United Nations/Canada Space4Women Expert Meeting

Building capacity to promote and advance gender equality in the space sector

October 30th – November 3, 2023 | Montreal, Canada

She Space Nigeria: Using exposure to satellite remote sensing to encourage pre-teens to learn about STEM subjects

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Abstract

This presentation illustrates how satellite remote sensing was used, to make STEM education accessible and inspiring to selected school children in Nigeria through the She Space International Program. The vision of She Space International is to enable school aged students to **experience academic research, team-work and international collaboration in an all-female setting**, designed to empower young women to continue in space science and research. The She Space Nigeria team comprised of seven preteen girls, aged 8 to 12 years. The girls, representing 5 out of the 6 geopolitical zones in Nigeria, were selected based on parental support. By introducing the girls to ArcGIS and using the Google Earth Engine to learn coding and cloud computing for visualizing and processing satellite data, the girls are trained on how to analyze the impact of flood incidences in the "Food Basket State" of Nigeria. The results of the analysis, the different skills acquisition, and the learning experience, as described by the girls, will be presented. The steps involved in implementing this multi-disciplinary, project-based learning program, in collaboration with She Space International, will also be highlighted. The presentation will conclude on how pre-teen girls can engage in academic research, from a very early age, and be encouraged to design and execute mini projects, using satellite derived and other types of remotely sensed data, to address local environmental issues.

Outline

- Background on collaboration with She Space International
- Implementation of She Space Nigeria
  - Selection criteria for participants
  - Concluded Research Activities and Results
  - Projected Research Activities
  - Skills acquisition and learning experience of the girls
- Conclusion on viable methods of promoting gender equality in the space sector

SHE SPACE INTERNATIONAL

In memory of Devorah Blumberg

Main Goals:

- Students will experience academic research, team work and international collaboration in an all-female setting designed to empower young women to continue in space science and research
- Students will utilize interdisciplinary remote sensing concepts to explore the status of vegetation under climatic conditions specific to each of their respective countries, which will integrate physics (optics and remote sensing), geography (climate and image analysis), and biology & chemistry (plant health and the factors affecting it)
- Students will gain experience presenting their scientific findings in diverse groups (to the other international participants)
- Students will learn about the space agencies and satellites launched by their various countries from the other participants
- Each group will present their impressions and understanding of the current status of women and the balance of genders in space sciences (and more generally) in their respective countries; the total group will discuss together how to encourage female participation in research and how to act as ambassadors for women in space science

Background on collaboration with She Space International

- Met the Director of She Space International (Shimrit) during the Space4Women Expert Meeting held in South Korea (2022)

Participating Countries:

- Germany
- Israel
- Ivory Coast
- **Nigeria (2023)**
- South Korea
- Spain
- Switzerland
- Togo
- USA

