SATELLITE–BASED ASSESSMENT OF NATURAL AND HUMAN-INDUCED ENVIRONMENTAL CHANGE IN LAKE ECOSYSTEMS: THE CASE OF KAINJI LAKE IN NIGERIA

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Presented at the 2nd Regional Workshop on Decision Making Support for Coastal Zone Management, Water Resources and Climate Change in Africa (15th -17th February 2010), International Conference Centre, Cotonou, Republique du Benin

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OUTLINE OF PRESENTATION

- Brief Introduction to CCCFR
- Introduction to the Project
- General Description of the Study Area
- Project Methodology
- Extracting Topographic Structure from DEM
- Assessing Land use change
- Analyzing Flood Maps of the Study Area
- Strategies for Reducing the impact of Flood within the Study Area
- Conclusion

COMBATING CLIMATE CHANGE IN NIGERIA

- The country has not yet formulated policies to enhance adaptation to climate change.

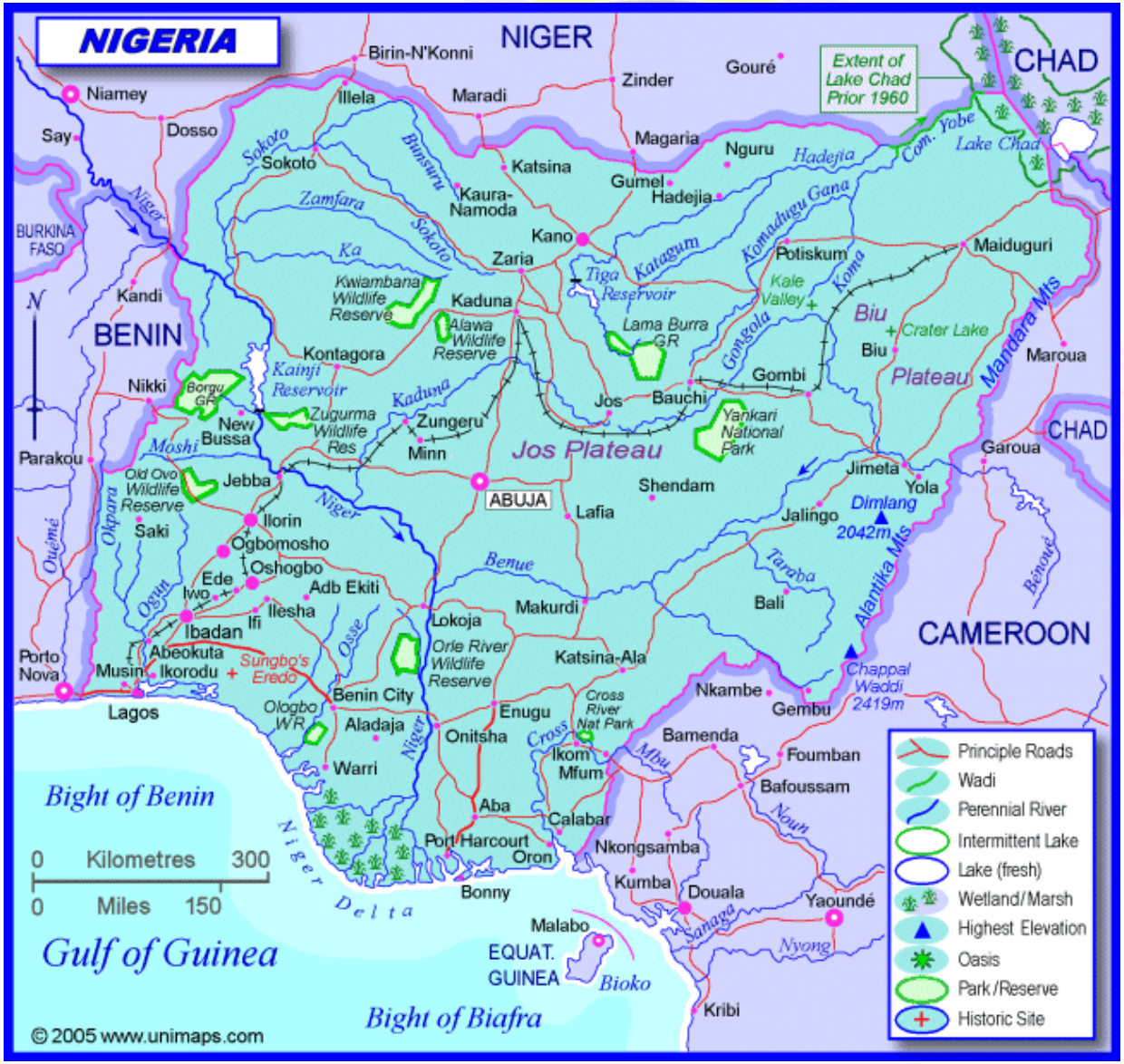
- HOWEVER, EFFORTS WERE MADE:
  - PRODUCTION OF 1ST NATIONAL COMMUNICATION, 2ND IS IN PREPARATORY STAGE;
  - HOUSE COMMITTEE ON CLIMATE CHANGE;
  - STRATEGY OF ACTION ON ADAPTATION ABOUT TO BE REVIEWED (WITH HBF);
  - CREATION OF SPECIAL CLIMATE CHANGE UNIT IN THE FEDERAL MINISTRY OF ENVIRONMENT;
  - PASSING OF BILL ON CLIMATE CHANGE COMMISSION BY SENATE AND HOUSE OF REPRESENTATIVES, SIGNING ??
- **LINKAGE CENTRE ON CLIMATE CHANGE AND FRESHWATER RESOURCES WAS PROACTIVELY ESTABLISHED IN 1995 HOSTED BY THE FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA**

