study involving careful water balance accounting on heavily instrumented small reservoirs in the Upper East Region of Ghana. SRP is a project of the CGIAR Challenge Program on Water and Food (Project 46) funded by the GTZ project BEAF. GVP scientists will utilize SRP data to improve the calibration and validation of linked economic-hydrologic models at catchment and White Volta scales, respectively, and will in turn contribute expertise in satellite radar RS methods useful to the SRP. SRP has been invited by BMZ/GTZ to submit a proposal for a second 3-year phase, and ZEF, via the GVP, is anticipated to be a formal partner.

The expansion of GVP groundwater studies during Phase III is designed to complement with CIDA via the Hydrogeological Assessment of the Northern Regions of Ghana project, a 2-year project commencing in October of 2005, which will focus on mapping and modeling of geologic (deep) groundwater. This study is intended to improve the effectiveness of borehole development programs, in which CIDA has been extensively involved for 3 decades. CIDA focus on hydrogeology will free GVP researchers to focus on shallow groundwater, an important source of water for informal dry season irrigation and domestic water supply; and on the modeling and measurement of groundwater recharge. CIDA and GVP will share data, and co-ordinate modeling efforts.

GVP (via ZEF) and the University of Heidelberg, Department of Tropical Hygiene and Public Health are developing a joint proposal provisionally titled Impact of climate change, water availability, human settlement, agriculture practice and soil degradation on malaria transmission risk, a comparative study between two climatic zones in Burkina Faso. The project is designed to exploit the complementarity between GVP and the Nouna Malaria Modeling Project. The MMP aims to develop malaria transmission models for children under five in the North-West of Burkina Faso, using environment parameters as driving forces. MMP research activities have been focused on Nouna District, Burkina Faso within the Soudano-Sahelian climate zone, an area of endemic malaria. GVP in turn maintains research sites in the area of Navrongo, in the Upper East Region of Ghana within the Sudano-Guinean climate zone. The Navrongo region has been the focus of a wide range of ecological, agricultural and water management studies; and hosts a regional malaria health institute. The proposed research methodology is based on an exchange of capacities between the two sites, with protocols developed at Nouna for the study of malaria transmission are duplicated (transferred) to Navrongo, and ecological, agronomic and related physical geographic findings transferred to Nouna.

In 2006, collaboration was initiated between GVP and the African Monsoon Multidisciplinary Analysis (AMMA), an international study of the dynamics of the West African Monsoon. We participated in the intensive field campaign during the summer of 2006 through shared use of Dano field station facilities. More information can be found at: http://www.ofps.ucar.edu/amma/amma_summary.htm

7. Post-GVP Technology Transfer and Opportunities for Ongoing Collaboration

The GVP will be completed when the scientific infrastructure, simulation tools, databases and other key components of the DSS framework will be transferred to a consortium of partner institutions within the Volta Basin. Experience has demonstrated that in order for complex, technically advanced scientific products and activities to be transferred successfully to their new host institutions, several conditions must be met. A partial list of these conditions includes the following:

- A consortium of partner institutions that are both capable and appropriately selected, with respect to technical capacity, existing mandate and willingness to accept responsibility for the allocated tasks
- Professional staff trained in the technical specialties required for continuation of project activities
- Properly designed and tested simulation tools, well matched to the requirements of decision-makers and stakeholders
- A history of successful applications or case studies, establishing both the integrity of the technology to be transferred, and the value of potential outputs
- A clearly defined allocation of responsibility; and efficient, tested modes of consultation and interaction between consortium members

- A strong set of incentives for ongoing participation

At this stage, the post-GVP research consortium has been identified, and in many cases the commitments formalized via MoU. Important partners committed to supporting ongoing scientific, educational or outreach activities post-GVP include: (a) The Volta River Basin Authority (VBA): this newly-constituted agency is designed to serve as a governance and advisory body to co-ordinate and harmonize the interests of the six riparian nations sharing the land and water of the Volta Basin. The newly established headquarters will be in Ouagadougou, and the Executive Director will be Ghanaian, as consistent with the status of these countries as primary stakeholders within the Basin; (b) International Water Management Institute, West African office (Accra); United Nations University, Accra and Bonn, Germany, having a regional mandate for training and research; and (d) Kofi Annan Centre of Excellence in ITC, as host of data archive and venue for computationally intensive activities.

Technical training and human capacity development are among the most successful outputs of the GVP to date, and should ensure that competent and motivated staff are available at key consortium research centers for many years to come. Upon completion, GVP will have trained roughly 35 Ph.D. and 15 M.S. scientists in a wide range of disciplines, of which the majority are from Volta Basin riparian states. The GVP is currently employing 4 project graduates as postdoctoral scientists, and a larger number have returned to their home institutes where they will be effective in supporting project continuation activities directly or indirectly.

The GVP has currently developed, and has tested or is preparing to test a wide range of simulation tools which will be transferred to consortium members as appropriate. These tools include the meso-scale climate model MM5, which provides both short-term forecasting and generates long-term climate change scenarios via dynamic down-scaling of General Circulation Model (GCM) output; the distributed parameter physical hydrology model WaSiM ETH, which simulates surface, soil and subsurface hydrology at high spatial and temporal resolution at the scale of the entire basin and important tributaries; the commercial water allocation model MIKE BASINS, a rule-based simulation platform that supports a wide range of policy simulation exercises at basin and tributary scale, including investment scenarios involving new infrastructure; and the Land Use Dynamic Simulator (GV-LUDAS), a multi-agent simulation system that allows detailed policy studies involving human-landscape interaction at community scale. Databases supporting all of the above simulation tools have also been developed.