DLR_School_Lab

ARCSSTE-E

KARI Korea Aerospace Research Institute

COURS LUMIÈRE

UFRPE

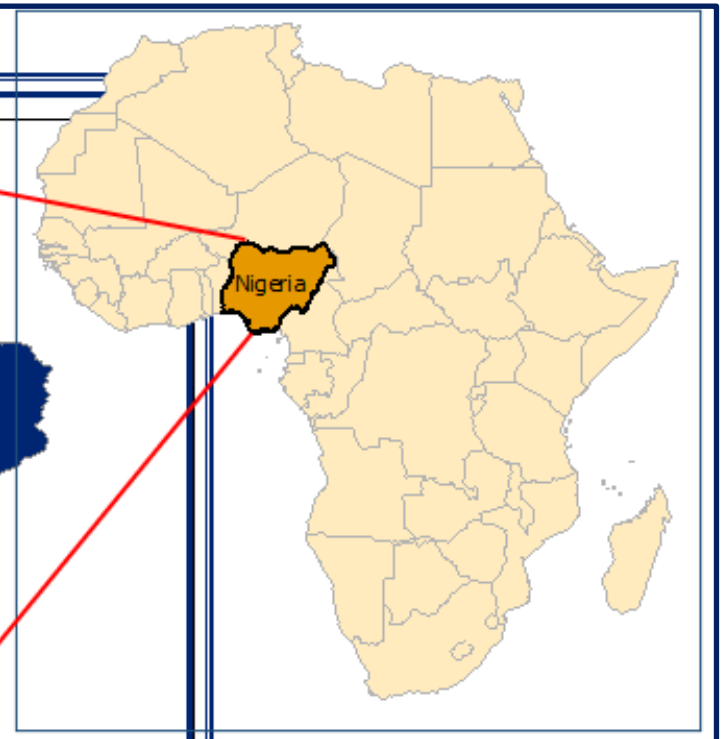
IES LAS MUSAS

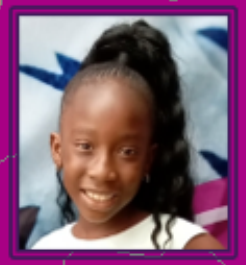
NPOC

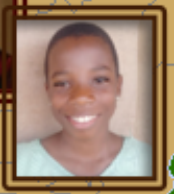