- **ONGOING RESTRUCTURING OF THIS CENTRE BEGAN IN 2008 TO EXPAND THE SCOPE TO EMBRACE KEY APPLIED RESEARCH THEMES**

BRIEF OF FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

- ONE OF THE FOUR SPECIALIZED UNIVERSITIES OF TECHNOLOGIES ESTABLISHED IN 1983 (WWW.FUTMINNA.EDU.NG);
- HAS TWO CAMPUSES: BOSSO CAMPUS AND GIDAN KWANO CAMPUS (10,650 HECTARES) ENOUGH LAND TO ESTABLISH SOLAR ENERGY GENERATION PLANTS (FAMU), AMONG OTHERS;
- LOCATED WITHIN THE NORTH CENTRAL ZONE OF NIGERIA IN A TRANQUIL AND PEACEFUL TOWN CALLED MINNA; A BUFFER ZONE BETWEEN THE FRONTLINE STATES AND COASTAL STATES;
- ACADEMIC STAFF STRENGHT OF 666 (IN 2009), OVER 10,000 STUDENT POPULATION

BRIEF OF FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA



BRIEF ON FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

- HOUSES FOUR SCHOOLS (FACULTIES): SCHOOL OF SCIENCE AND SCIENCE EDUCATION, SCHOOL OF ENVIRONMENTAL TECHNOLOGY, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY AND SCHOOL OF AGRICULTURAL TECHNOLOGY

- THREE ADDITIONAL SCHOOLS WERE RECENTLY CREATED (2009): SCHOOL OF INFORMATION AND COMMUNICATION TECHNOLOGY, SCHOOL OF ENTREPRENEURSHIP AND MANAGEMENT TECHNOLOGY AND SCHOOL OF HEALTH SCIENCES AND TECHNOLOGY

- 5 CENTRES, AMONGST THESE IS CCCFR, AND TWO DIRECTORATES;

CENTRE FOR CLIMATE CHANGE AND FRESHWATER RESOURCES

- ESTABLISHED AS LINKAGE CENTRE TO THE FEDERAL MINISTRY OF ENVIRONMENT FOR THE CONDUCT BASIC AND APPLIED RESEARCH AND TRAINING ACTIVITIES ON CLIMATE CHANGE ISSUES (VULNERABILITY, ADAPTATION AND MITIGATION)

- LOW LEVEL OF AWARENESS ON AND LIMITED FUNDS TO PURSUE CLIMATE CHANGE ACTIVITIES SLOWED DOWN THE CENTRE'S PROGRESS UNTIL 2004 (ACTION PROJECT TO COMBAT CLIMATE CHANGE INDUCED DISASTERS IN NIGERIA: $700,000 USD)

- ADMINISTERED AND MANAGED BY THE BOARD OF GOVERNORS CONSISTING OF RELEVANT EXTERNAL AND INTERNAL STAKEHOLDERS (E,G. NIGERIA METEOROLOGICAL AGENCY, FEDERAL MINISTRY OF ENVIRONMENT (SPECIAL CLIMATE CHANGE UNIT), FED. MINS OF SC AND TECH

- THE TWO FLOOR FACILITY HOUSES OFFICES, LABORATORY FOR CLIMATE MONITORING, ANALYSES AND MODELING, TRAINING /CLASS ROOM

CENTRE FOR CLIMATE CHANGE AND FRESHWATER RESOURCES

- Restructured to consist of five units with coordinators reporting to the director. Expertise is drawn from various departments within the University, and nationally and internationally, if need be. The Units are: climate change unit, food security unit, water resources unit, indigenous climate change technologies unit and geospatial analyses unit

- Expertise drawn from various relevant departments within the university:
  - Food security Unit: (department of crop production, soil science, animal production (livestock and poultry), food technology, agricultural economics and extension technology;

- Water Resources Unit: Department of water resources, aquaculture and fisheries technology, Geology, Public Health

- Climate Change Unit: Department of Geography (climatology, meteorology etc), Mathematics, Computer Science;

CENTRE FOR CLIMATE CHANGE AND FRESHWATER RESOURCES

- Indigenous Climate Change Technologies Unit: Departments of mechanical engineering, chemical engineering, civil engineering, building, agricultural and bio-resource engineering, electrical and electronics engineering, physics, industrial and technology education;

- Geospatial Analyses Unit: Department of, Geography (Geostatistics, GIS and RS), Urban and Regional Planning, Computer Science and Mathematics;

TRAINING PROGRAMMES:

- CCCFR has introduced a certificate course aimed at linking disaster risk reduction with climate change adaptation called DVARR (Climate Change induced Disaster Vulnerability Assessment and Risk Reduction): Basic, Advanced and Professional Certificates;