Abstracts of Completed Ph.D Theses under GLOWA-Volta Project

Ph.D Thesis Completed in 2003

Traore, C. (2003): **Epidemiology of Malaria in a holoendemic area of rural Burkina Faso.** Doctoral thesis, Medical Faculty, Ruprecht-Karls-University Heidelberg

Abstract: The goal of this study was to contribute to the existing knowledge in the epidemiology of malaria in a high-transmission area of rural Burkina Faso. The study has included data from six methodological different studies conducted in the area over the period 1999-2001: (1) entomological study, (2) zinc supplementation study, (3) ITN study, (4) community factors and malaria study, (5) chloroquine efficacy study, and (6) mortality study. All data on malaria morbidity and mortality have been collected in children under the age of three years from 6 of the 41 villages of the CRSN study area. These six villages were purposely selected to represent the rural study population in its socio-cultural, demographic and geographical diversity.

In conclusion, this study has demonstrated that malaria is the major cause of morbidity and mortality in children aged 0-3 years living in a holoendemic rural area of Burkina Faso. As chloroquine is still sufficiently effective as first-line treatment drug in falciparum malaria in Burkina Faso, malaria control efforts should concentrate on early treatment of young febrile children through their mothers in the villages and on appropriate referral to the peripheral health centers in case of non-response. In addition, protection of all young children with ITN should be promoted in the malaria endemic areas.

Ph.D Theses Completed in 2004

Agyare, W.A. (2004): **Soil characterization and modeling of spatial distribution of saturated hydraulic conductivity at two sites in the Volta Basin of Ghana.** Ecology and Development Series No. 17

Abstract: One of the key parameters in hydrological and climate change modeling is a good estimation of the soil hydraulic properties in the region of interest. This study investigates the spatial distribution and variability of soil physical properties, with emphasis on saturated hydraulic conductivity (Ks) at two pilot sites in the Volta Basin of Ghana. It focuses on the potential of pedotransfer functions (PTFs) and artificial neural network (ANN) approach for estimating Ks. Saturated hydraulic conductivity was observed to be highly spatially variable; however, it can be estimated using selected PTFs and ANN for soils in the Volta Basin based on soil parameters that can readily be obtained from detailed soil maps.

Ajayi, A.E. (2004): **Surface runoff and infiltration processes in the Volta Basin, West Africa: Observation and Modeling.** Ecology and Development Series No. 18

Abstract: The study presents the analyses of field observations and simulation experiments with an event-based, two-dimensional hydrodynamic model. The model summarizes the interactions between temporally dynamic rainfall, infiltration process and surface runoff in a catchment with varied soil physiohydraulic properties, surface-roughness, slope-lengths and vegetation structure. Both observation and simulation results indicate that, the observation scale affects runoff coefficient and runoff discharge per unit area. The effect of scale is the result of spatial variability in infiltration opportunities, which vary with the slope length and distribution of saturated conductivity, leading to different transmission losses potential during runoff routing downslope. The magnitude of the difference is influenced by surface and vegetated microtopography; which determine the flow rate.

Braimoh, A.K. (2004): **Modeling land-use change in the Volta Basin of Ghana.** Ecology and Development Series No. 14

Abstract: Land change studies in a 5,400km2 area within the Volta Basin of Ghana were carried out using satellite image and socio-economic analyses. The dominant change process was conversion of natural vegetation to cropland at an annual rate of 5%. Reversible land change trajectories involving accumulation of woody biomass indicate a certain level of rainfall-induced ecosystem resilience. Linear and logistic regressions identified agricultural land suitability, distance from main market and localities, child-dependency ratio and population density as the main drivers of change. Policy measures that would relieve human pressure on vegetation resources, guarantee food supply and promote commercialization of agriculture are suggested.

Codjoe, S.N.A. (2004): **Population and Land Use / Cover Dynamics in the Volta River Basin of Ghana, 1960 - 2010.** Ecology and Development Series No. 15

Abstract: The study assesses effects of population growth on agricultural land and forest in the Volta River Basin of Ghana. Most districts of the research area are experiencing shortfalls in land suitable for agriculture and deforestation. The number of farm holdings is decreasing and practice of fallow lands (last consequences of the former shifting cultivation) is also vanishing. Although households are wealthier due to new sources of off-farm income, the use of tractor, inorganic fertilizer and improved seed variety for farming is still low due to high costs. On deforestation, increases in fuel wood use and agricultural extensification are the major causes.

***Duadze, S.E.K. (2004*)**: **Land use and land cover study of the savannah ecosystem in the Upper West Region (Ghana) using remote sensing.** Ecology and Development Series No. 16

Abstract: The study investigates land use and land cover classification methods, land use and land cover change detection and the drivers of the changes in the Upper West Region of Ghana. Stratification of LANDSAT images prior to classification improves classification accuracy. Savannah woodland area decreased from 1986 to 2000, while areas of farmland, mixture of grasses and shrubs as well as water bodies increased. The soils under closed savannah woodland have the highest fertility, whereas the farmland ones have the lowest. From 1984 to 2000 population increased by 32% (75% are farmers). Declining soil fertility of farmlands and growing population induce expansion of farmland, causing loss of woodland.

Intsiful, J.D. (2004): **Upscaling of land surface parameters through inverse SVAT modeling.** Ecology and Development Series No. 20

Abstract: The accurate representation of subgrid scale effects in climate models has been an issue of great controversy. In an attempt to resolve this controversy, a model-independent technique was developed in this study to upscale land surface parameters through inverse-SVAT modeling. Upscaling laws are derived, that map the distributed land surface parameters of a heterogeneous land surface to their corresponding effective parameter. Simpler averaging methods of comparable performance are derived from the inverse modeling results, which drastically reduce the computational effort. The proposed method shows better performance than most well known methods. More importantly, the method is applicable in many fields.