Space eXchange Switzerland

University of Zurich[UZH]

She Space Nigeria







Geopolitical Zones

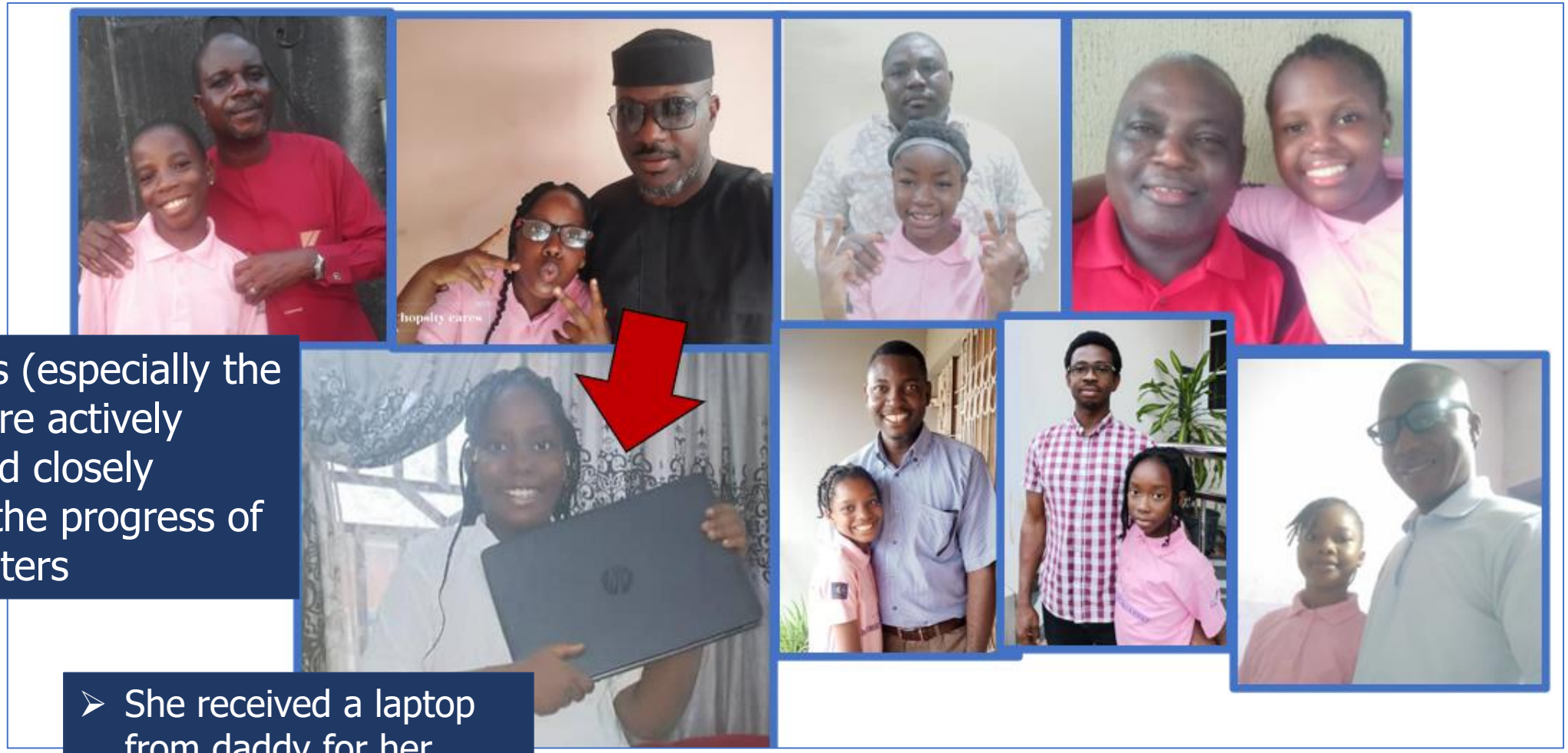
- North Central
- North East
- North West
- South East
- South South
- South West

