Rebecca Boger
Department of Earth and Environmental Sciences
Brooklyn College
SWAT Conference, Toledo, Spain, 15 June 2010

COMMUNITY BASED WATERSHED MODELING IN NIGERIA

Outline

- Background:
  - Research goals and objectives
  - Study area
- SWAT
  - Research framework for community involvement
  - Data sets and collection
  - Initial model development
- Next steps
- Community capacity building

Why Nigeria?
Citizen Science in Developing Countries

GLOBE contacts provide

- Network of schools – teachers and students
- Universities: Bowen University and Federal University of Technology (FUTA)
- National and State Government support (to some extent)

Needs are great in Nigeria (and throughout Africa and other places in the world)

- Poverty, food and health
- Poor infrastructure for environmental monitoring
- Lack of data!
- Science and technology capabilities limited. Get diversified support:
  - Universities
  - Government
  - NGOs

Devise research project

- Provides scientific data for water resources and climate change
  - Useful for basic research and management
  - SWAT: creating database/research framework
- Involves citizens
  - Secondary schools
  - Universities
  - NGOs
- Builds local capacity

Water Resources: Urban

Water Resources: Rural

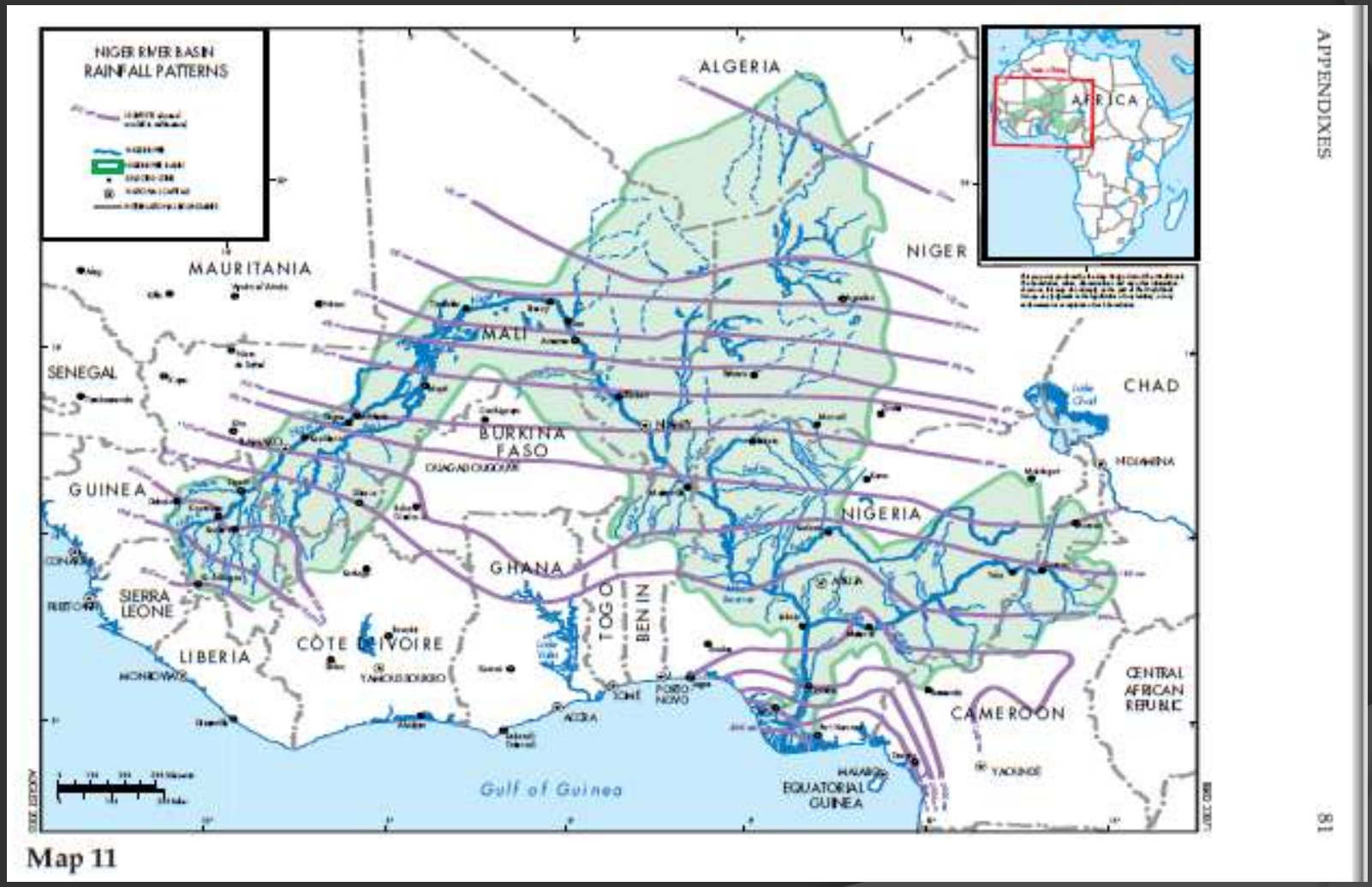
Impact in Africa - Water Resources and Climate Change

IPCC 2007 report

- Climate change is likely to directly impact children and pregnant women because they are particularly susceptible to vector- and water-borne diseases, e.g., malaria is currently responsible for a quarter of maternal mortality. Other expected impacts include: increased heat-related mortality and illness associated with heat waves (which may be balanced by less winter-cold-related deaths in some countries);
- Increased prevalence of some vector-borne diseases (e.g., malaria, dengue fever), and vulnerability to water, food or person-to-person diseases (e.g. cholera, dysentery) (see Section 9.4.3);
- Declining quantity and quality of drinking water, which worsens malnutrition, since it is a prerequisite for good health;
- Reduced natural resource productivity and threatened food security, particularly in sub-Saharan Africa (see Sections 9.4.3,9.4.3, 9.4.4, 9.6.1).