Obeng-Asiedu, P. (2004): **Allocating Water Resources for Agricultural and Economic Development in the Volta River Basin.** Doctoral thesis, University of Bonn, Germany

Abstract: The decreasing availability of freshwater in the Volta basin has been a major issue between Burkina Faso and Ghana, who occupy more than 80 percent of the basin. Both countries are expected to face water stress in the near future, and the absence of appropriate framework for coordination and cooperation between them could lead to conflicting relations, fostering mutual suspicion and inaccurate reports of their activities. However, it is likely that significant amounts of water will be reallocated from agriculture to higher valued domestic and industrial demands and this trend could fuel competition among the water-using sectors in the basin. Population pressure and changes in the hydrological cycle could also influence the future competition for water in the Volta basin. Although the Volta River has a great development potential, lack of investment in infrastructure development has plagued the basin. The impacts of these developments on water users in the basin have not been studied.

Hypotheses

1. The complex dynamics, tradeoffs and intersectoral water resource competition observed among various water uses is best explained in an integrated river basin framework.

2. River basin modeling, coupled with an appropriate institutional base can provide an effective mechanism for overcoming institutional, social, and cognitive limitations in dealing with complex water resource management problems.

The main aim of this study is to evaluate the costs and benefits as well as the tradeoffs and complementarities across water using sectors in the Volta River Basin, specifically Burkina Faso and Ghana.

The output of this work is the evaluation of alternative mechanisms (scenario analysis) for inter-sectoral water allocation through the development of an empirical model, which integrates the hydrological-institutional characteristics of water allocation in the Volta river basin; and analyzes the economic costs and benefits of water use in the various sectors. The optimization model is coded in GAMS.

Oguntunde, P.G. (2004): **Evapotranspiration and complimentarity relations in the water balance of the Volta Basin: field measurements and GIS-based regional estimates.** Ecology and Development Series No. 22

Abstract: This study concerns evapotranspiration, which accounts for 90% of the water balance in West Africa. At field level, crop and bare-soil albedo measurements were used to build simple models based on phenology, zenith angle and soil surface conditions. Interactions between tree water flux and environmental variables were examined. The complementarity Advection-Aridity (AA) relationship model adequately simulates the spatio-temporal distribution of regional ET rates. The monsoon clouds, harmattan and seasonal changes in surface albedo influence evapotranspiration processes in the Volta Basin. The good performance of the improved AA model indicates its utility for providing independent estimates of ET. These results are valuable input to eco-hydrology and climate models.

Osei-Asare, Y. (2004): **Household Water Security and Water Demand in the Volta Basin of Ghana.** Doctoral thesis, University of Bonn, Germany

Abstract: Ghana is water abundant but experiences seasonal and perennial water scarcities. The Volta basin of Ghana, the area of study, covers about two thirds of the land surface and is affected by the global climate change. This is manifested in large rainfall variability as expressed in periodic droughts. The extent of water availability, accessibility, quality and usage are issues to contend with and thus the motivation for this study. This study identifies the factors that determine a household's choice for domestic water sources using the discrete choice model and employs a conditional nested logit model. This choice has health and agricultural productivity implications. The determinants of rural household water demand are estimated using multiple regression analysis based on household utility maximisation theory. Estimating the demand for quality drinking water adopts three distinct approaches: First, the conventional approach where water is considered as potable or not potable; second, the perceptional approach where households rate water as good or bad quality; third, the bacteriological quality approach where water samples are taken to test for the presence of Escherichia Coli. Since the explanatory variables are identical and may have correlated errors, a seemingly unrelated regression model is then applied using feasible generalised least squares estimation method. Coping costs are derived with the opportunity cost of time spent fetching water considered. They give an indirect estimate of households' willingness to pay to secure water and represent the lower bound of willingness to pay for water. Using the 300 enumeration areas of the Ghana Living Standards Survey 4 (GLSS4) conducted by the Ghana Statistical Service in 1998/99 as sampling units for this study, Principal Component and Cluster Analysis are conducted to select representative communities with a random selection of households thereafter. This study seeks to provide adequate information to effectively plan and manage the scarce water resources and immensely contribute to Ghana's new Vision 2020 with respect to the water sector that seeks to attain 100% safe water supply coverage in all urban areas and over 90% coverage in rural areas.

Ph.D Theses Completed in 2005

Bagamsah, T.T. (2005): **The impact of Bushfire on Carbon and Nutrient Stocks as well as Albedo in the Savanna of Northern Ghana**. Ecology and Development Series No. 25

Abstract: Bushfires are an important ecological factor in tropical savannas. This study assesses the role bushfires play with regard to the carbon and nutrient fluxes in the savanna ecosystem of northern Ghana. Long-term repeated bushfires lead to serious losses of nitrogen with subsequent land degradation and to the release of considerable amounts of carbon dioxide into the atmosphere, which could affect the regional and even the global climate.

Compaore, H. (2005): **The impact of savannah vegetation on the spatial and temporal variation of the actual evapotranspiration in the Volta Basin, Navrongo, Upper East Ghana.** Ecology and Development Series No. 36

Abstract: Evapotranspiration was studied in savannah areas of the Volta Basin using remote sensing data and the Surface Energy Balance Algorithm for Land (SEBAL) model. Land-use and land-cover types, tree density as well as soil moisture distribution were identified as the most important biophysical and hydrological parameters influencing the spatial and temporal variation of evapotranspiration at the beginning and end of the dry season. In future studies, the long-term dynamics of the land cover should be included in the assessment of the hydrological role of savannahs in the Volta Basin.

Howard, N.K. (2005): **Multiscale analysis of landscape data sets from northern Ghana: Wavelets and pattern metrics.** Ecology and Development Series No. 31

Abstract: A fundamental characteristic of all landscapes is spatial heterogeneity, which is scale-dependent. To understand how spatial heterogeneity of landscapes in the Volta River Basin varies with scale, wavelet and pattern metric analyses were employed. The results of the wavelet analysis suggest that the normalized difference vegetation index and the fields of the digital elevation model are statistically self-similar and contribute to the basis for understanding how to assimilate landscape data into coarser resolution models. The results of the pattern metric analysis suggest that there is no optimal scale for characterizing spatial heterogeneity, and comparisons between landscape metrics must be based on the same spatial resolutions and extents. In addition, the results may provide practical guidelines for scaling spatial patterns.