N
W E
S

0 60 120 240 360 480
Kilometers

The She Space Nigeria team is made up of seven preteen girls, aged 8 to 12 years

Selection of Participants with Parental Support



- The parents (especially the fathers) were actively involved and closely monitored the progress of their daughters

- She received a laptop from daddy for her birthday gift

Spatio-temporal analysis of the impact of 2022 flood incident on the "Food Basket State" of Nigeria

Aim:

To analyze the impact of 2022 flood incident on the crop land in Benue State, Nigeria

Objectives

- Analysis of ground measured rainfall data (2012 to 2022) with Excel Spread Sheets
- Use satellite derived data and the Google Earth Engine to prepare flood maps
- Estimate how much crop land was destroyed by the flood in 2022

Training the Girls

Training sessions commenced in February 2023 till date

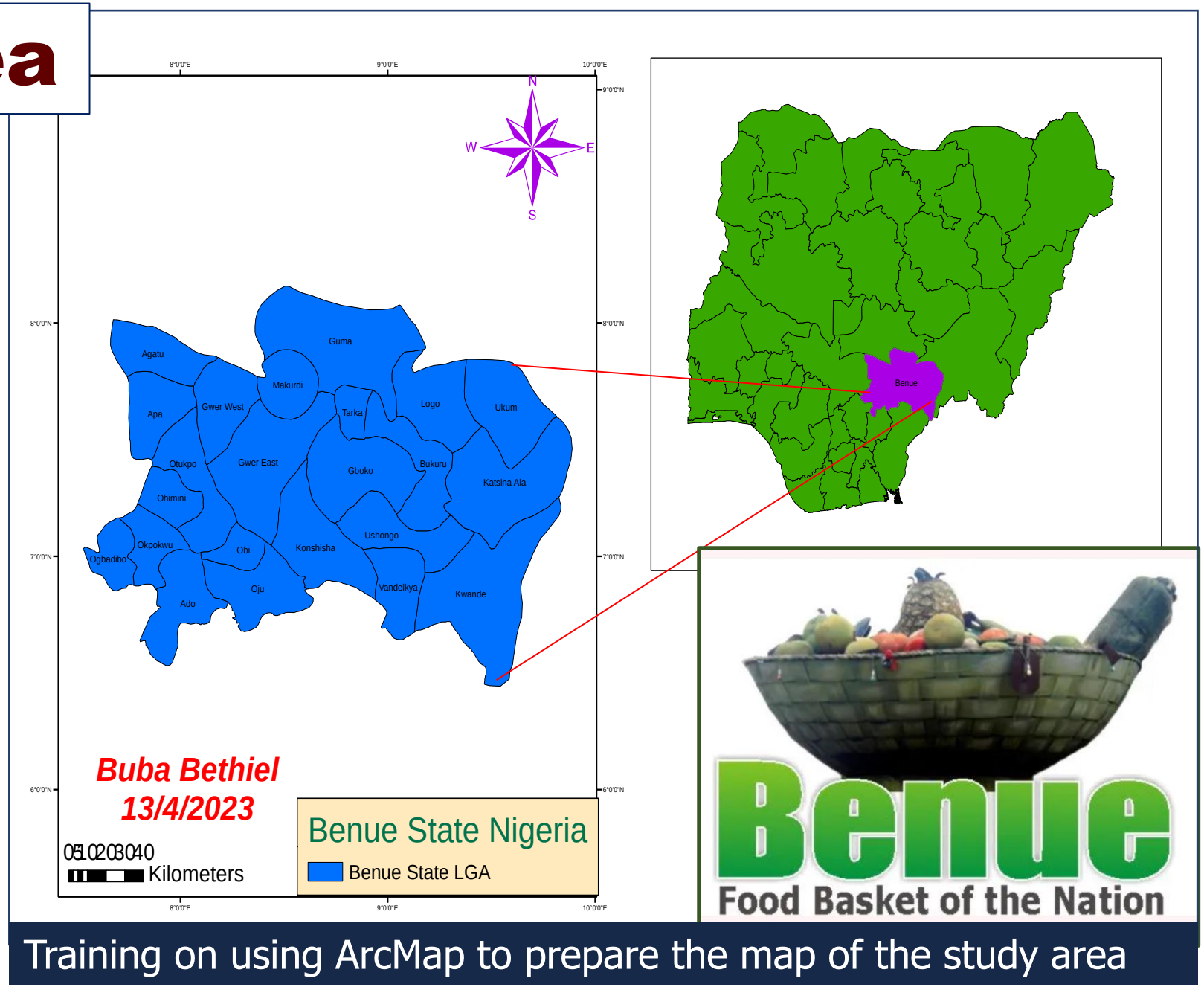
- After official school hours on selected days
- During the vacation periods