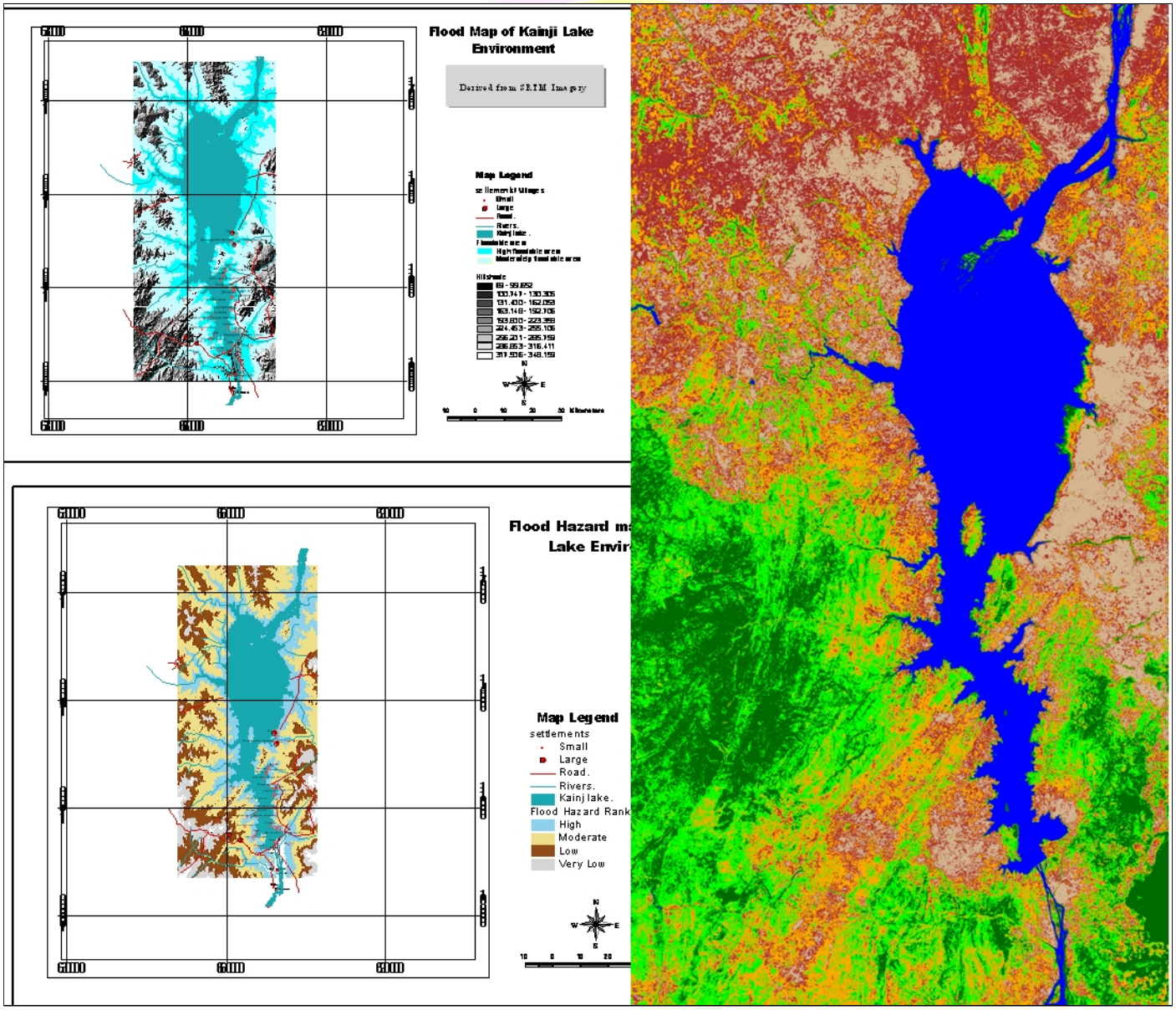
- **Others include short term training workshops on climate change adaptation assessment for various sectors; climate change mitigation (REDDS, CDM etc); climate modeling, analyses and prediction; and climate change policy analysis and appraisal;**

CENTRE FOR CLIMATE CHANGE AND FRESHWATER RESOURCES

- TRAINING PROGRAMMES:
  - Gradual build up to degree programmes on climate change;

- MOST RECENT RESEARCH ACTIVITIES (2009):
  - Case Studies of Sustainable Land Management Approaches to Mitigate and Reduce Vulnerability to Climate Change in Sub-Saharan Africa: The case of Niger state, Nigeria (IFPRI)
  - Climate Change, its Impacts and Adaptation: Gendered Perspective from Northern Nigeria (HBF)

THE STUDY


Flood Map of Kainji Lake Environment
Derived from SRTM Imagery
Map Legend
Flood Hazard Rank
High
Moderate
Low
Very Low
Kainji lake.
Rivers.
Road.
Small
Large

Introduction

- Inland waters are known to be sentinels and integrators of human impacts on terrestrial and aquatic ecosystems. Whether it is the cycling or fate of nutrients, organic carbon, contaminants, or pathogens, the water that drains these systems provides critical signals of past and present disturbance that, in turn, provide the foundation for forecasting future impacts (Williamson et al 2008).

  - Carbon processing rates of these ecosystems can facilitate in**tegration of the impacts of environmental change across a broad range of landscapes** from local (extinction of endemic species) to global scale (climate change).

  - Global climate change is transforming aquatic ecosystems (Poff *et al. 2002).*

  - Critical questions to provide answers to included: **how do we begin to understand the causes of large-scale changes in aquatic ecosystems, and how can we forecast and prepare for those changes?** (Peters et al. 2008)

  - The study presented here is the preliminary stage of a study on Kainji Lake of Nigeria which will eventually address two key large scale environmental forcings: land use and climate change

General Description of Study Area

- Aside from land degradation within the study area, the floods of 1999, among others, in the Kainji Lake catchment area highlighted the menace of what should normally be a blessing to nearby communities "construction of multipurpose reservoirs"

- Supplies hydro electric power to not only Nigeria, but some of Nigeria's neighbours as well etc.

- Location: Lat 9°45' to 11°0'– Long 4°15' to 4°50'. It is surrounded by: Niger and Kebbi States

- The Kainji Reservoir: length of 139km, width of 24 km i.e. 3336 km^2 in area

- It is underlain by two major types of rocks: crystalline igneous and metamorphic rocks of Pre-Cambrian Basement Complex; sands and gravel beds of Sedimentary formations. Soils consist of dry but fine to coarse grained sand, red laterite soil, deep gravely loam etc.