***Martin, N. (2005*)**: **Development of a water balance for the Atankwidi catchment, West Africa – A case study of groundwater recharge in a semi-arid climate.** Doctoral thesis, University of Göttingen

Abstract: The weathered zone covering the base rocks of the West African Man Shield serves as the primary source of groundwater in wide areas of the Volta River basin. Knowledge of the processes and the annual rate of groundwater recharge is a prerequisite to sustainable groundwater resources management. This study assesses the water budget of a 275 km² river catchment in the semi-arid north of Ghana. The core of the presented research is the determination of groundwater recharge using an integrated approach which combines field methods with water budget and groundwater modeling. The study also presents a conceptual model of the hydrogeological system and relevant aquifer parameters.

Schüttemeyer, D. (2005): **The surface energy balance over drying semi-arid terrain in West Africa.** Doctoral thesis, Wageningen University, The Netherlands

Abstract: One of the fundamental aspects of current research in earth system science is the proper understanding of land-atmosphere interactions. The role of the land surface is crucial in the climate system, since a large fraction of incoming solar radiation passes through the atmosphere and is converted at the surface into turbulent fluxes. For numerous regions, including the semi-arid regions, only little knowledge is available about the diurnal and seasonal cycle of land surface interactions. The semi-arid areas pose a big challenge due to the large contrasts of dry and wet situations within a seasonal cycle. This is especially valid for the semi-arid region in West Africa, since it is one of the most climatically sensitive and ecologically unstable regions in the world. The variability of weather and climate in the region is strongly influenced by

complicated interactions and feedbacks between the land and the atmosphere. To analyze and to predict these interactions and feedbacks it is inevitable to measure and model the involved components. Since standard methods for this purpose are not always applicable to the heterogeneous surface in West Africa, new measurement and modeling techniques have to be applied.

The overall objective of this thesis is to analyze and to model the land surface interactions in the Volta basin, West Africa, by using meteorological data obtained in the framework of the GLOWA-Volta project. A focus is put on diurnal and seasonal time scales. For measuring turbulent fluxes the key instrument is the large aperture scintillometer. This robust method yields area-averaged fluxes over complex terrain, which are required when analyzing meteorological data from heterogeneous surfaces. It is found that it is a suitable technique for the kind of environment also in comparison to different measuring techniques. Based on the analysis of the measurements, two different land surface schemes are evaluated. Both schemes are not able to reproduce the measured seasonal cycle in surface fluxes. Several changes are proposed to obtain enhanced model performance.

Based on the earlier findings a model is constructed, combining the best parts of each of the two land surface schemes. It is shown that the performance of the new formulation is more realistic. Using a factorial design as the sensitivity analysis method it is assessed, which parameters are the most important. Furthermore it is found that those important parameters and their interactions change significantly during one season. As a final step the gained knowledge is utilized to construct a simple satellite based algorithm to obtain surface water flux as the important flux on a regional basis. For evaluating this first order approach the large aperture scintillometer is utilized to evaluate fluxes on satellite pixel scale.

Tsegai, D. (2005): **The Economics of migration in the Volta basin of Ghana: Household and district-level analysis.** Doctoral thesis, Center for Development Research (ZEF), Bonn

Abstract: The study addresses migration determinants and effects in the Volta Basin of Ghana. The study is carried out at household and district levels, in which the two major data sources are the household survey and the Ghana Census 2000 data (a complete matrix of inter-district migration flows) respectively. Based on the household survey data, this study investigated the determinants of the decision to migrate within the Volta Basin of Ghana with a special emphasis on the role of migration income affecting household migration decisions. To do this, it built upon the New Economics of Labour Migration (NELM), a theory which considers the role of intra-household exchange of information for the migration decision of household members. As migrants are non-random part of the population, the migration equation was corrected for selectivity bias using the Heckman procedure. The direct and indirect effects of rural out-migration in the source community are also examined using the survey data. Iterated Three Stages Least Squares (3 SLS) method was employed to determine and measure the net effect of migration on the income sources of households. This study, using the Ghana Census 2000 data, also attempted to explain gross inter-district migration flows by readily relating migration to certain aggregate proxy district-level variables. The gravity model is employed and modified to include basic district characteristics.

Estimation results showed statistically significant effects of income differential on the households' decision to participate in migration. This result lends credence to the importance of economic incentives on the intra-household migration decision making process. Results of the 3 SLS model also showed that the loss of labour to migration has a negative effect on household farm income in source areas. However, there is also evidence that remittances sent home fully compensate for this lost-labour effect, contributing to household incomes directly and also indirectly by stimulating farm and non-farm self-employed production. Consequently, these findings present evidence in support of the NELM hypothesis that remittances loosen constraints on production and the imperfect market environments characterizing rural areas in developing countries.
In the district level analysis, important district attributes explaining the 'in' and 'out' flows are illuminated. Based on the findings of the preliminary analysis and pertinent theoretical reasons, the 'gross' migration, instead of the 'net' migration flow approach is chosen. Results demonstrate that there is much overlap between places of moderately high in- and out-migration rates. Overall, migration in the Volta Basin of Ghana is predominantly over short distances and economic factors and health facilities play a significant role in directing migration flows in the Volta Basin of Ghana.