Introduction to the Study

- While Nigeria typically experiences seasonal flooding, the floods of 2022 were the worst in the country since the flood incidents recorded ten years ago, in 2012.
- The flooding has been blamed on unusually *heavy rains* and climate change as well as the release of water from the Lagdo Dam in neighbouring Cameroon, which began on 13 September 2022.
- The 2022 floods in Nigeria affected most of the country, displacing over 1.4 million people, killing over 600, and injuring more than 2,400.
- Over 200,000 homes were completely or partially destroyed by the floods, and vast farmlands were ruined.

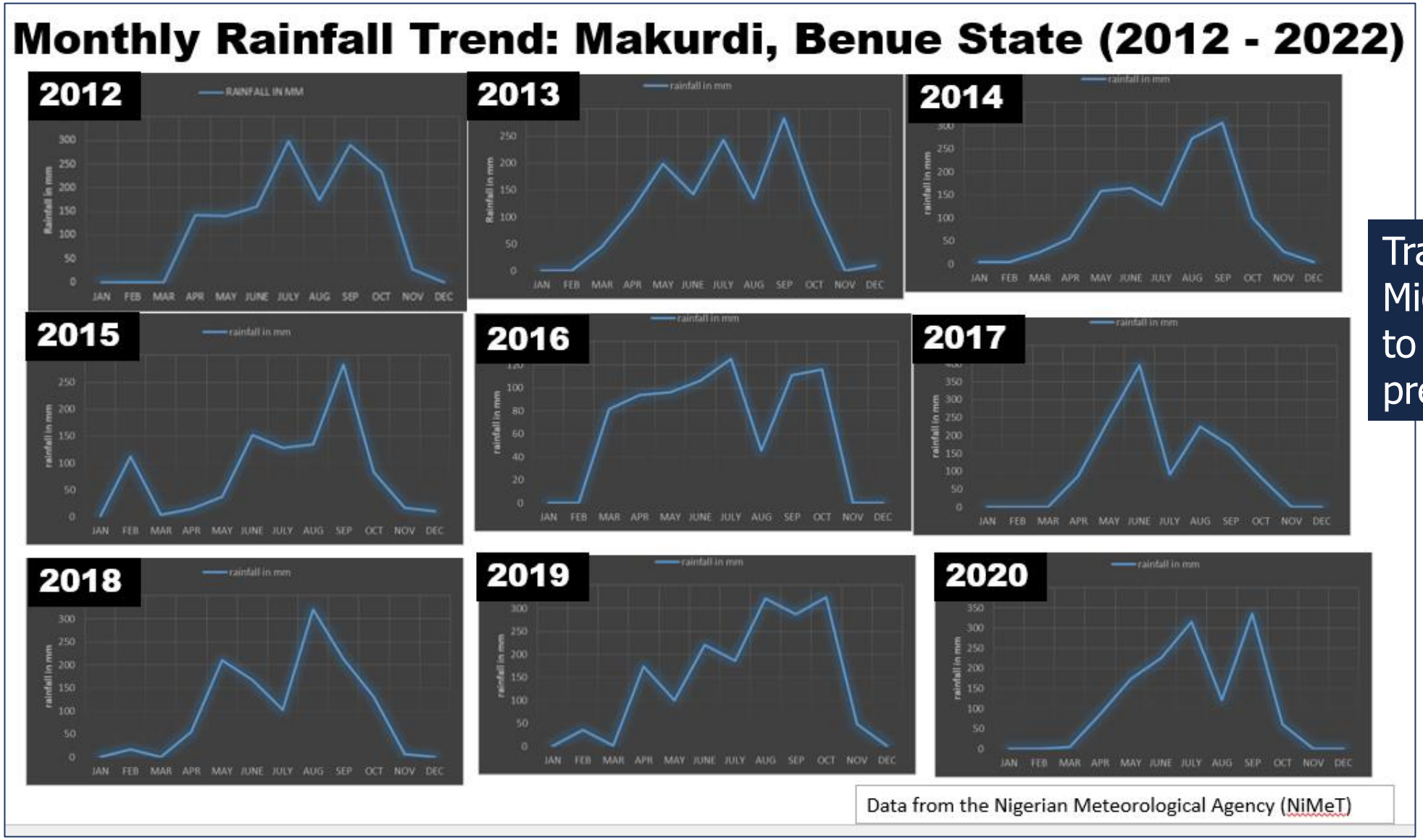
The Study Area

- Nigeria is made up of 36 States and the Federal Capital Territory (FCT)
- Benue State is known as the "Food Basket of the Nation"
- Because of the rich agricultural produce which include yam, rice, beans, cassava, potatoes, maize, soya beans, sorghum, millet and cocoyam.