- Vegetation type consist of Secondary Guinea Savannah comprising of dense riparian woodlands, short scattered thick barked trees and shrubs etc

General Description of Study Area

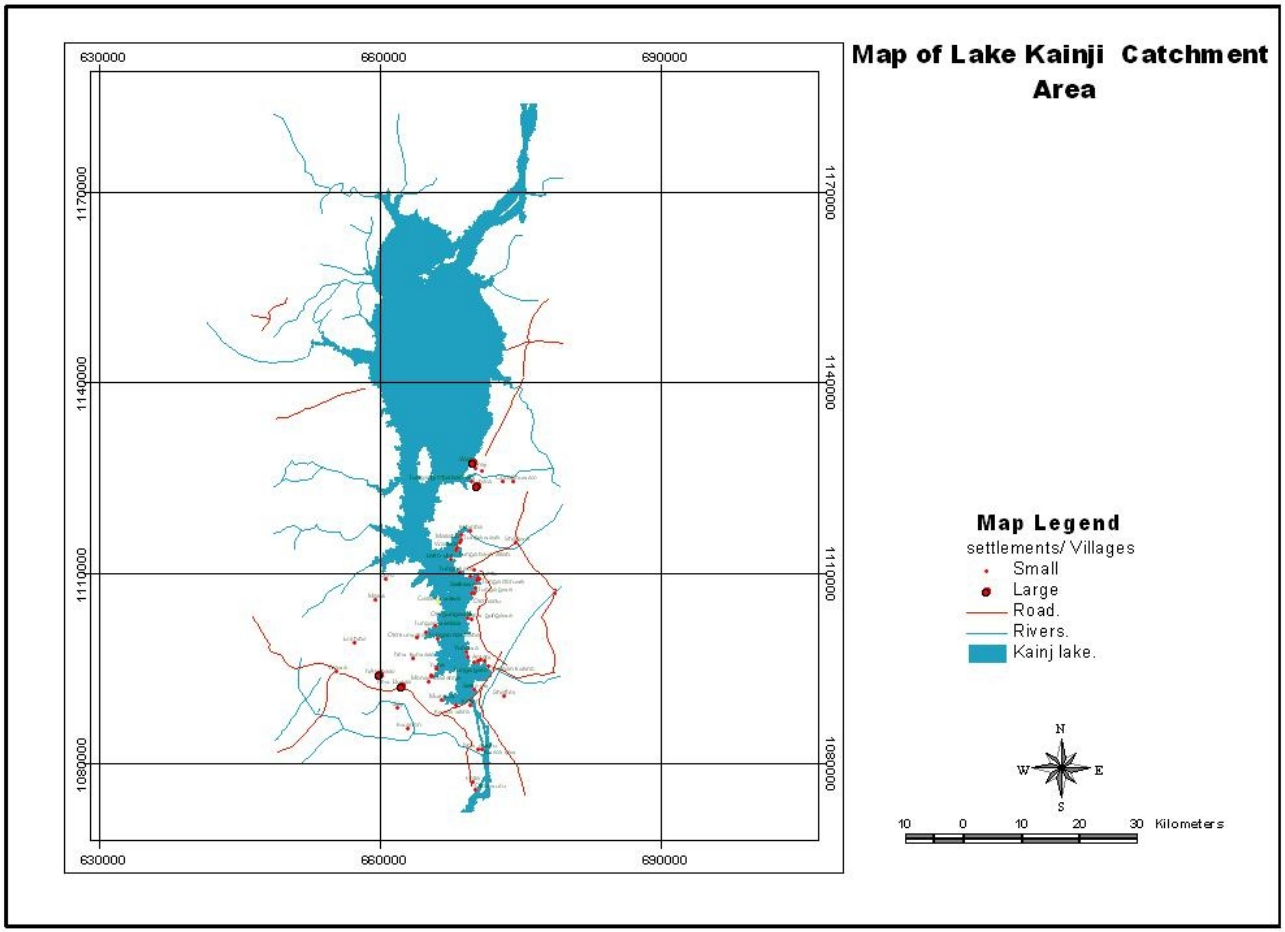


Figure 1 Geographic Location of the Study Area

Data Description

Satellite	Date of Acquisition	Path/Row	Level of Correction	Source
SRTM	February 2000			GLFC USGS EROS Data Centre
SPOT 1	March 1990 January 2000 December 2001	067/329; 067/330	System Corrected	SPOT Image, Toulouse
LANDSAT 4 LADSAT 7	October 1986 April 2000	191/053 191/053	Level 2A	GLFC USGS EROS Data Centre
NIGERIASAT-1	2004			NASRDA, Abuja

Table 1 Remotely Sensed datasets used for the study

Project Methodology

Remote Sensing Image Processing:

- Images were contrast stretched, mosaiced and georeferenced to fit the required map projection (UTM) using ERDAS Imagine
- SRTM was co-registered to NigeriaSat-1, LANDSAT and SPOT images
- Density slicing was performed on the SRTM; hillshaded relief image was also generated
- Topography was visualized by draping classified Landsat over DEM
- Unsupervised classification technique (Isodata) was performed on data from the three satellite systems mentioned above. Six classes were determined: water body, mostly trees/woodland/shrubs, mostly shrubs and dense grass, mostly row cropping and some grazing (intensively cultivated), mostly grazing and some row cropping (extensively cultivated), and denuded areas with some agricultural activities.