Yilma, T. (2005): **Modelling farm irrigation decisions under rainfall risk in the White-Volta Basin of Ghana: A tool for policy analysis at the farm-household level.** Doctoral thesis, Center for Development Research (ZEF), Bonn, Germany

Abstract: Poor natural resource base coupled with weak policies and institutional set ups made poverty in the semi-arid tropics of northern Ghana prevalent. Rainfall risk in particular is important in limiting the use of improved technologies such as fertilizer and in decreasing agricultural productivity. Farm households living in the White-Volta basin of the Upper East Region of Ghana share this episode. Expansion of irrigation agriculture was long perceived as a development strategy to solve the multifaceted problems in the study area.

This perception led to an investment on both medium and small scale irrigation. However, the existing stringent macroeconomic regime in Ghana limited the public sector's capacity to finance irrigation. Nevertheless, the increasing gap between local production and demand for cereals like rice kept irrigation expansion as a core strategy in Ghana's rural development endeavor up to now. Using both primary and secondary datasets this study analyzed determinants of household irrigation decision in the White Volta basin of the Upper East Region of Ghana. The study also built a Safety-First Risk Programming Model to simulate the impact of different policy interventions on subsistence and commercial farm households' irrigation decisions. The findings of this study suggest that household asset endowments in general and labor endowment in particular play significant role in farm households' irrigation decision. Both econometric and simulation analyses showed a complementarity between household irrigation decision and off-farm participation. The complementarity confirms well with the observation that in the absence of credit services farmers resort to alternative sources of finance such as off-farm income to finance irrigation. A significant increase in agricultural finance to commercial farmers increases their demand for labor that could be profitability supplied by the subsistence farm group. Finally, the findings of this study suggest that expansion of irrigation promotes the use of mineral fertilizer.

Ph.D Theses Completed in 2006

Amisigo, B. (2006): **Modelling River Flow in The Volta Basin Of West Africa**. **A Data-Driven Framework**. Doctoral Thesis, TU Delft

Abstract: In this thesis, a riverflow modelling framework developed for monthly riverflow prediction in the Volta Basin is presented. By analysing available catchment rainfall, runoff and potential evapotranspiration series in the basin using methods such as correlation plots, autoregressive (AR) and autoregressive with exogenous input (ARX) modelling, it is shown that the monthly catchment rainfall-runoff process is better characterised by non-linear models. First, a spatio-temporal linear dynamic model employing the Kalman smoother and the Expectation-Maximisation (EM) algorithm was developed and applied to filling in short gaps in daily riverflow series in the basin. This model was found to be a very good and powerful tool for filling in such data gaps.

Then, two non-linear modelling frameworks - a non-linear autoregressive and moving average with exogenous input (NARMAX) polynomial and a data-based mechanistic (DBM) modelling framework - were developed and applied to the monthly rainfall-runoff series in the basin for river catchment runoff prediction. The NARMAX model was able to capture much of the nonlinearity in the runoff generation process and provided good predictions of riverflow. However, it is a purely black-box formulation providing no physical interpretation of the runoff process in the basin. The DBM framework was very successful in representing the runoff mechanism in the basin, adequately predicting monthly river runoffs. Unlike the NARMAX models, the DBM framework is a grey-box that provided physically interpretable results at the catchment scale. Results from this modelling framework show that monthly runoff in the basin can be interpreted to occur in two pathways: a fast flow pathway and a slow, mainly delayed flow, pathway. Catchment effective rainfall in the basin was found to have a power law relationship with catchment runoff. In addition, the Identification of unit Hydrographs And Component flows from Rainfall, Evaporation and Streamflow (IHACRES) type effective

rainfall-catchment wetness non-linear relationship in which the basin drying time constant is exponentially related to basin potential evapotranspiration, was found to be suitable for characterising the runoff processes in the basin. Therefore, it is recommended that data-driven approaches be considered as the most appropriate for riverflow modelling in the Volta Basin. This is due, in part, to the fact that the approaches provide very good results that are, to some extent, physically interpretable and also because the quality, quantity and diversity of hydrological data used for riverflow modelling In the basin are too poor to enable effective use of the more elaborate distributed hydrological models.

Jung, J. (2006): **Regional Climate Change and the Impact on Hydrology in the Volta Basin of West Africa**, Doctoral Thesis, IMK-IFU, Garmisch-Partenkirchen

Abstract: A comparison the GCM output, as well as the RCM output for present-day climate simulation to observations showed a wet bias over the Sahel and a sufficient accuracy in temperature representation for the ECHAM4, present-day simulation (1961-1990). In the regional climate simulations, the displacement of the Inter Tropical Discontinuity (ITD) to the North at the beginning of the rainy season, as well as the displacement South, at the end occur too early. Rainfall also showed a negative deviation along the coast but a sufficient accuracy in the Volta Basin.

The results of the MM5 and WaSiM simulations show an annual mean temperature increase by 1.2-1.3_C in West Africa and the Volta Basin. This temperature change significantly exceeds inter-annual variability. Mean annual precipitation increases for both, the sahelian and the coastal region of West Africa. Averaged over the region of the Volta Basin, this increase is about 5%. Only in the Sahel, the mean annual change signal exceeds simulated inter-annual variability. Spatially the increase is highly heterogeneous, reaching from -20% to +50%. A dipole pattern of rainfall variability in the Sahel and the Guinea Coast region was detected for June and July. An overall increase in precipitation was found for September, and a strong decrease for April. Causes for the rainfall variability were found in the dynamics of the Tropical Easterly Jet (TEJ), the African Easterly Jet (AEJ) and in the position of the ITD. For the Volta basin it is demonstrated, that the decrease in April at the beginning of the rainy season is not only connected to smaller rainfall amounts, but also to a delay in the onset of the rainy season. In addition, inter-annual variability in the Volta Basin increases in the early stage of the rainy season, while annual mean aridity in the Volta Basin does not change significantly.

No significant changes in discharge follow the precipitation decrease at the onset of the rainy season. During the rainy season, most of the surplus rainfall evaporates, due to the increase in potential evaporation, as a consequence of higher near surface air temperatures. The study demonstrates the ability of the coupled modelling system to reasonably simulate West African climate and hydrology conditions. For the selected scenario and time slices, the change signal in precipitation, as well as surface and subsurface hydrology variables lies with few exceptions, within the range of inter-annual variability, whereas temperature shows a clear increase.