Source: http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch9s9-7.html

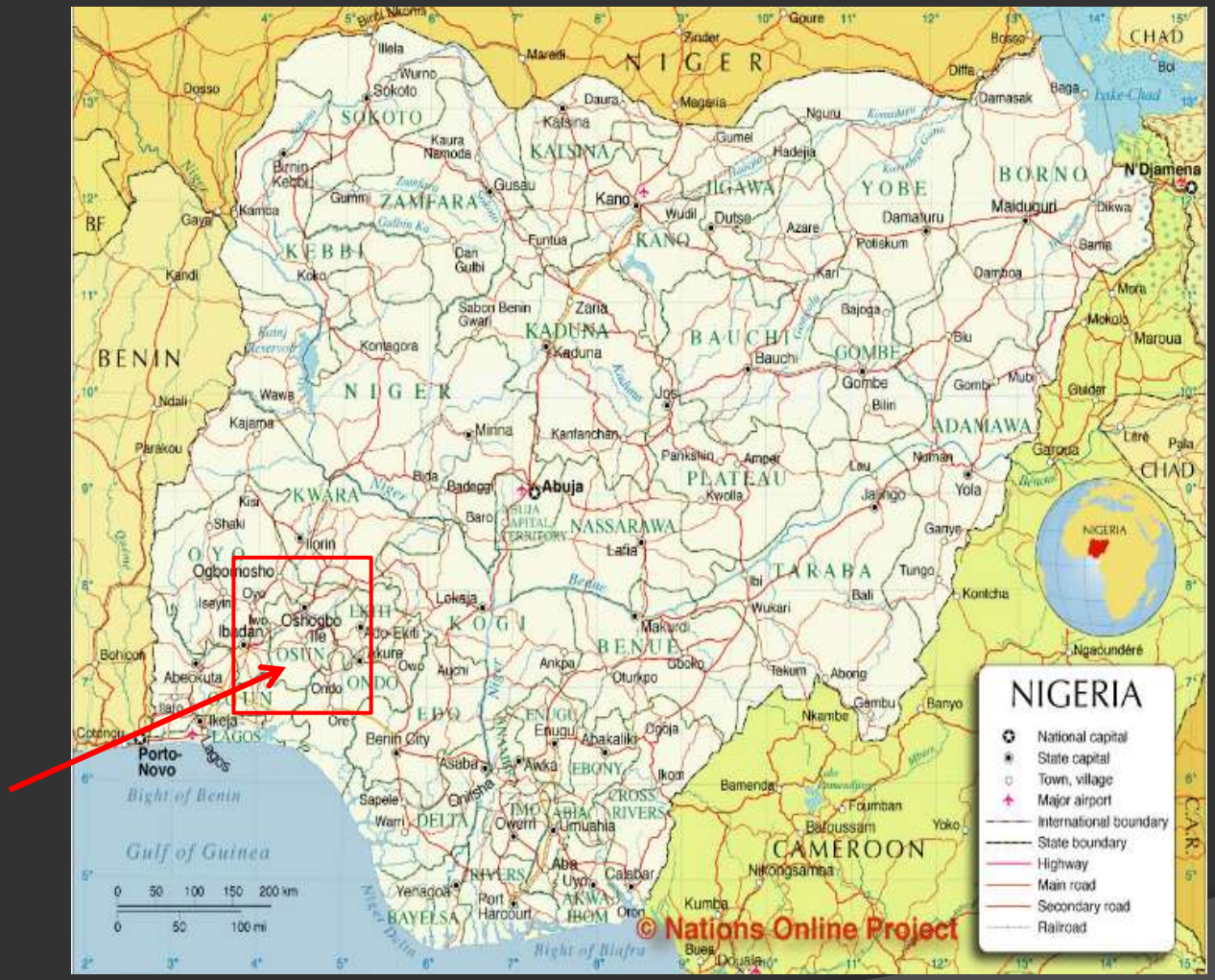
Rainfall Isobars



Source: Andersen et al., 2005. Niger River Basin: Vision for Sustainable Development


NIGERIA
V
IV
III
II
I
Precipitation Zones (mm/year)
I 1250 -2500
II 750 - 1250
III 500 - 750
IV 250 - 500
V 100 - 250
Proposed Data logger location
Existing Data logger location

Pilot Study Area



Approx: 4.2N, 7.6°E

Annual precip: 800-1200 mm
Annual temp: 28°C

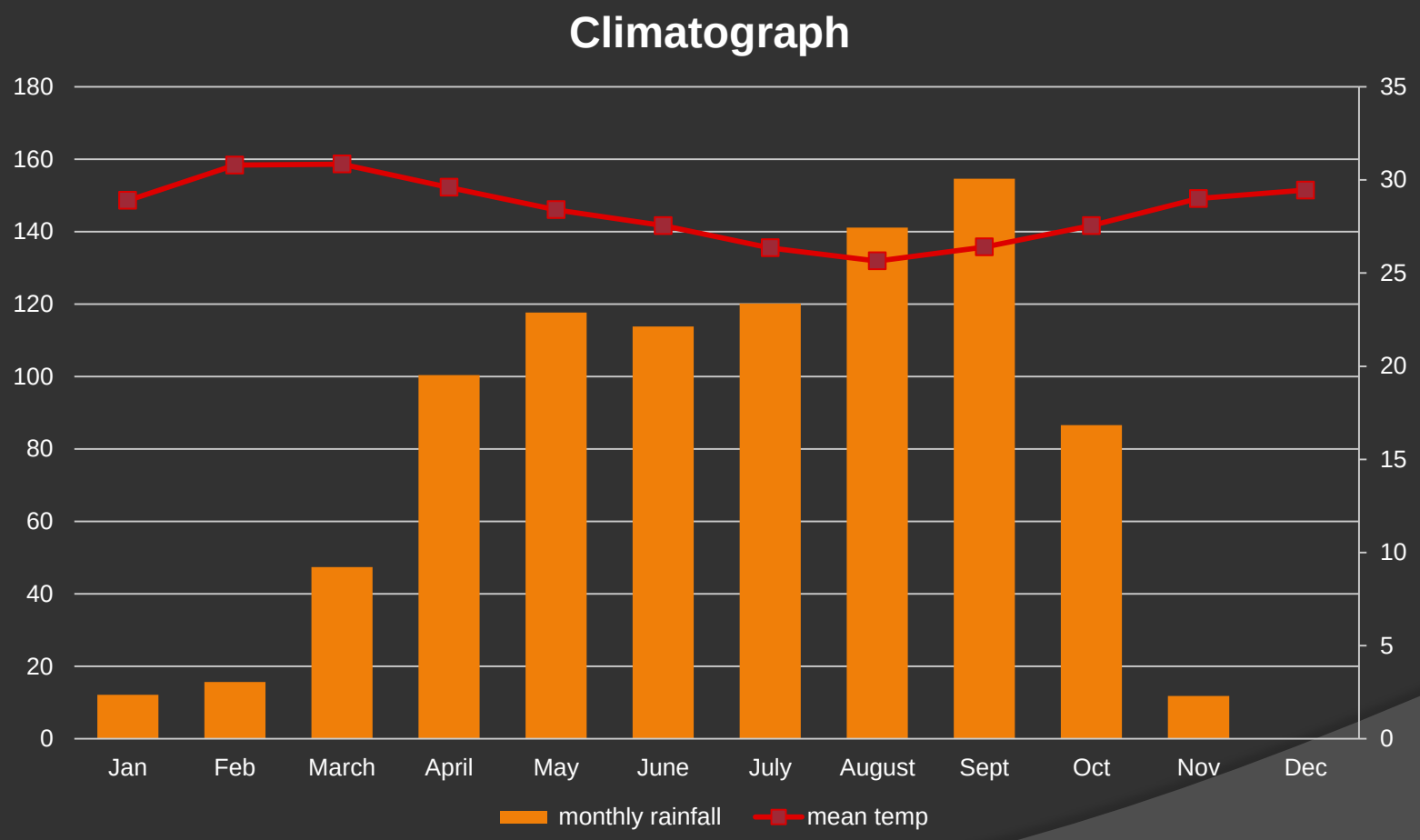
Topography: rolling hills, ranging 80-540m

Soils: largely sandy; highly weathered iron rich - Ferrasols, Lixisols, Acrisols, Nitisols

LULC: mainly agriculture and forest/shrubland

Agriculture: corn, yam, cassava, plantain/banana, legumes

Weather Data

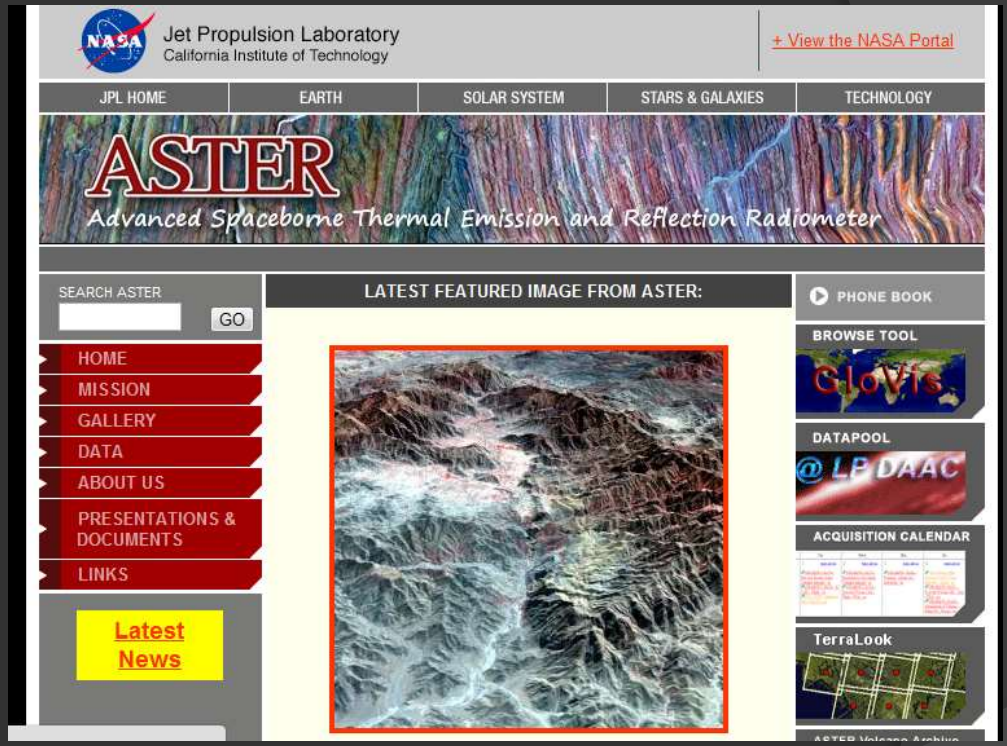


Outline

- Background:
  - Research goals and objectives
  - Study area
- SWAT
  - Research framework for community involvement
  - Data sets and collection
  - Initial model development
- Next steps
- Community capacity building