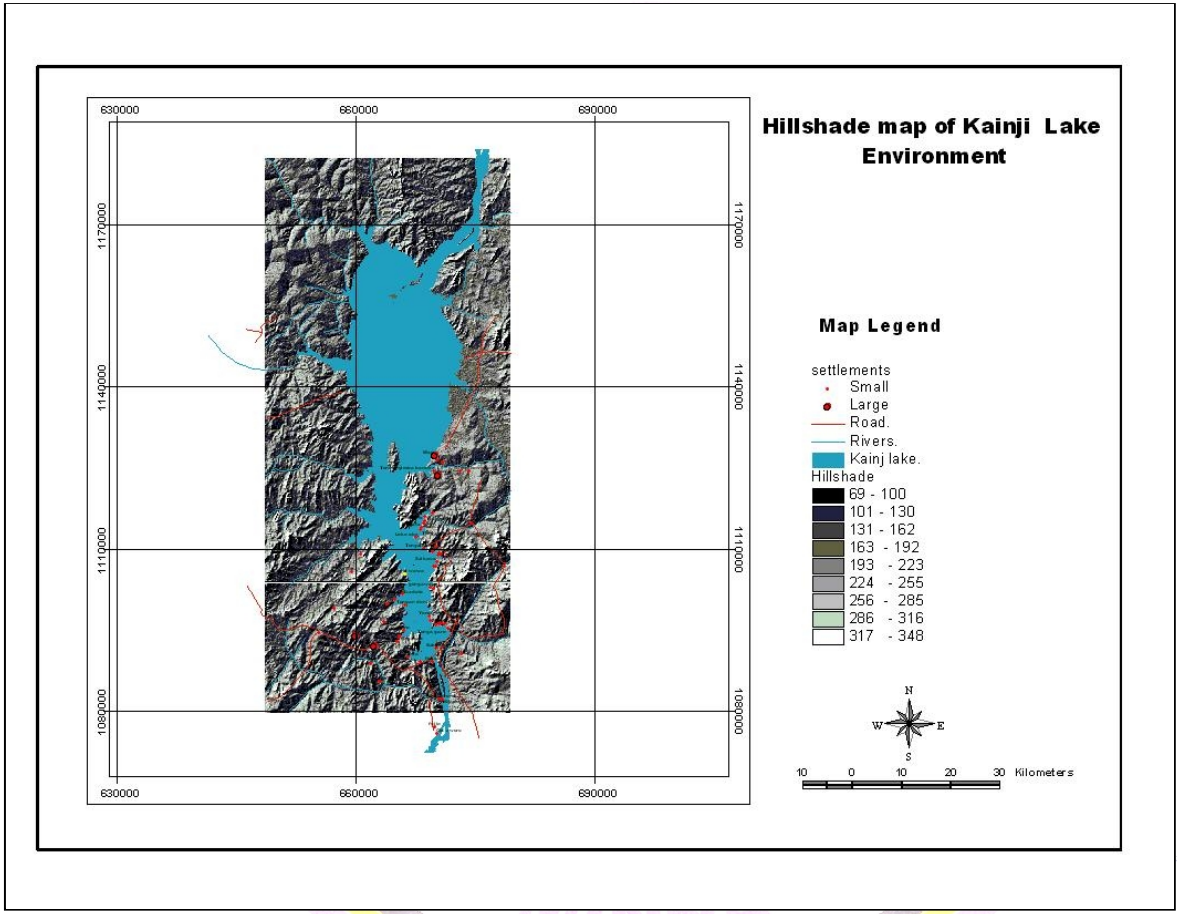
Project Methodology

Geographic Information System (GIS) Data Processing:

- The geomorphologic approach that involves the analysis of the landforms and the fluvial system was employed in this project to zone and assess flood hazard. The other option, hydrologic approach requires the use of meteorological, hydrological and catchment conditions dataset, which are often incomplete and of poor quality.
- The main datasets that were integrated are the landuse/landcover and the SRTM DEM using ArcView.
- Through onscreen digitization, three separate layers were created from the land cover map: roads, settlements and drainage pattern (rivers and streams).
- To determine the vulnerability of the settlements, locations of 58 communities within a given proximity (within 5 – 20km to the Lake) were determined using GPS and incorporated into the analysis.
- Though recent population data would have been very useful for creating population density in this research, they were inaccessible as at the time of the study.
- Rainfall data is conspicuously absent because it was assumed that spillways operated by dam management release excess flood water downstream of the reservoir during periods of heavy rainfall.

Extracting Topographic Structure from DEM

Hillshaded Relief Map:

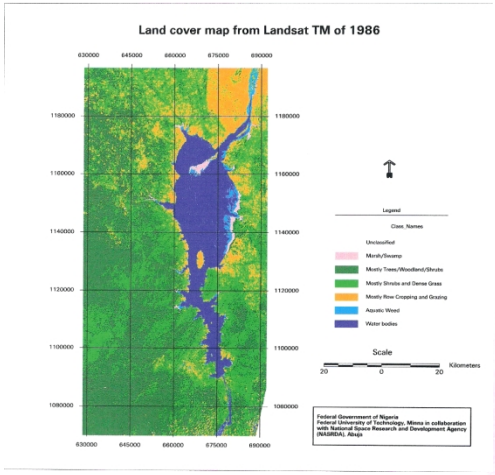


- Elevation within the study area ranged between 69 metres – 348 metres above mean sea level

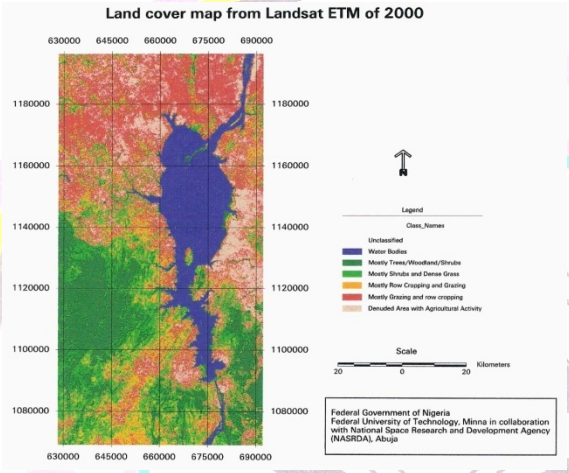
- Three dimensional view of the study area, lowest and highest elevation appear as very dark and white tones respectively