Ph.D Theses Completed in 2007

Eguavoen, I. (2007): **"Now you have a new pump, you have to manage it." Household water management, water rights and institutional change in Northern Ghana.** Doctoral Thesis, ZÉF / Cologne University

Abstract: The study is concerned with water - a natural resource, which embodies a combination of specific and unique characteristics. One of them is the incorporation of it in the human body. "Though we appear to be solid, we are really liquid bodies […] And although we tend to dry up a little bit as we grow older, we still remain mostly water (about 65 percent)" (Hillel 1994: 20). Freshwater is indispensable and irreplaceable for human life, especially for primary uses, such as drinking, food preparation and hygiene. It is necessarily interwoven with human societies, their settlements and their history. Water management is embedded in local resource management schemes, which also embrace other natural resources, such as land, flora and

fauna. It is informed by interactions between people and their natural but also their socio-political environment. Management practices and rules over resource use and allocation may be adapted to the environment and transferred from generation to generation and in this way become a part of the institutional repertoire of a society. But the environment also undergoes changes and people react towards these changes. At the same time, human activities shape their socio-political but also their natural environment. This dissertation focuses on such changes and interrelationships by the examination of household water and its local management.

Laube, W. (2007): **Changing Resource Regimes in Northern Ghana: Actors, Structures and Institutions**, Doctoral Thesis, ZEF Development Studies Vol. 4. Münster: LIT Verlag

Abstract: In Northern Ghana, regimes regarding land and water that were based on spiritual beliefs and the local kinship system have been changing since the colonial promotion of indirect rule and the forceful acquisition of resources for development purposes by the government. This has led to a situation, in which inclusionary rules, norms and values have been partly replaced with formalized and rather exclusionary institutions. This thesis uses the example of the Tono Irrigation Project to show how, within the framework of changing national and global economic, political and ideological structures, different actors, such as small-scale and commercial farmers, earthpriests and chiefs, project personnel as well as local and regional politicians, have invested considerable bargaining power in the ongoing negotiation process over the institutional control of and access to (natural) resources. The book describes a precarious local power balance and a complex institutional framework in which different actors rely on different institutional frameworks and changing political alliances in order to pursue their interest.

F2. Antonio's GLOWA Volta Database Questionnaire

The GLOWA Volta Data Questionnaire

For getting a better understanding of your current situation in data management issues (related to current GVP or water management activities) we please you to give us a short overview about your work environment in relation to data and its management by filling in this questionnaire. We don't need at this moment a detailed analysis, so answers in **catchwords** will be adequate. The questionnaire is constructed for being filled out in 20 minutes. If you aren't in the situation to answer one of the questions please skip it or ask me for help.

Thanks a lot for your help!

Antonio Rogmann, Data Management Team - GLOWA Volta Project
Accra, 01.06.07

Personal Information

Name:

Position:

Mail/phone (office):

Working/Official Information

Your Institution/Organization?

What are the current concerns and priorities of your organization in sectors water resources?

To which partner institutions are you mainly related in your daily work?

Software / Data / Data flows

Which (specialized) software / models are you using (e.g. ArcView, WEAP, Excel…)?

What is the thematic content of data used by you or your team? Please specify if possible

☐ Hydrological data (e.g. discharge): **……..**

☐ Meteorological data (e.g. precipitation): **.....**

☐ Data on Economics (e.g. agricultural markets):**……..**

☐ Data on Sociology (e.g. demography):**……..**

☐ GIS data (e.g. land cover, land use):**……**

☐ others: **……**

Do you or your organisation collect any data directly from any site?

☐ yes

☐ no

Data flows

From where do you usually receive/collect your data (institutions / organisations)?

How do datasets reach you?

☐ per mail

☐ per CD/DVD sent by post

☐ download from a server, hosted by: **……**

☐ I have to pick up the data personally

☐ others:**……**

Do you regularly share data outside of your own department (e.g. model outputs, own measurements)? If yes, to whom?

How do you deliver the data?

☐ per mail

☐ per CD/DVD sent by post

☐ download from a server, hosted by: **……**

☐ the data has to be picked up personally

☐ others:**……**

When you search for (new) data, how do you get information about sources or providers?

☐ the data sources are known
☐ asking colleagues or partner institutions
☐ by using a data inventory which is hosted by **……**
☐ using search facilities in the internet
☐ searching in meta databases in the internet, hosted by **……..**
☐ others:**…….**

Are you missing data which is needed for your ongoing or further activities? If yes, which one?

Data Management (Standards)

How is the data stored in your department?

☐ each researcher has his data stored locally on his computer
☐ a database is part of the internal network
  ☐ within a file system
  ☐ within a relational database. Database management system (if known): ……....

☐ on external data mediums (CD, DVD, …)
☐ others:**……**

Do your department / organization maintain an inventory or a meta database indicating available data?

☐ meta database
☐ catalog
  ☐ digital
  ☐ on paper

If you (your organization) are (is) maintaining a meta database, which database management system and standard is in use?

Which problem(s) regarding the use of data are you faced with?

☐ It's difficult to get information about required data in respect to
  ☐ the provider
  ☐ the quality of data
  ☐ the content and formats of data
  ☐ use rights / prices
  ☐ the software (versions) data has been processed
  ☐ others **…….**

☐ It's difficult to get the datasets required in respect to
- ☐ getting access to data
- ☐ quality of data (gaps, outliers ….)
- ☐ formats
- ☐ others:**……..**

Do you handle data with reserved copyrights?

☐ yes
☐ no
☐ partly

Do you have a dedicated data manager / administrator in your department? (If yes, please provide his name and contact address)

Thank you!!!