Data sources: DEM

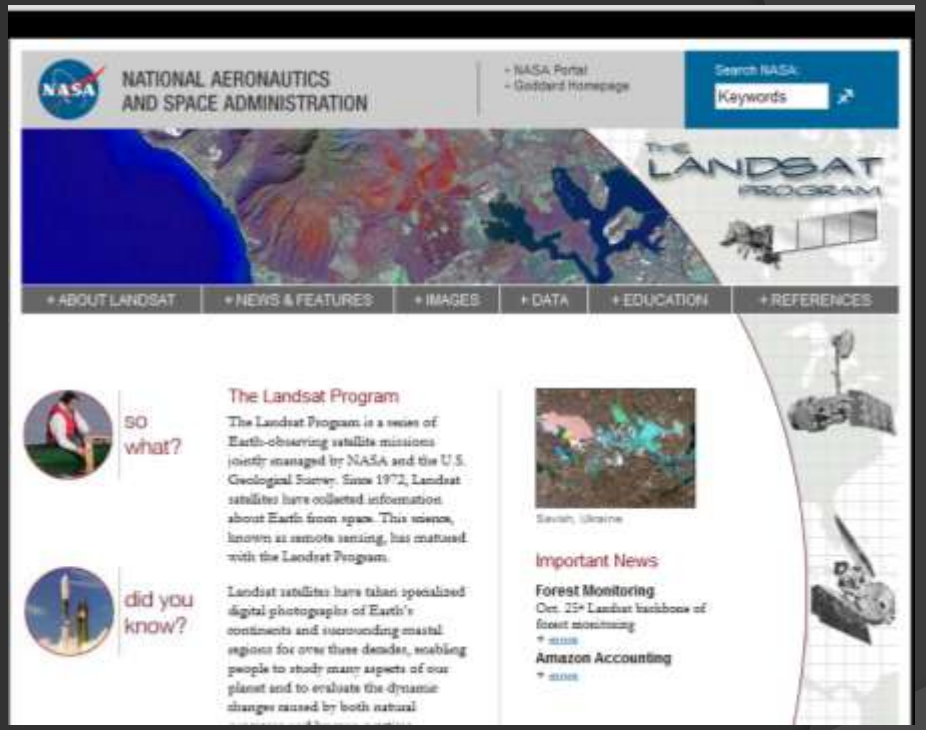
- ASTER
- 30 m resolution
- Free downloadable
- Warehouse Inventory Search Tool (WIST)
  - https://wist.echo.nasa.gov/~wist/api/imswelcome/



http://asterweb.jpl.nasa.gov/

Data for LULC

- Landsat
- 30 m resolution
- Free, downloadable
- USGS Earth Explorer
  - http://edcsns17.cr.usgs.gov/EarthExplorer/

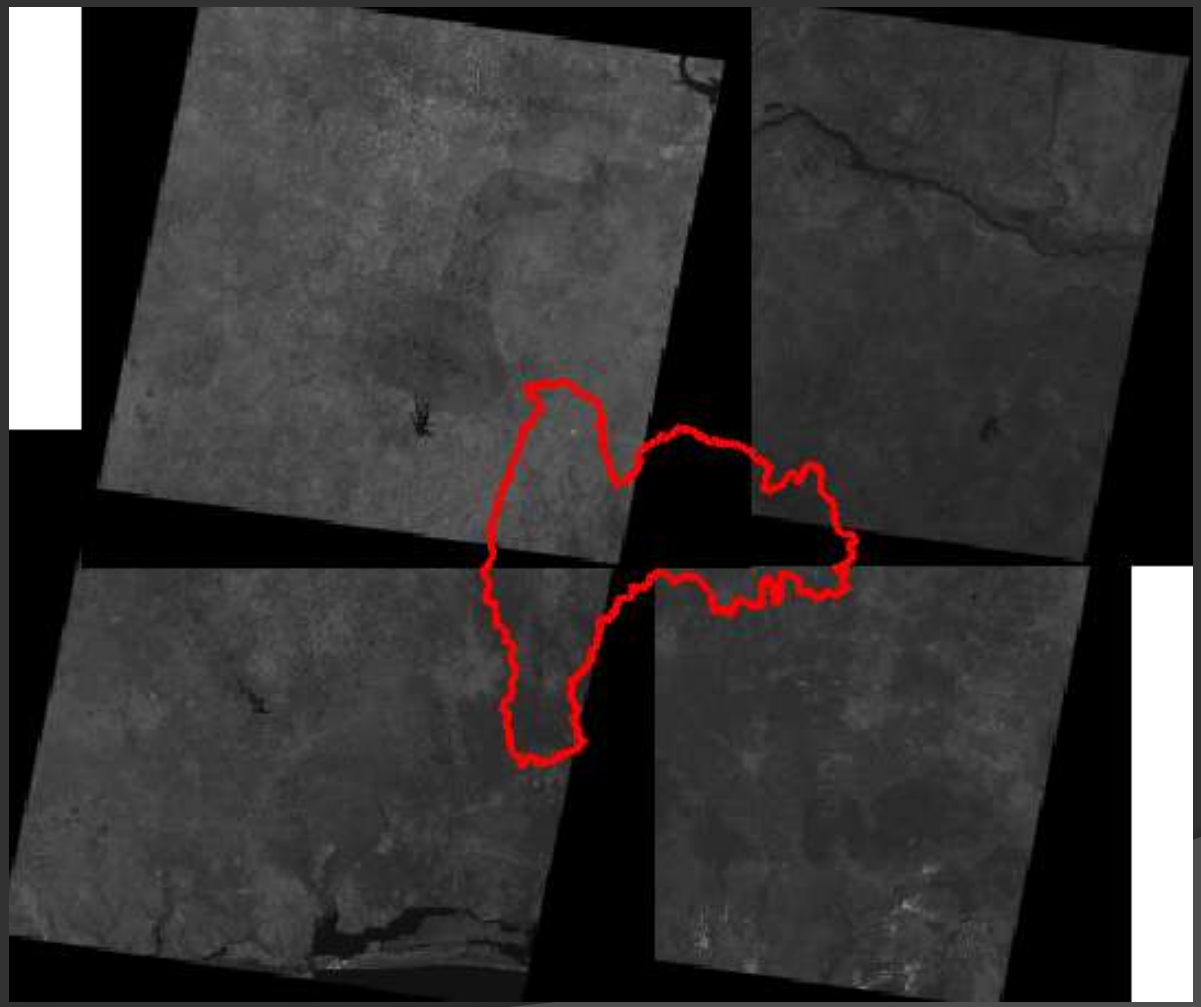


http://landsat.gsfc.nasa.gov/

Creating a LULC Map

- Input for SWAT
- Idrisi software
- Landsat data: study area covers 4 scenes
- Unsupervised clustering (so far)
- Accuracy assessment
- Iterative process