Analyzing Kainji Lake Area Land Cover Maps using Landsat images

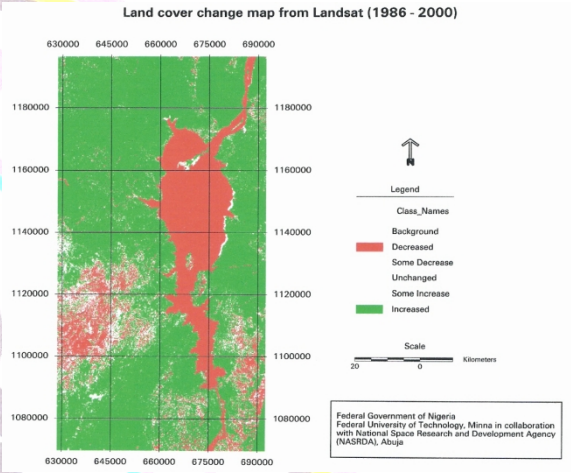
- Analyzing 1986 and 2000 Land Cover Maps; change map between 1986 and 2000



1986



2000



1986 - 2000

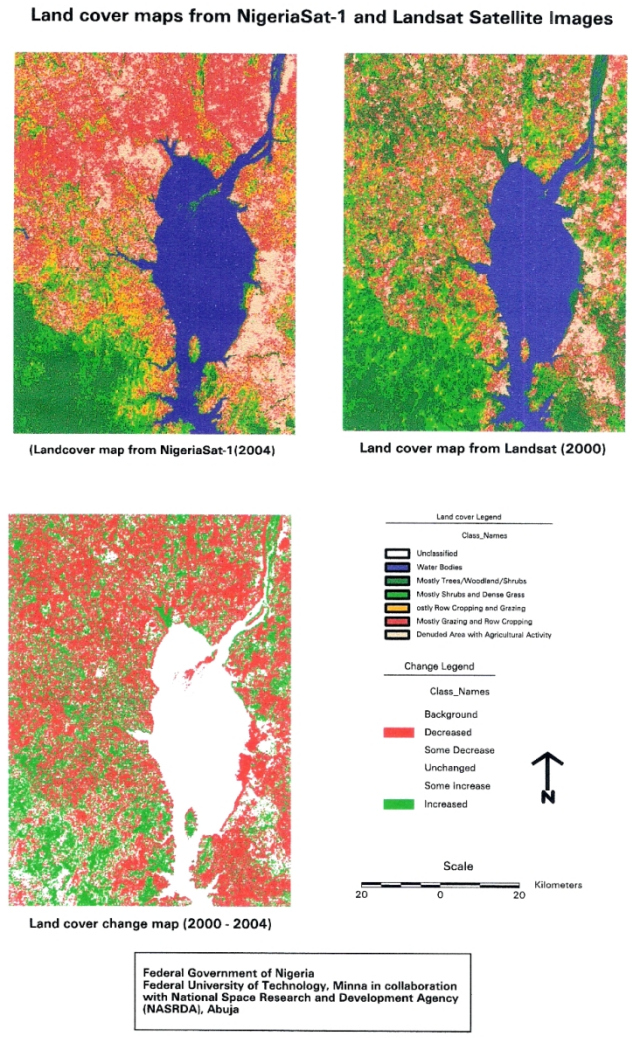
- Highest coverage: mostly shrubs and dense grass, mostly trees/woodland/ shrubs and mostly row cropping.

- Highest coverage: mostly grazing and some row cropping, mostly row cropping and some grazing, and mostly shrubs and some dense grasses.
- Denuded areas with some agricultural activities became prominent

- Unchanged: 141,582 ha (white)
- Increased: 508,773 ha (green) – agricultural activities and denuded areas.
- Decreased: 162, 391 ha (red) – mostly trees/woodland/shrubs and reservoir area
- Evidence of degradation

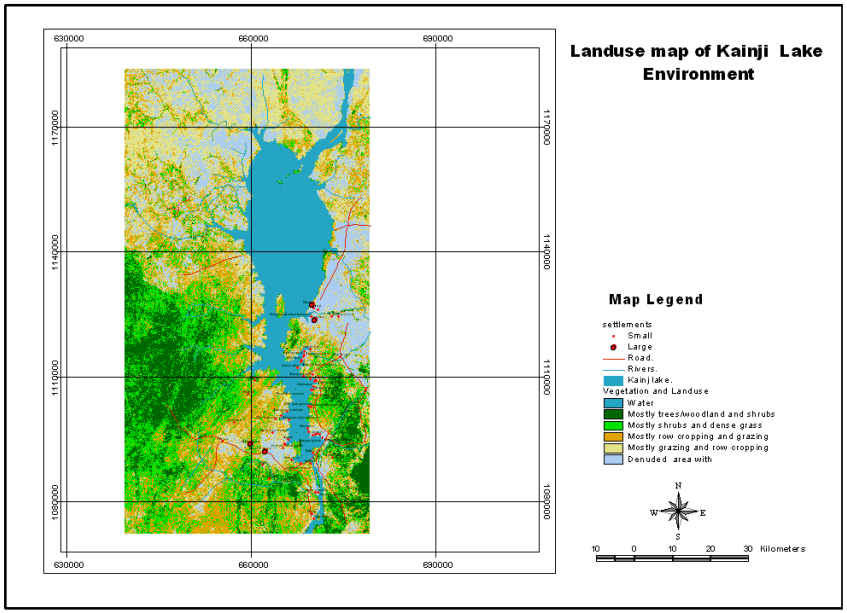
Analyzing Changes in Land Cover 2000 – 2004 using LANDSAT AND NIGERIASAT-1

- Total area utilized was a little less than the Landsat coverage (542,525.6)



- Highest coverage: mostly row cropping, mostly grazing and some row cropping, and mostly shrubs and dense grass.
- Compared to 2000: mostly grazing and some row cropping had decreased implying that more areas had come under cultivation by 2004.
- Highest % increase: mostly shrubs and dense grass (58.6%).
- Highest % decrease: mostly grazing and some row cropping (26%).
- Water bodies (earth dams/ponds, rivers/stream) decreased by 2.5%, an indication that some of these categories had dried up at the time of imaging.