F3. Names/addresses/contact numbers (phone/e-mail) of Participants who attend

	Name	Participate		Affiliation	Address	E-mail Address	Phone
1	**Mr. Ben Ampomah**	**yes**	**WRC**	**Water Resources Commission**	Box CT 5630, Accra	byampomah@yahoo.com	244874138
2	**Mr. Isaac Asamoah**	**yes**	**WRC**	**Water Resources Commission**	Box CT 5630, Accra	gzoris2000@yahoo.com	244266187
3	**Dr. Kankam-Yeboah**	**yes**	**WRI**	**Water Research Institute**	Box m.32, Accra	kyeb59@yahoo.com	287298328
4	**Dr.Emmanuel Bekoe**	**yes**	**WRI**	**Water Research Institute**	Box m.32, Accra	eobekoe@yahoo.com	242729297
5	**Mr. Zinedeme Minia**	**yes**	**GMA**	**Ghana Meteorological Agency**		meteo@africaonline.com	243658291
6	**Mr. Ayilari-Naa Juati**	**yes**	**GMA**	**Ghana Meteorological Agency**	Box 9471 KIA, Accra	juatia@yahoo.co.uk	244747052
7	**Mr. Jonathan Allotey**	**yes**	**EPA**	**Environmental Protection Agency**	Box m326, Accra	jallotey@epaghana.org	662693
8	**Mrs. Jewel Kudgawu**	**yes**	**EPA**	**Environmental Protection Agency**	Box m326, Accra	jkudgawu@epaghana.org	662465
9	**Mr. J.W. Sutherland**	**yes**	**VRA**	**Volta River Authority**	Box MB 77, Accra	jwsutherland@yahoo.co.uk	0244321955/02 5120388
10	**Mr. Charles Addo**	**yes**	**VRA**	**Volta River Authority**			27572400811
11	**Mr. Christian Siawor**	**yes**	**GWCL**	**Ghana Water Company Limited**	Box M 194 Accra	chrissiaw@yahoo.com	24235498
12	**Mr. Kwabena Boateng**	**yes**	**GIDA**	**Ghana Irrigation Development Authority**	Box MB 154, Accra	kwabenaboateng07@yahoo.com	0242320697/02 1662050
13	**Prof. Esi Awuah**	**yes**	**KNUST**	**Civil Engineering Department**		esiawuahrt@yahoo.com	
14	**Mr J. Wellens-Mensah**	**yes**	**HSD**	**Hydrological Services Department**	Box MB 501, Accra	hsd@ghana.com	677383
15	**Mr. Harold Clottey**	**yes**	**HSD**	**Hydrological Services Department**	Box MB 501, Accra	hsd@ghana.com	208167788
16	**Mr. Alhassan L. Abdulai**	**yes**	**SARI**	**Savanna Agricultural Research Institute**	Box TL 52, Tamale	alabdubi@yahoo.co.uk	244577646
17	**Dr. Osman Gyasi**	**yes**	***SARI***	***Savanna Agricultural Research Institute***			
18	**Dr. M k Nkrumah**	**yes**	**UDS**	**UDS: Faculty of Integrated Development Studies**	P.O.Box 520, Wa, UWR	mk1950_2000@yahoo.com	244591236
19	**Mr. Ted Y. Annang**	**yes**	**VBRP**	**University of Ghana, Legon –VBRP**	P.O.Box LG 209, Legon	niiyemoh@ug.edu.gh	0208362522(3)
20	**Dr. Felix Assante**	**yes**	**ISSER**	**University of Ghana, Legon_ISSER**	Box LG 74, Legon	fasante@ug.edu.gh	244635190
21	**Prof. C. Gordon**	**yes**	**CAW**	**Center for African Wetlands**	P. O.Box 67, LEG	afriwet@	572835
22	**Dr. W.E.I Andah**	**yes**	**CPWF**	**Challenge Program on Water and Food**	WRI BOX M 32 Accra	weiandah@africaonline.com.gh	775511
23	**Mr. James Oppong**	**yes**	**SRI**	**Soil Research Institute**		aojppong@yahoo.com	246619410
24	**Ms. Basilia**	**yes**	**CONIWAS**	**Coalition of NGOs in Water and Sanitation**	PMB KA 24, Air Port Accra	coniwas@yahoo.com	21250816
25	**Mr. Nii Boi Ayibotele**	**yes**	**GWP**	**Ghana Country Water Partnership**	Box OS 981 OSU	ayibotele@ghana.com	761007
26	**Mr. Emmanuel Donkor**	**yes**	**WA-net**	**WA-net: West Africa Capacity Building Network**		donkordce@yahoo.com	277426013
27	**Mr. P. Francis Ampomah**	**yes**	**TREND**	**Training and Research Network for Development**	Box WS 425 Accra	pfampadu@yahoo.com	244547105
28	**Mr. Obiri Samuel**	**yes**	**CEIA**	**Centre for Environmental Impact Analysis**	Box 61, Cape Coast	obirisamuel@yahoo.com	244708322
29	**Mr. Richard Twum**	**yes**	**VBDF**	**Volta Basin Development Foundation**	Box MB 516, Accra	twums@yahoo.com	244451033
30	**Mr. Michael Kordetey**	**yes**	**VBDF**	**Volta Basin Development Foundation**	Box MB 516, Accra	mike@yahoo.com	244939587
31	**Dr. Y. Opoku-Ankomah**	**yes**	**CSIR**	**Counsel for Scientific and Industrial Research**	P.O.Box M.32	yankomah@yahoo.com	244611470
32	**Mr. Samuel Nortey**	**yes**	**IMS**	**Institute of Mathematical Sciences**	Box LG197 Legon, Accra	ssamnot@yahoo.com	246145490