Landsat Scenes

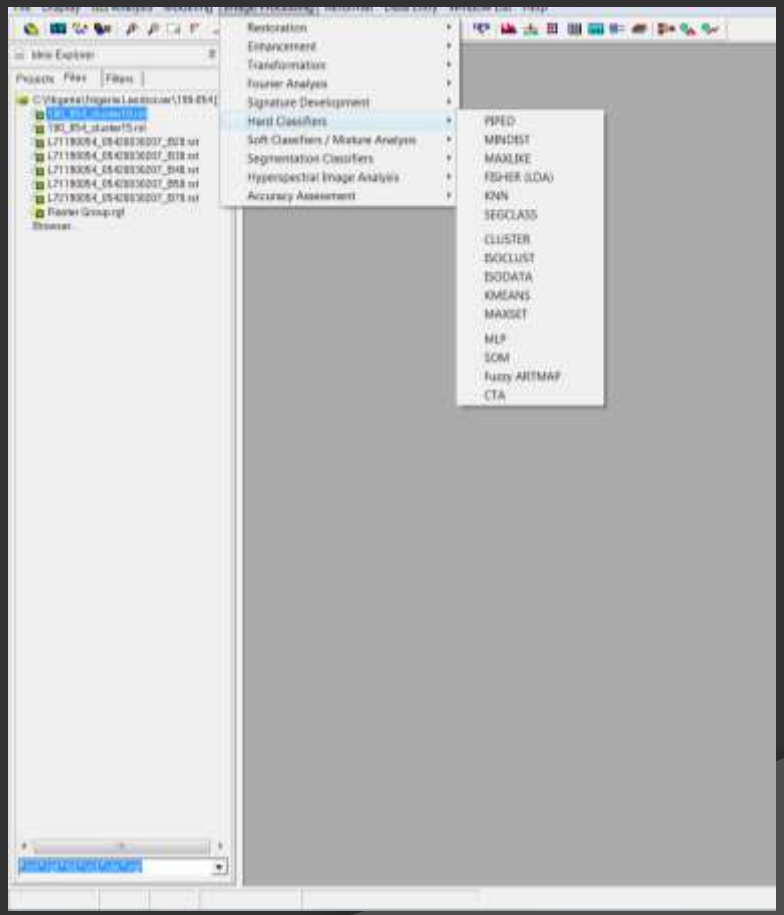


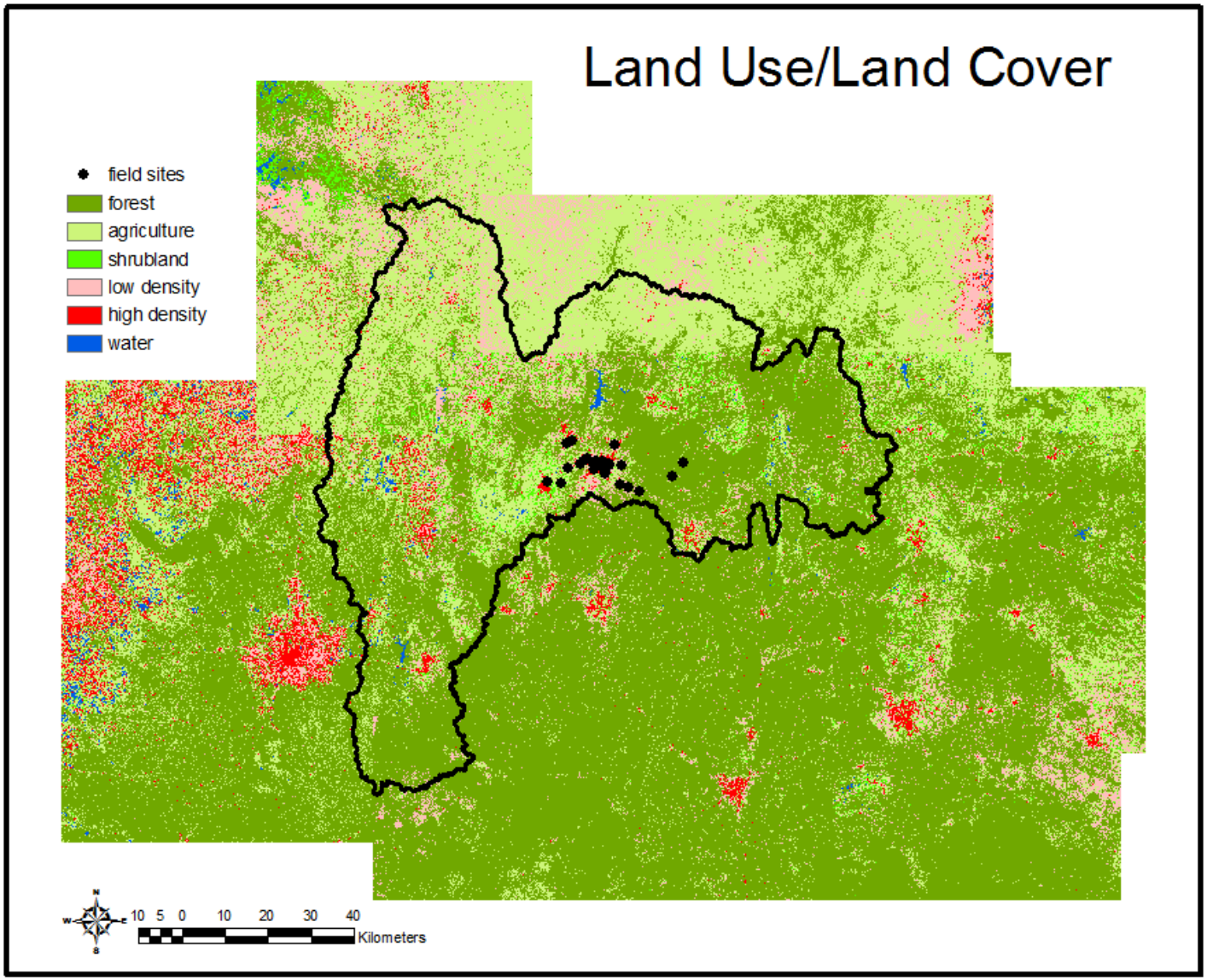
Clustering methods

- Spectral classification using bands 2, 3, 4, 5, 7
- Each scene classified separately and then brought into ArcGIS and mosaiced
- Initial LULC identification based on field data collected in May 2010 and Google Earth
- USGS NLCD classification scheme
  - http://landcover.usgs.gov/classes.php
  - Integrates well with SWAT

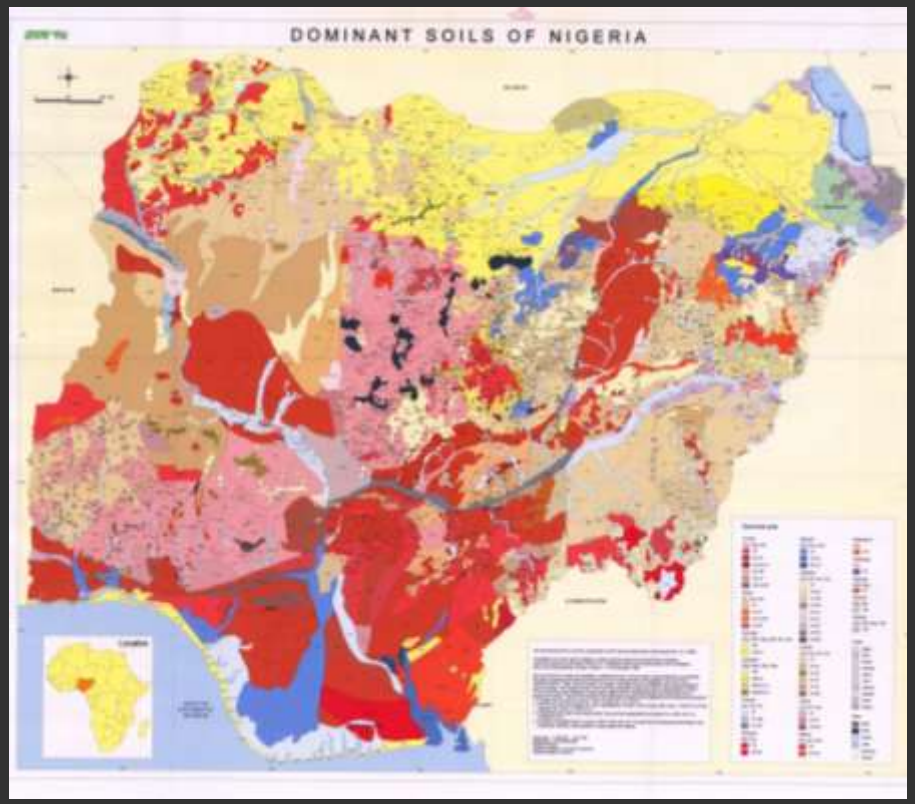
Idrisi Clustering Methods

- Variety of unsupervised and supervised methods offered
- Initially using unsupervised
- CLUSTER method chosen with 15 classes that were later reduced to 6