Land Use Map of Kainji Lake Area (2000/2001)



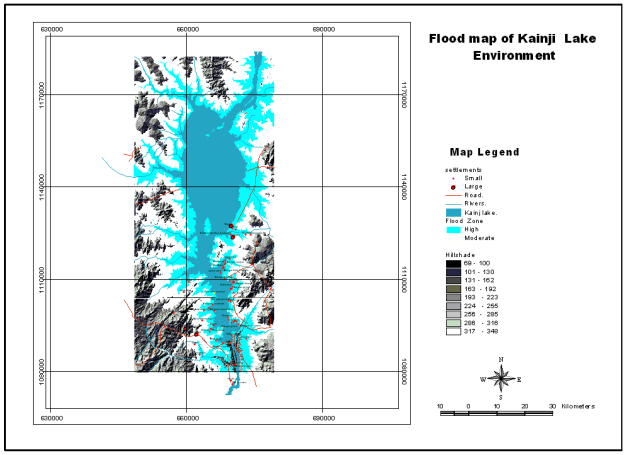
- Created by superimposing three themes: roads, rivers/stream/lake and settlements in ArcView's GIS environment.

- SPOT used because of high resolution to show 58 fishing/farming communities located between the middle and lower courses of Kainji reservoir. Only 25 communities could be conveniently placed on the updated map.

Analyzing Flood Maps of the Study Area

Flood Hazard Map:

- The essential parameters: elevation, floodable/surface waters, land cover types and the river/lake morphology.



Hazard + Hill shaded Relief

- Degree of flood susceptibility were ranked: high, moderate, low and very low
- Highest susceptibility within the first 3 kilometres from the reservoir including river channels and surface water body lying between 69 – 162metres above sea level; lowest being at least 15km away and greater than 193 meters above sea level.

- The main land cover categories within this zone are agricultural (various degrees or row cropping and grazing; denuded areas mostly found in the northern and eastern part of the area

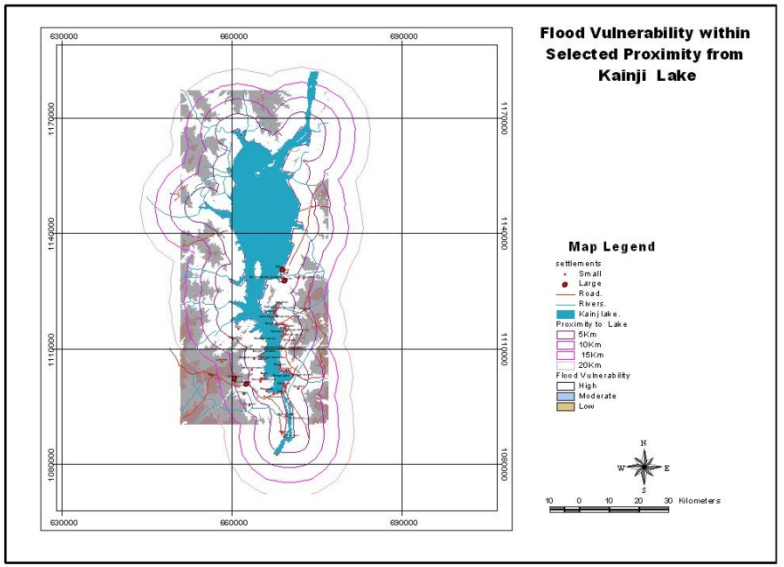
- Lowest susceptibility areas mostly covered by trees/woodland/shrubs or shrub and dense grass.

Analyzing Flood Maps of the Study Area

Flood Vulnerability Map:

- Degree of loss to this set of elements (population, farmlands, houses and schools etc) to flood in this area with poor infrastructural development was mapped

- Most of these are vulnerable to floods especially if the flood extent falls within 5km from the Lake ranging between 163 – 193 above sea level.



Dist. to Settlements (km)	Rate	Vulnerability
Less than 5	1	High
Btw 5-10	2	Moderate
Above 10	3	Low
Land cover Category		
Intensive/extensive agric	3	High
Shrubs/dense grass/denuded	2	Moderate
Trees/Woodland/Shrubs	1	Low
Distance to roads (km)		
Less than 5	3	High
Btw 5 – 10	2	Moderate
Greater than 10	1	Low

Table 4 Vulnerability Rank

Analyzing Flood Maps of the Study Area

Flood Risk Map:

- Usually prepared using estimated total cost of the property and economic activity disrupted/destroyed by flood as well as population affected

- Here, flood hazard map was overlain on flood vulnerability as existing cost estimates and population figures are unreliable or inaccessible.

- Damage and risk to life remain high because the communities depend on fishing and farming; the communities visited are strategically located between 50 – 1000metres from the lake, widespread and small.