33	**Mr. Dominic Pokperlaar**	**yes**	**IMS**	**Institute of Mathematical Sciences**	Ghana Met. Service, Box 9, Tamale	soami-pokperbar@yahoo.com	244437372
34	**Ms Shirley Akasreku**	**yes**	**KACE**	**Ghana-India Kofi Annan Centre of Excellence in ICT**	PMB, Accra	shirleyak@aiti-kace.com.gh	249301186
35	**Mr. Kwasi Kwakwa**	**yes**	**KACE**	**Ghana-India Kofi Annan Centre of Excellence in ICT**	PMB, Accra	kwasik@aiti-kace.com.gh	243362546
36	**Dr. Yaw Osei-Asare**	**yes**	**UoG**	**University of Ghana, Legon –Agric.**		yankomah@yahoo.com	244611470
37	**Prof. SGK Adeku**	**yes**	**VBRP**	**University of Ghana, Legon –VBRP**		s_adiku@ug.edu.gh	243713900
38	**Mr. Benjamin D. Ofori**	**yes**	**VBRP**	**University of Ghana, Legon –VBRP**		benod_ofori@yahoo.co.uk	208134292
39	**Mr. Samuel S. Koranteng**	**yes**	**VBRP**	**University of Ghana, Legon –VBRP**		skoranteng@ug.edu.gh	244721188
40	**Ms. Araba Aikins**	**yes**	**WRI**	**Water Research Institute**	P.O.Box M. 32	arabaaikins@yahoo.com	244470902
41	**Mr. Abrefa Darasuh**	**yes**	**UoG**	**University of Ghana, Legon**	P.O.Box. LG 68, Legon	abrefad@yahoo.com	242020426
42	**Mr. Manful Desmond**	**yes**	**WRC**	**Water Resources Commission**			763651
43	**Mr. Kwabena Boateng**	**yes**					
44	**Mr. E. K. Atubra**	**yes**	**VRA**	**Volta River Authority**			
45	**Mr. Jonathan Hagan**	**yes**	**VRA**	**Volta River Authority**			
46	***Dr. Wolfram Laube***	**yes**	**GVP/ZEF**	**GLOWA-Volta Project /Zentrum für Entiwicklungsforschung**		wlaube@uni-bonn.de	246309917
47	***Dr. Victor Afari-Sefa***	**yes**	**GVP/ZEF**	**GLOWA-Volta Project /Zentrum für Entiwicklungsforschung**		vafaris@uni-bonn.de	49228731879
48	***Dr. Wilson Agyare***	**yes**	**GVP/SARI**	**GLOWA-Volta Project /SARI**		wagyare@hotmail.com	244058675
49	***Dr. Barry Boubacar***	**yes**	**GVP/IWMI**	**GLOWA-Volta Project /Zentrum für Entiwicklungsforschung**		b.barry@cgiar.org	244772525
50	***Dr. Barnabas Amisigo***	**yes**	**GVP/WRI**	**GLOWA-Volta Project/WRI/UNU-INRA**			
51	***Dr. Konadu Acheampong***	**yes**	**UNU-INRA**	**United Nations University-INRA**	UNU-INRA, PMB, KIA, Accra	acheampong@inra.unu.edu.gh	
52	***Mr. Antonio Rogmann***	**yes**	**GVP/ZEF**	**GLOWA-Volta Project /Zentrum für Entiwicklungsforschung**		arogmann@uni-bonn.de	49228734904
53	***Dr. Dilnesaw Alamirew***	**yes**	**GVP/UNU**	**GLOWA-Volta Project/UNU-INRA**		dilnesaw@yahoo.com	246739851
54	***Prof. Karl Harmsen***	**yes**	**UNU-INRA**	**United Nations University-INRA**		karlharmsen@yahoo.com	21500396
55	***Mr. Raymond Kasa***	**yes**	**GVP**	**GVP-PhD Student**	IWMI, PMB, CT 112, Accra	rkasei@uni-bonn.de	208122243
56	***Mr. Daniel Spalthof***	**yes**	**GVP**	**GVP-PhD Student**	IWMI, PMB, CT 112, Accra	spalthof@uni-bonn.de	246771533
57	***Ms. Lumor Mawuli***	**yes**	**GVP**	**GVP-M.Sc. Student**		maclumor@yahoo.com	244533990
58	***Ms. Yongxuan Gao***	**yes**	**IWMI**	**International Water Management Institute**		xuan.gao@tufts.edu	7812678003
59	**Mr. Joseph Dodoo**	**yes**	***GBC-radio***				
60	**Mr. Yahaya Kwamoah**	**yes**	***GBC-radio***				
61	**Mr. Micheal Yeboah**	**yes**	***Times***				
62	**Ms. Joyce Anti**	**yes**	***Spectator***				
63	**Ms. Monika A. Paintsil**	**yes**	***Spectator***				
64	**Mr. R. K. D. Van Ess**	***no***	***CWSA***	***Community Water and Sanitation Agency***			

65	**Mr. John Aduakye**	***no***	***CWSA***	***Community Water and Sanitation Agency***			
66	**Dr. K.Pelig-ba**	***no***	***UDS***	***UDS: Faculty of Applied Sciences***			
67	**Dr Nathaniel K. Howard**	***no***	***UCC***	***University of Cape Cost***			
68	**Dr. Charles Rodgers**	***no***	***GVP/ZEF***	***GLOWA-Volta Project /Zentrum für Entiwicklungsforschung***			
69	**Dr. Shiloh Osae**	***no***	***IMS***	***Institute of Mathematical Sciences***			
70	**Dr. Steve Tonah**	***no***	***UG***	***Dep. Of Sociology***			
71		***no***	***MWH-water***	***Min. of Water, Works and Housing (Water Directorate)***			
72		***no***	***MoFA***	***MFA: Ministry of Food and Agriculture***			
73		***no***	***ISODEC***	***Integrated Social Development Centre***			