Training on using ArcMap to prepare the map of the study area

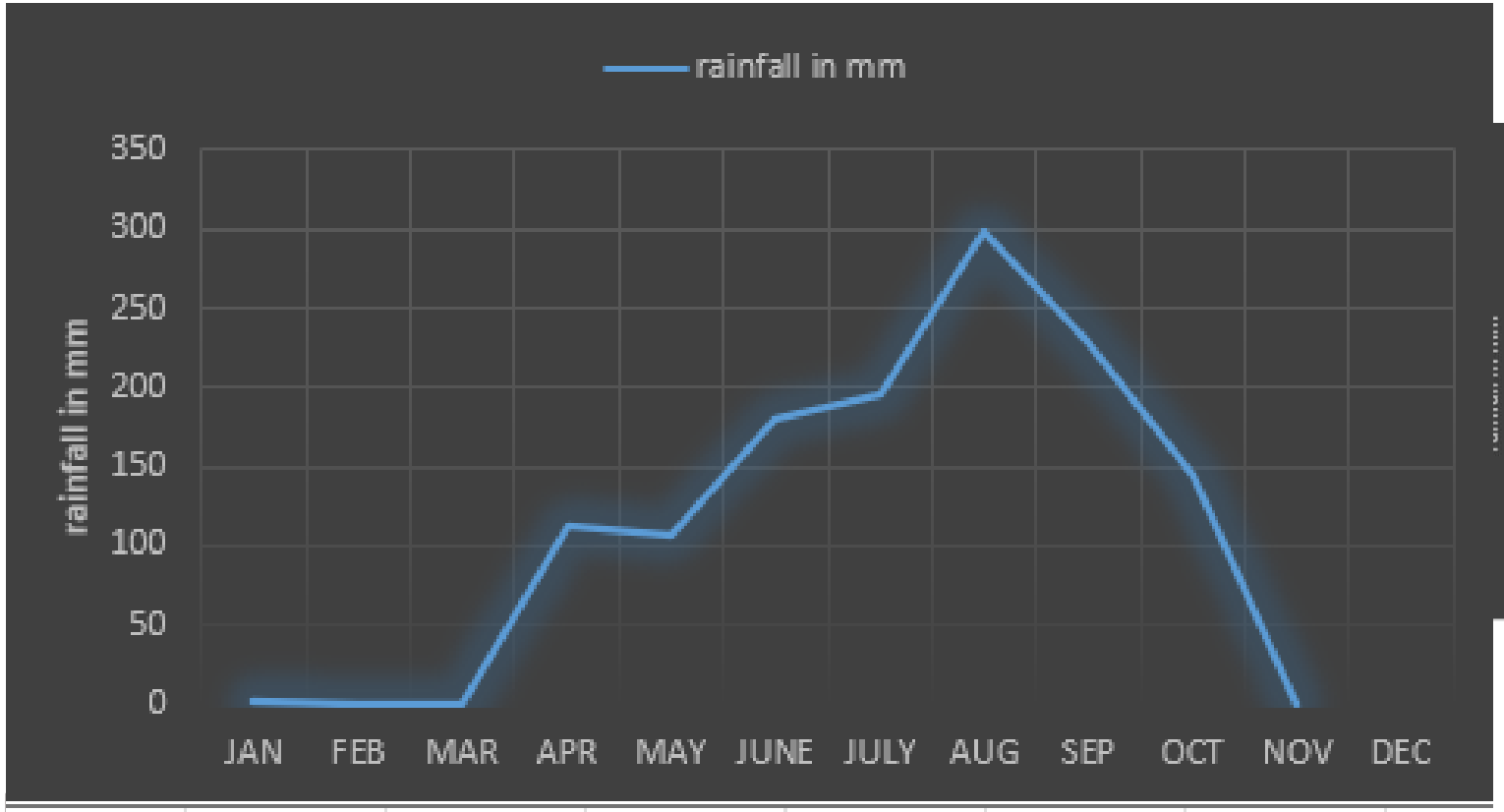
Results

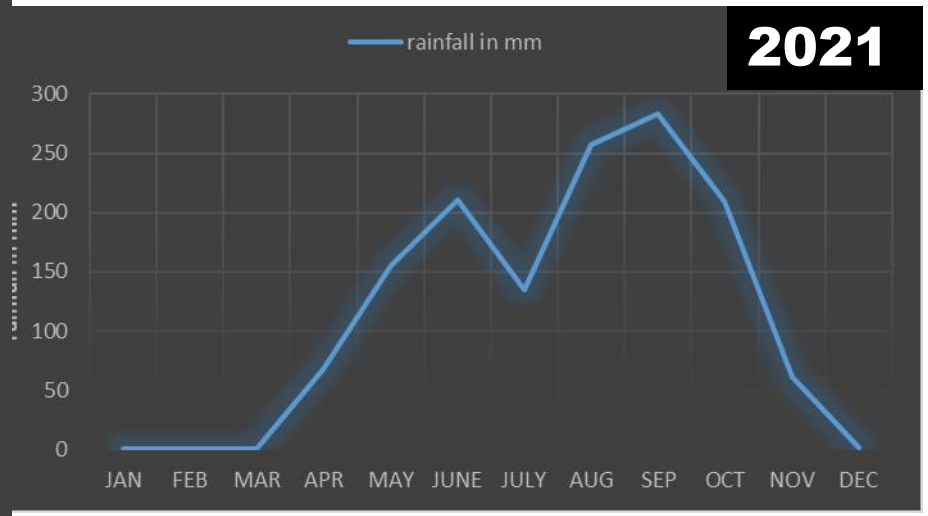