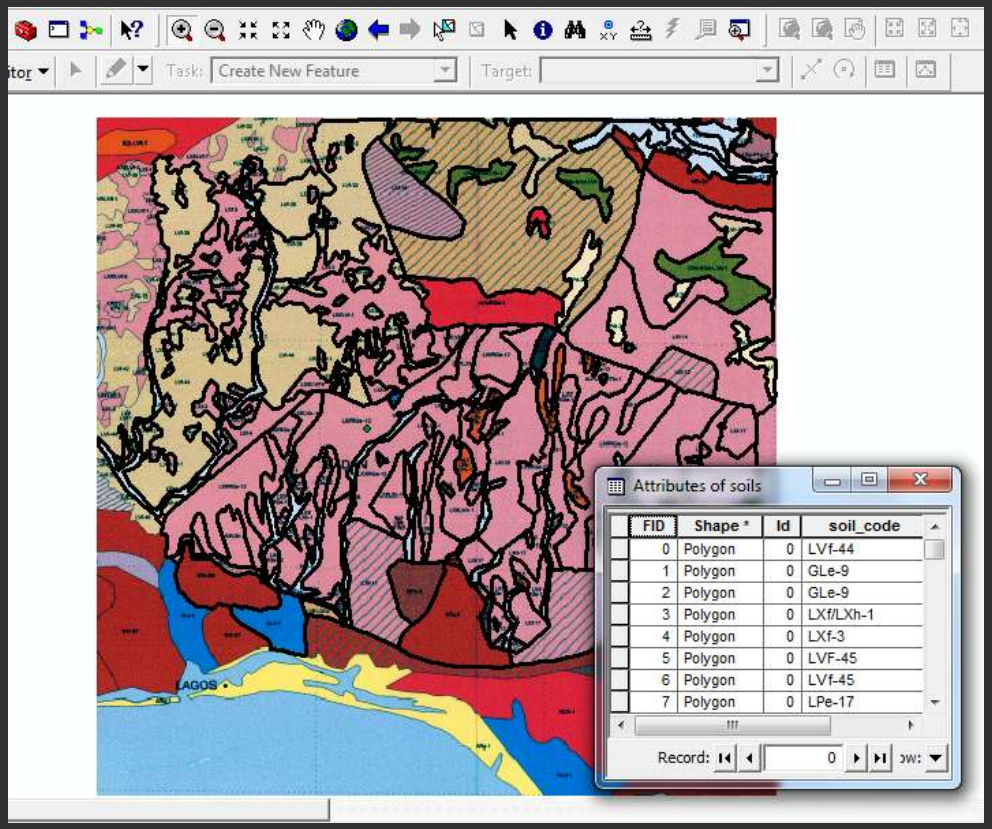

Land Use/Land Cover
field sites
forest
agriculture
shrubland
low density
high density
water
10 5 0 10 20 30 40
Kilometers

Soil Data



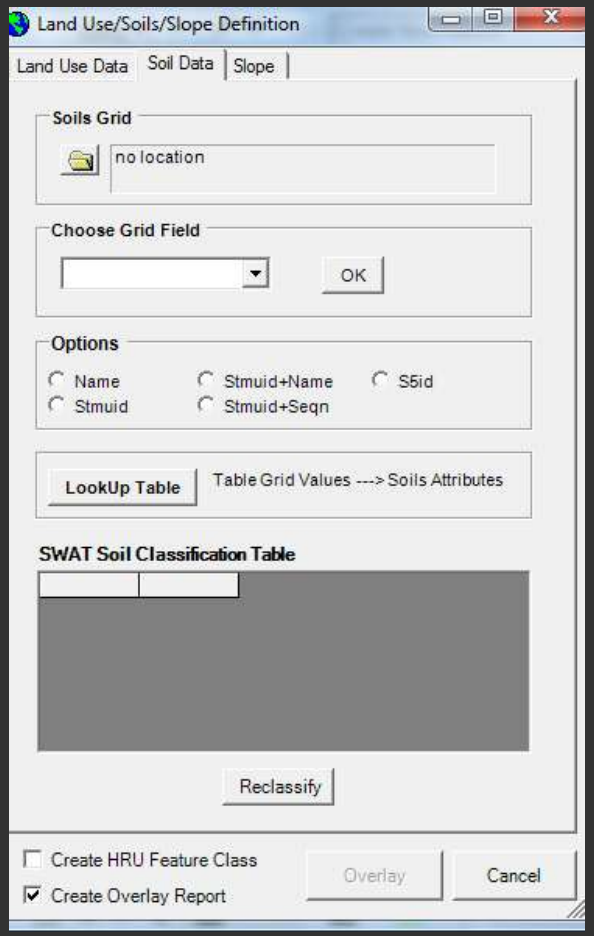
- Soil map of Nigeria
- 1:1,300,000 scale
- Sonneveld B.G.J.S. (1996)
- Pdf downloadable at European Digital Archive of Soil Maps (EuDASM); http://eusoils.jrc.ec.europa.eu/esdb_archive/eudasm/africa/lists/s1_cng.htm

Soil Data Processing

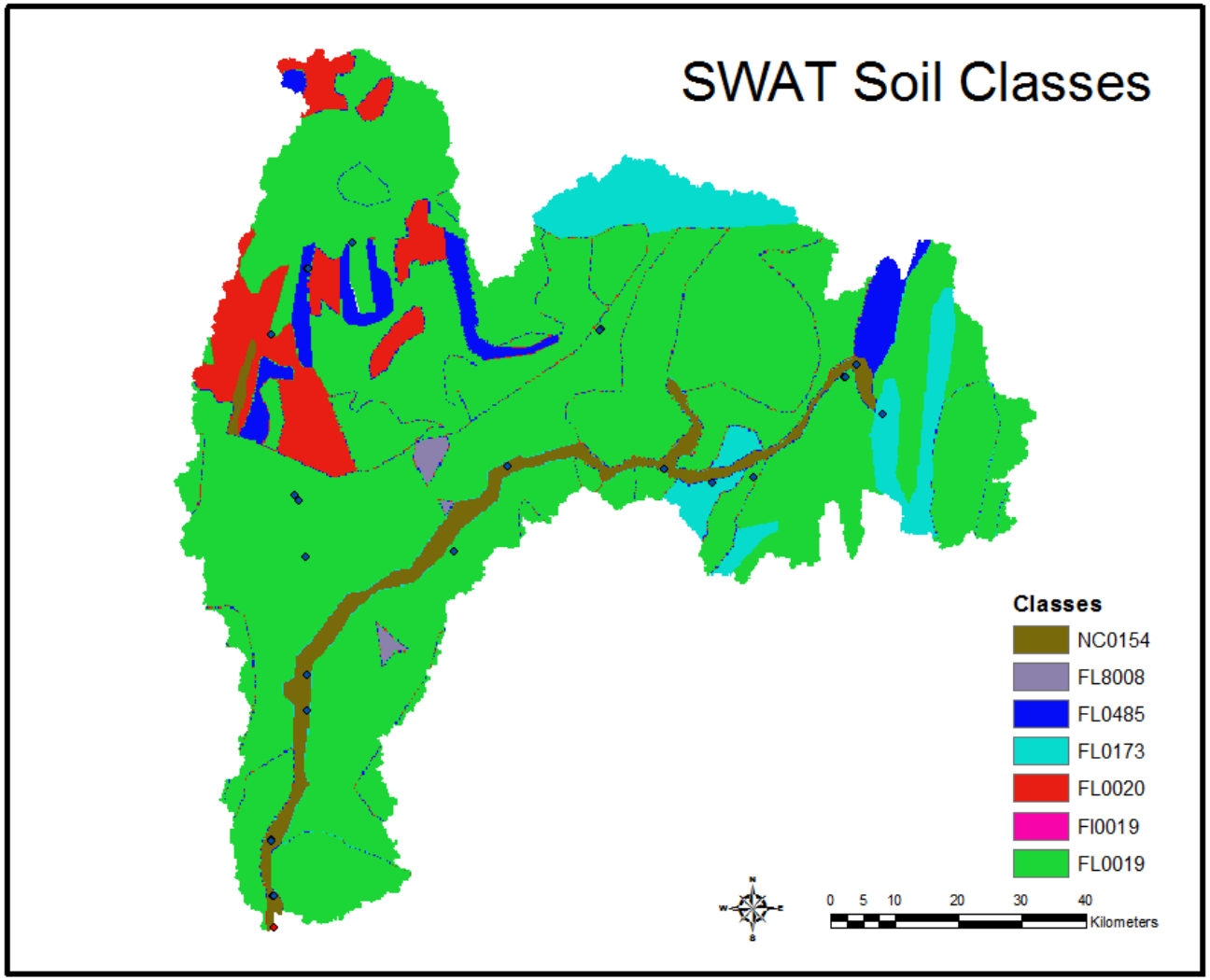


- Field soil samples taken for texture analysis to update model inputs.
- For initial model development, used US comparable soil datasets
- ArcGIS
  - Georeference
  - Digitize soil type polygons
  - Create raster file

Soil Data



- Soil data based on US data – STATSGO
- Made best estimates of Nigerian soils in US database based on the Nigerian map, soil samples and personal knowledge of the area.