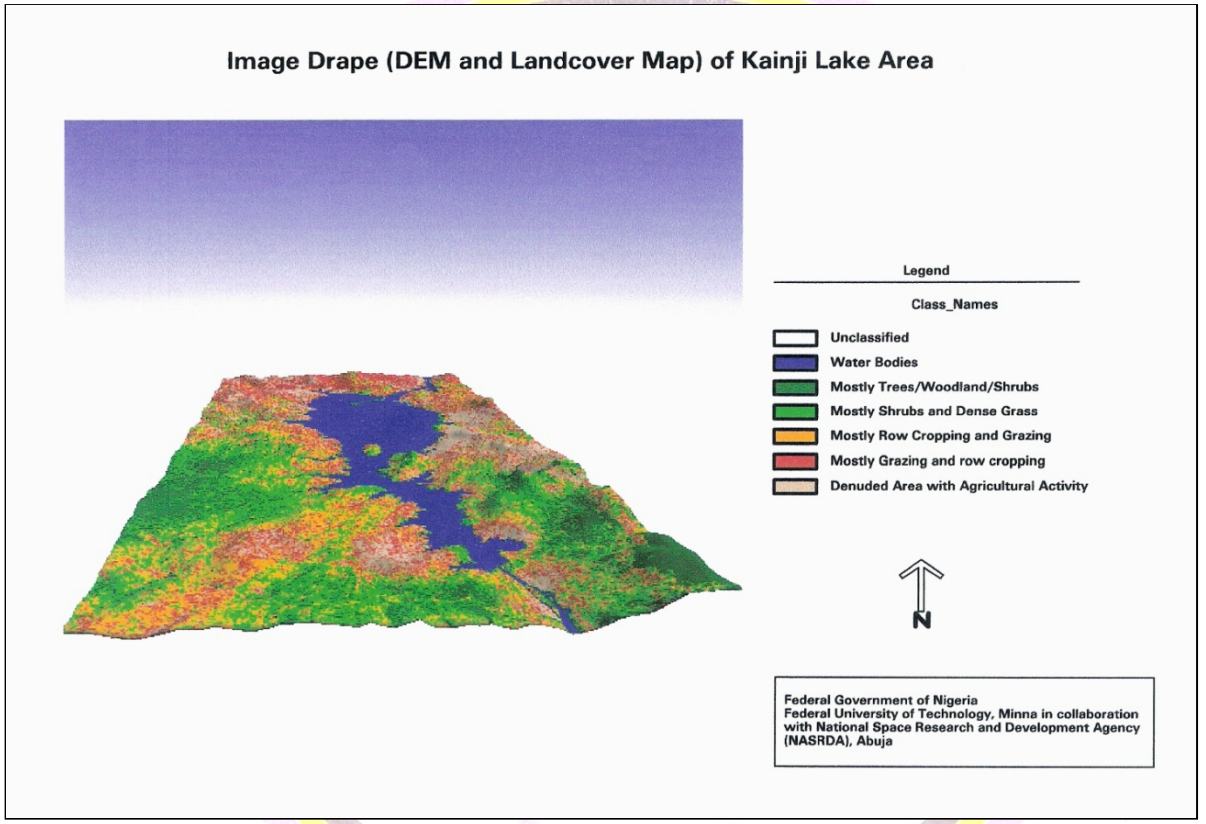
- Major communities include New Bussa, Wawa, Shuwata and Libata are approx 10km away.

- Farmlands are at risk as floods extend to 500m away from the river bank,
- Flood waters usually cover rock outcrops (5meters high) located Yunawa, a river bank community

- Roads and buildings are destroyed either dampness or flood waters.

Extracting Topographic Structure from DEM

Image Drape:



- A ‘bird’s eye view’ provided by satellite images showing the topography of the study area with corresponding land cover types. Elevated areas are clearly shown in the northern, south eastern and south western sectors of the area. The valley through which the river flows downstream towards Jebba Dam is also indicated.

Strategies for Reducing the Impact of Floods

- Despite the attempt by communities to adapt to seasonal flooding, there is the urgent need for disaster reduction strategies (and climate change adaptation strategies) to enable more resilience to floods;

- This disaster cannot be prevented completely using structural measures (expensive); properly designed and operated flood works may reduce damage within physical and economical limits; but have negative impacts on life, property and the natural environment; e.g. construction of levees may lead to internal flooding, diversion of flow changes natural habitat etc;

- For large infrastructural projects EIA and land capability studies must be embarked upon to protect the communities from unforeseen damages but at the risk of loss of farmlands;

- Adoption of non-structural measures appears to be more viable and with less environmental impacts (Degraff 1989; Giespel 1993);

- Adaptation options for flood risk reduction should mainly emphasize decreasing the hazards, or eliminating vulnerability or a combination of both;

Strategies for reducing the impact of floods

- Developing a comprehensive land use plan to prevention expansion or creation of new settlements; may include well planned relocation; as well as embarking on coordinated afforestation programmes upstream most especially;

- Government and other stakeholders should invest in building safe houses that are less susceptible to damage from humidity or moisture or flood waters; awareness should be created on the risks involved in the language understood by the community and authorities to supervise pre-disaster and post disaster management measures;

- Design and installation of functional Flood Forecasting and Warning Systems;

- Collaborative work between stakeholders e.g. NEMA, NIMET, NASRDA etc, CBOs, NGOs, Academia and the media to propose policies and adaptation measures for reducing negative impacts etc;

- Using scientifically sound database and information; community participation and commitment of the policymakers in improving the lives and livelihood of communities is a MUST for success to be achieved.

Conclusion

- A Post Project Workshop that held last year in June brought stakeholders from key states that are within the catchment area of the Lake and their recommendations are being considered in a Phase II of the Project.

- On a regional scale, a Worldbank GEF project, I believe, has commenced on the Niger River Basin from Fouta Djallon to Niger Delta, which will hopefully enable us: **understand the causes of large-scale changes in this aquatic ecosystem, as well forecast and prepare for climate change, among others;**

- In conclusion, there is the need to "speak the language" understood by all categories of stakeholders for a better appreciation of earth observation data; similarly, the beneficiaries need to articulate their needs properly for the solutions to be provided (appropriate data).

- In CCCFR, we have taken a stride, with your contributions in the discussions that have been on since yesterday: **WE SHOULD BE ABLE TO TAKE A GIANT LEAP!!**

MERCY BEAUCOUP (E) !!!

Acknowledgement

(1) ARSEMEWA (Courtesy UNESCO)
(2) NASRDA
(3) Africans in diaspora (Dr A. A. Abiodun, Dr Justin Ahanhanzo, Dr Jimmy Adegoke etc)