SWAT Soil Classes
Classes
NC0154
FL8008
FL0485
FL0173
FL0020
FI0019
FL0019
0 5 10 20 30 40
Kilometers

Weather Data

- Created custom weather generator
- Local Hobo data loggers since Sept. 2009
- NOAA global daily summary
  - Nigeria datasets very incomplete
  - Used dataset in Save, Benin along a similar latitude and climatic regime, although still considerable missing data

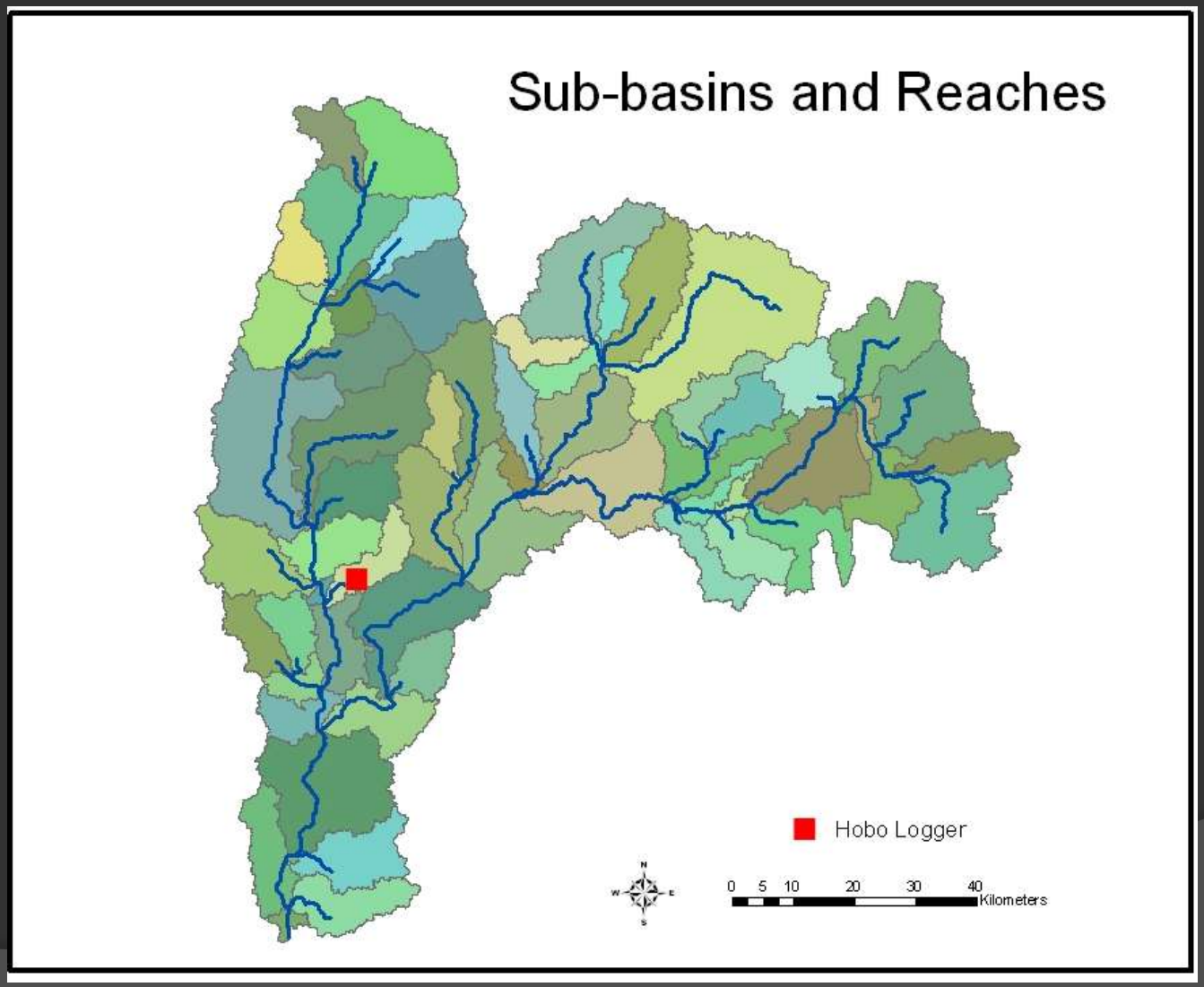
Hobo Data Loggers

Data: air temperature, rainfall relative humidity, barometric pressure, insolation, leaf area index, and soil moisture and temperature at 3 depths (10, 30, and 50 cm)
Will be installing wind speed and direction in August or September

Loggers collecting data every 5 minutes

Graduate students and teachers download data and send via email

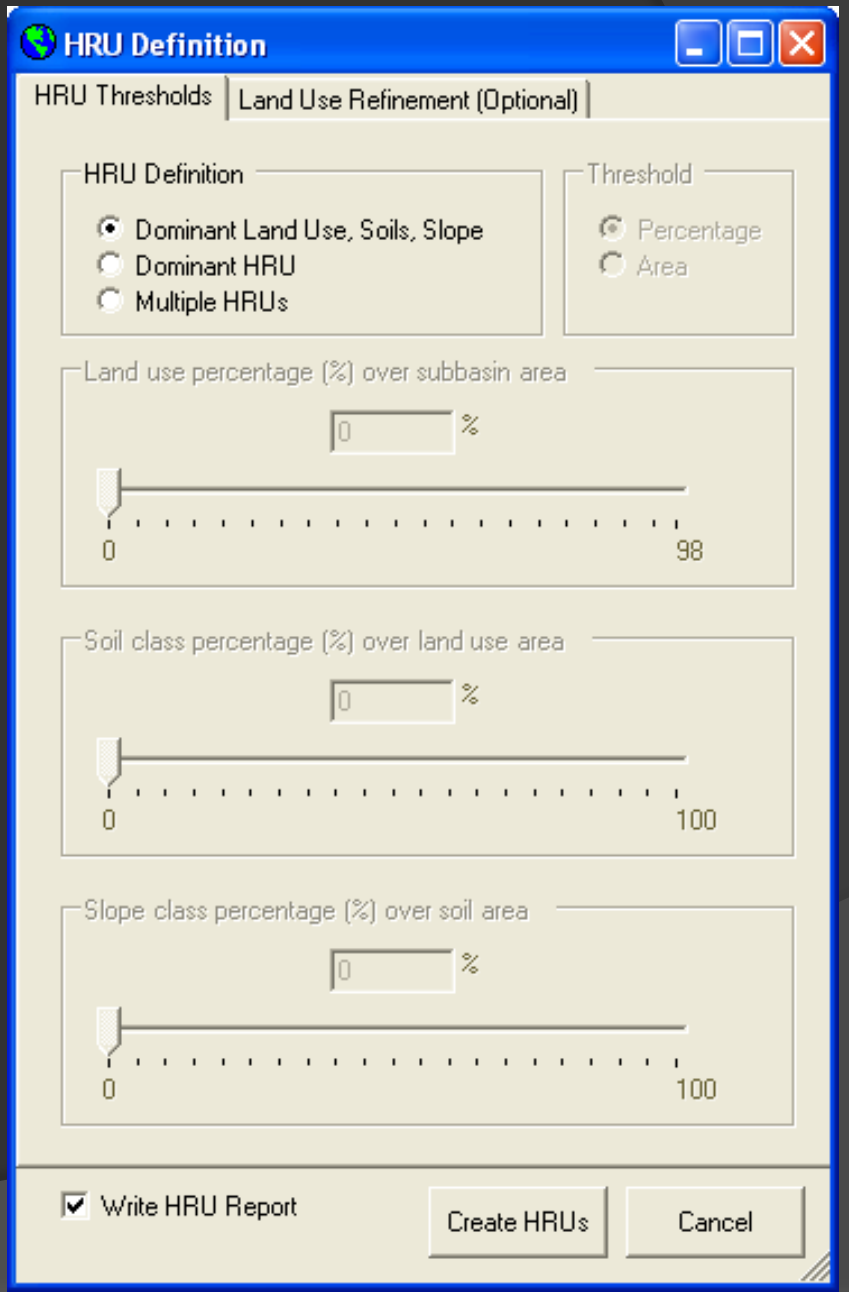
Watershed delineation

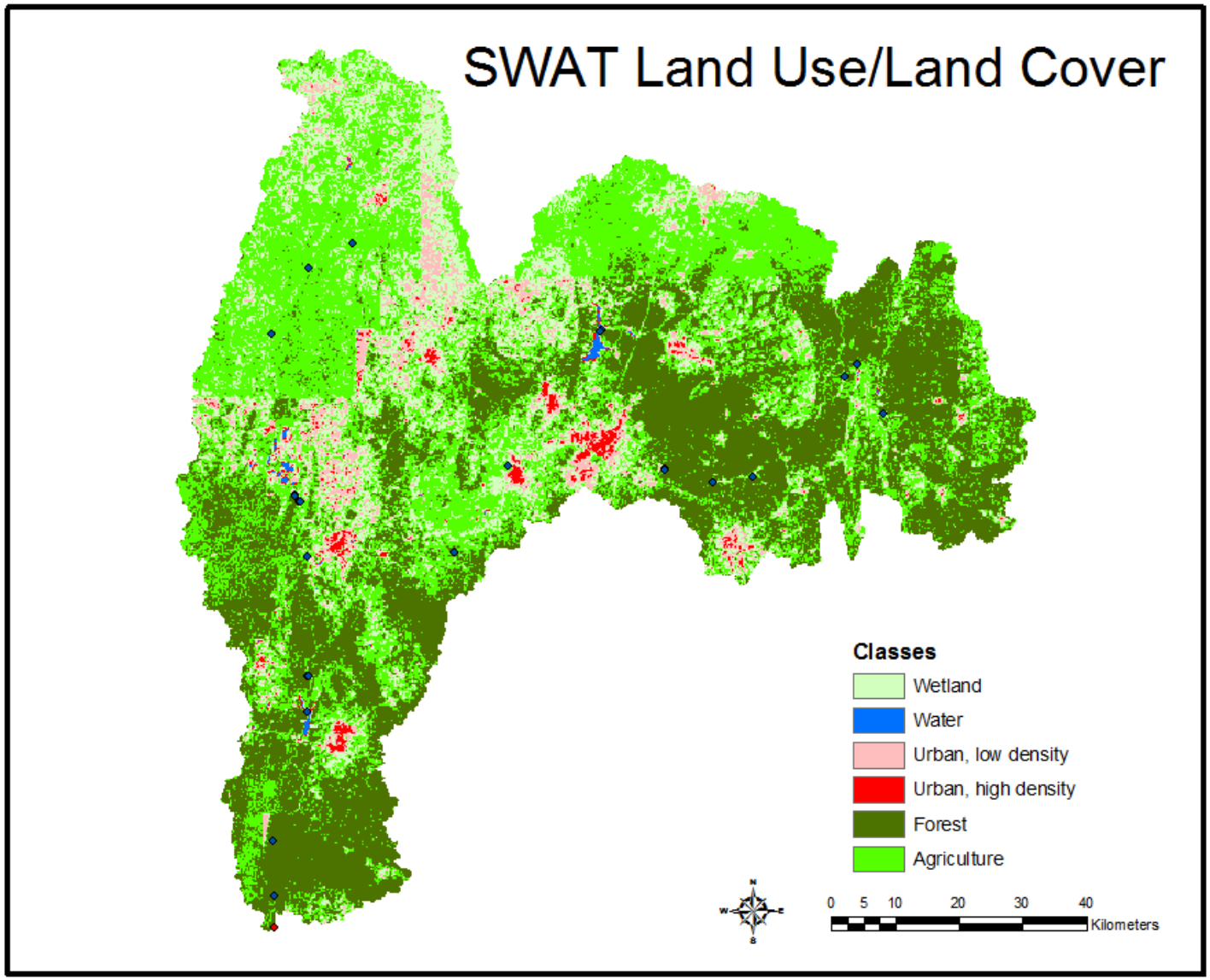


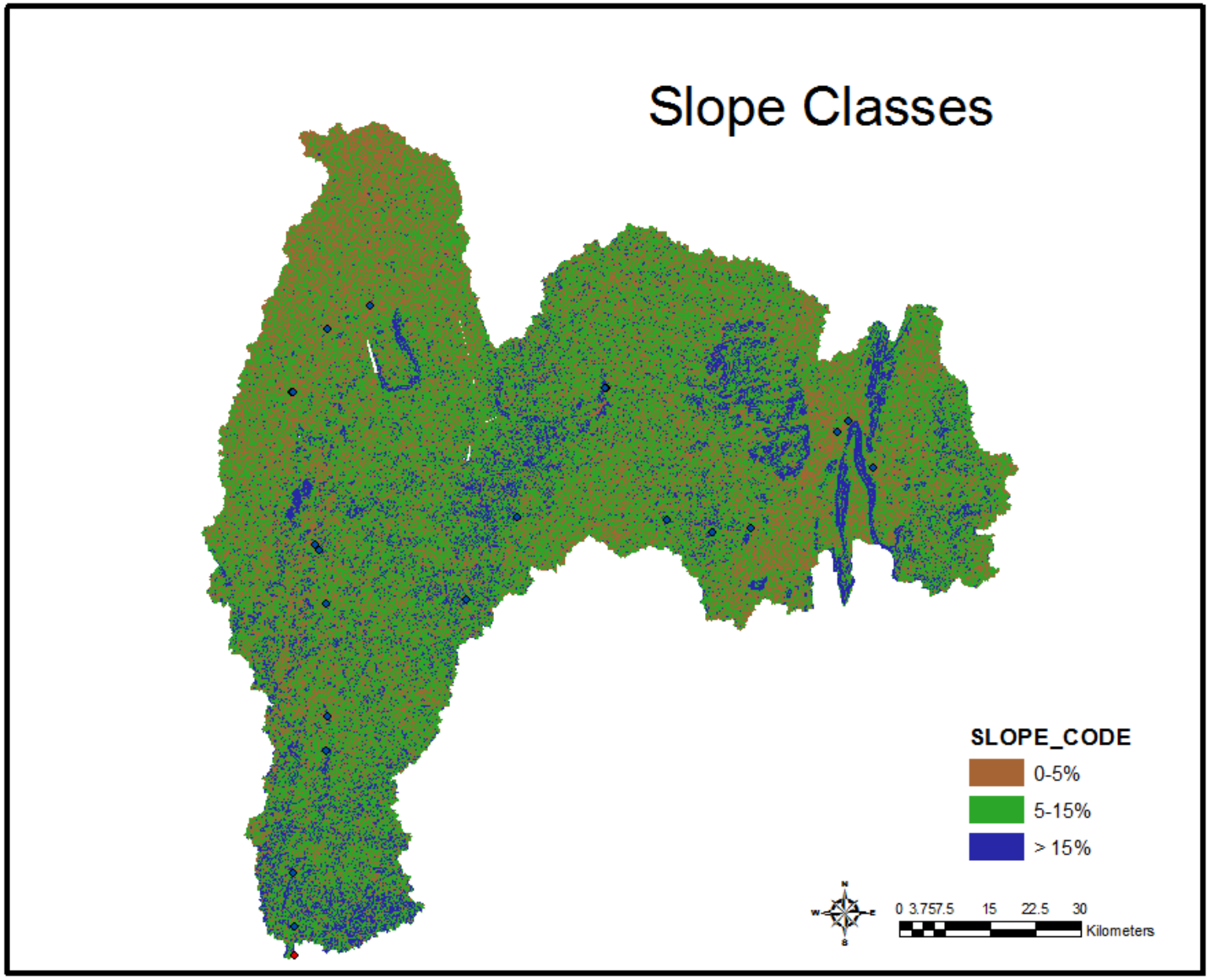
8000 km2
63 sub basins

Defining HRU

- At this stage, trying different thresholds
- Trying to get a “feeling” for the best way to characterize the HRUs

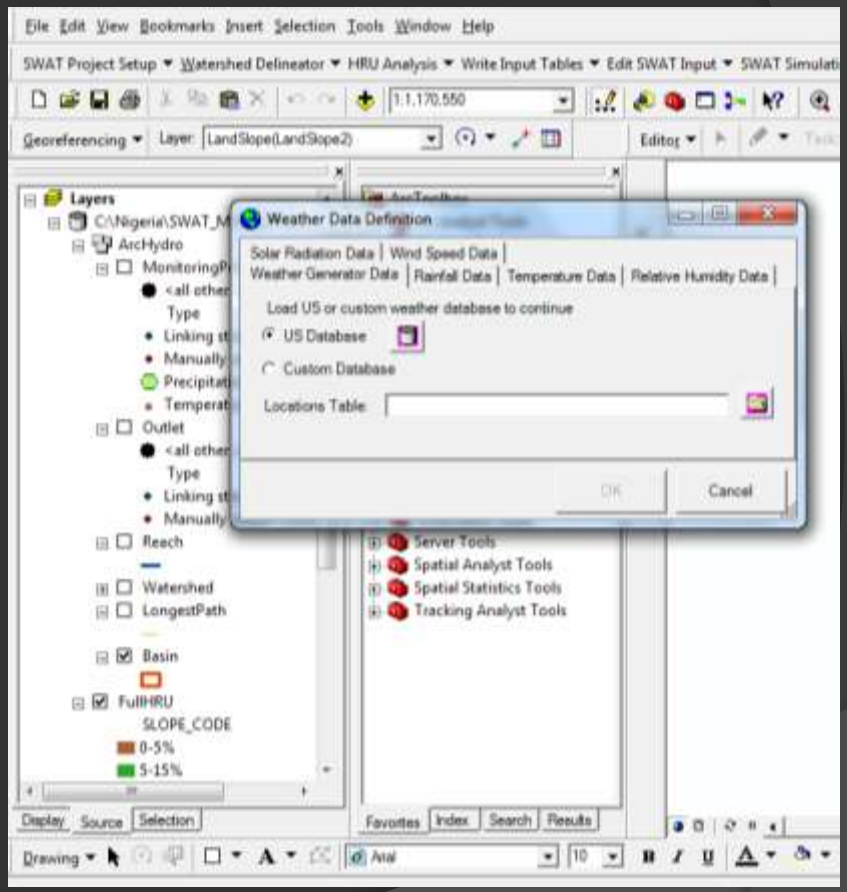



SWAT Land Use/Land Cover
Classes
Wetland
Water
Urban, low density
Urban, high density
Forest
Agriculture
0 5 10 20 30 40
Kilometers


Slope Classes
SLOPE_CODE
0-5%
5-15%
> 15%
0 3.757.5 15 22.5 30
Kilometers

Challenges with Data Inputs

- Non-US applications
- Specific data formatting
- But now that I have been working with the program for a bit, getting a better understanding of how it works; large learning curve



Outline

- Background:
  - Research goals and objectives
  - Study area
- SWAT
  - Research framework for community involvement
  - Data sets and collection
  - Initial model development
- Next steps
- Community capacity building

Immediate Next Steps

- Improve LULC data input through ground validation
- Edit management parameters: tillage, soil moisture, plant growth
- Quantify water use: collected initial survey data
- Explore use of remote sensing data
- Analyze soil samples collected to improve soil inputs
  - Brooklyn College now USDA approved facility to bring in foreign soils
- More weather data – longer term datasets and other variables
- Experiment with SWAT simulation
- Sensitivity analysis, calibration, validation?

Ultimately

- Develop realistic watershed budget?
- Refine process for Osun State; working with new Governor – hopefully establishing one or more science centers
- Find funding to apply approach in other communities northward along the moisture gradient – great challenge – US tax $ for US interests; better chance with Nigerian counterparts
- Model impacts of climate change scenarios on these watersheds

Outline

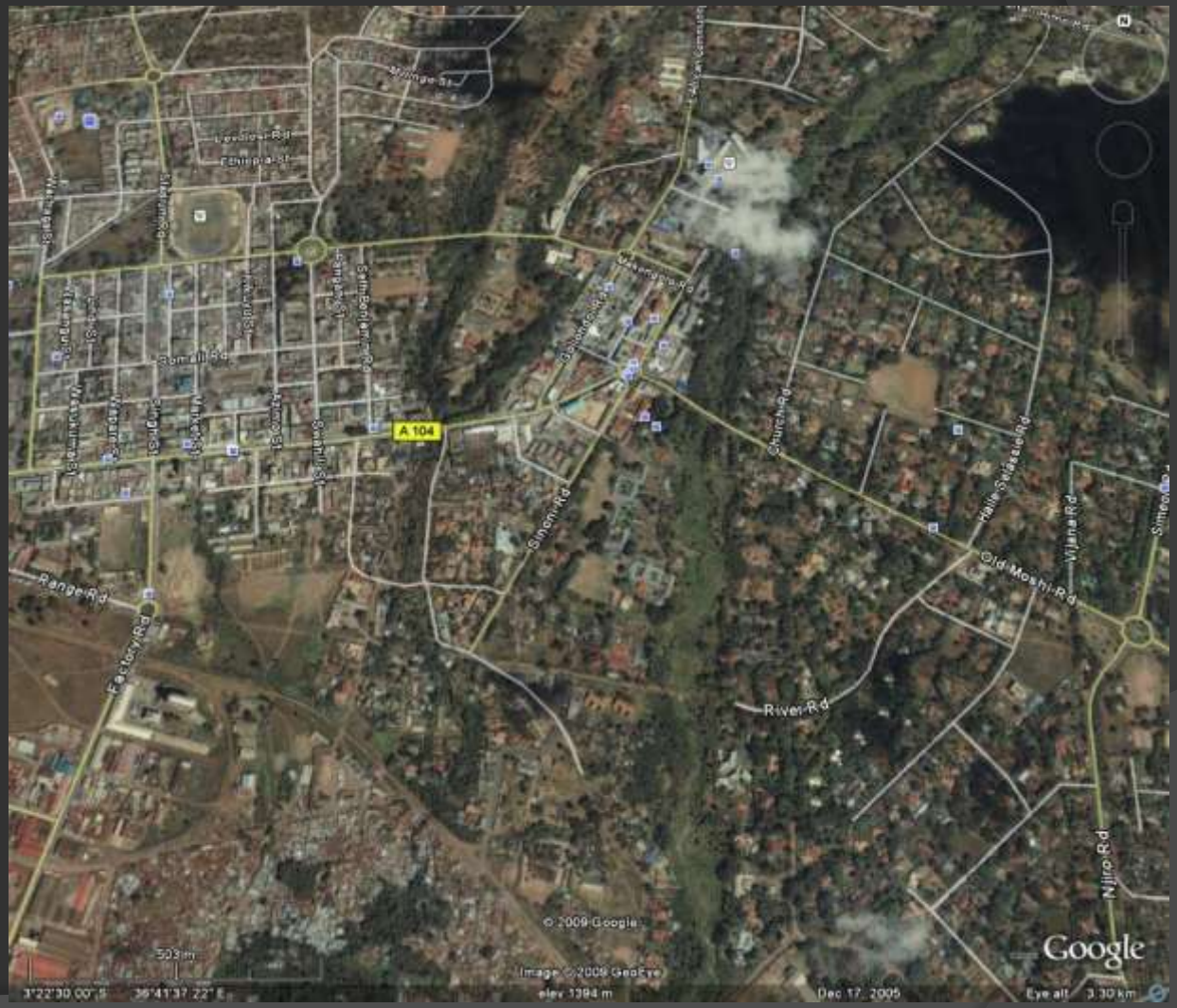
- Background:
  - Research goals and objectives
  - Study area
- SWAT
  - Research framework for community involvement
  - Data sets and collection
  - Watershed model
- Next steps
- Community capacity building

Community Involvement and Capacity building

- Workshops
- Field campaigns
- Development of new and adaptation of materials for African context
- Student research – flexible approach allows for diverse environmental data collection to be put to use

Field Campaign: May 2010

Where do you think mosquitoes breed around here?



Osogbo Workshop Format

Day	Activity	Science Process
1	Introduction to materials; learning data collection techniques	Asking questions, making predictions and hypotheses Developing sampling strategy and field logistics
2, 3, 4	Divided into two groups and sampled in urban and rural environments	Data collection
5	Group discussion, graphing and mapping	Data analysis and synthesis, interpretation
6	Student and teacher presentations	Communication of results

Days 2, 3, 4: Data Collection

Day 5: Data Analysis

Impacts on Teachers

- “Initially before this exercise, I used to have the impression that all these things we are doing in sciences are not practicable… it is not real. Even when I was in secondary school, I used to think that all we are doing is magic... But going through these exercises makes me know and believe that all we are doing is practicable, that we can equally derive an hypothesis, prove it and even put it into law.”

Funding and Contributors

- Funding: PSC CUNY and Tow Fellowship, GLOBE Seasons and Biomes Project
- Professor Raifu Durodoye from North Lake College, Texas, Dr. Russanne Low from University of Nebraska
- Nigerian Support
  - Secondary School teachers in Osun State, Mr. Ife Balogun and Professor Ahmed Balogun from FUTA, Esther Faboro from Bowen University

Thank you!