Training on using Microsoft Excel Sheet to analyze data and prepare Charts

Results

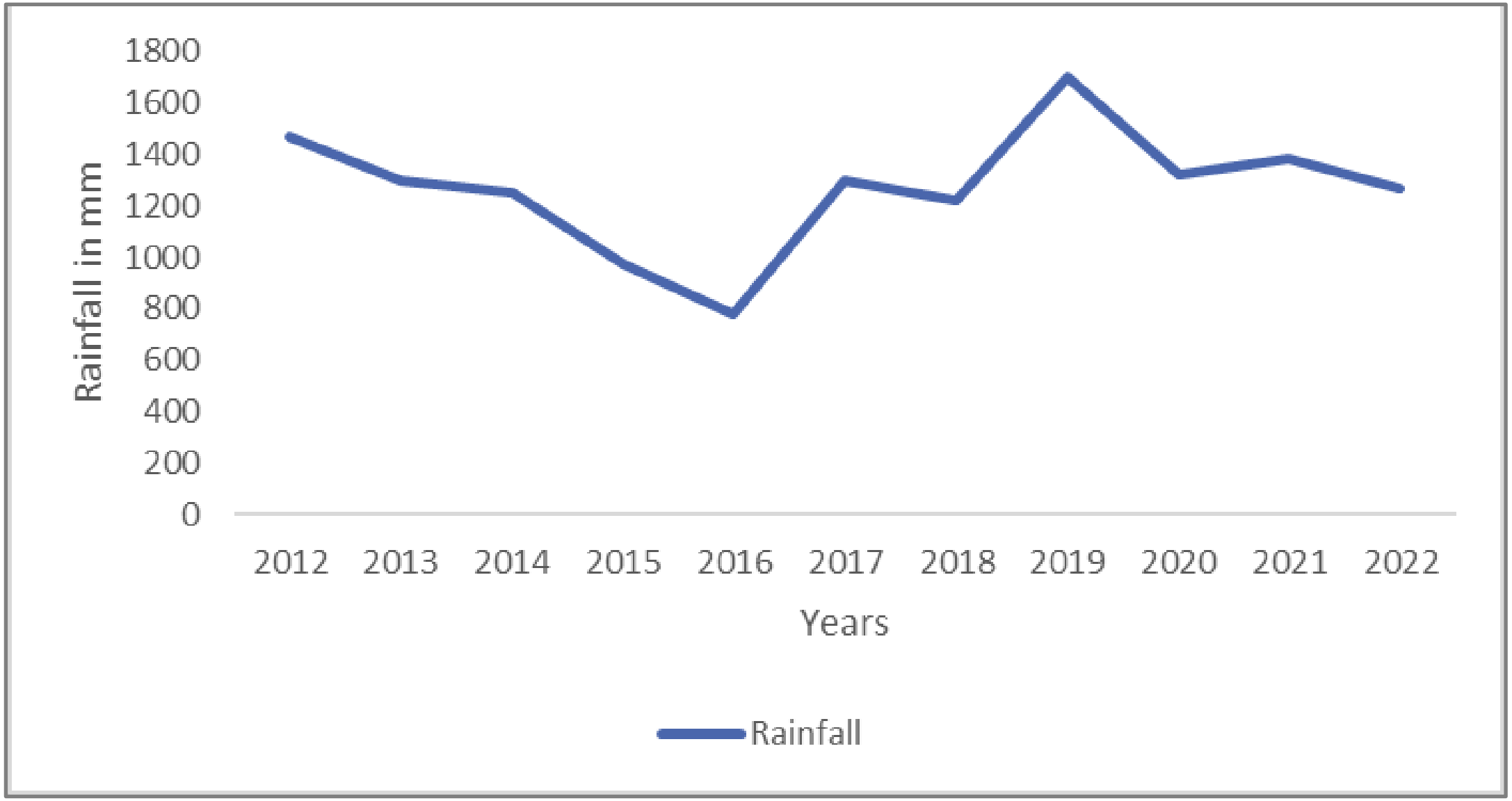
Rainfall in Makurdi, Benue State in 2022



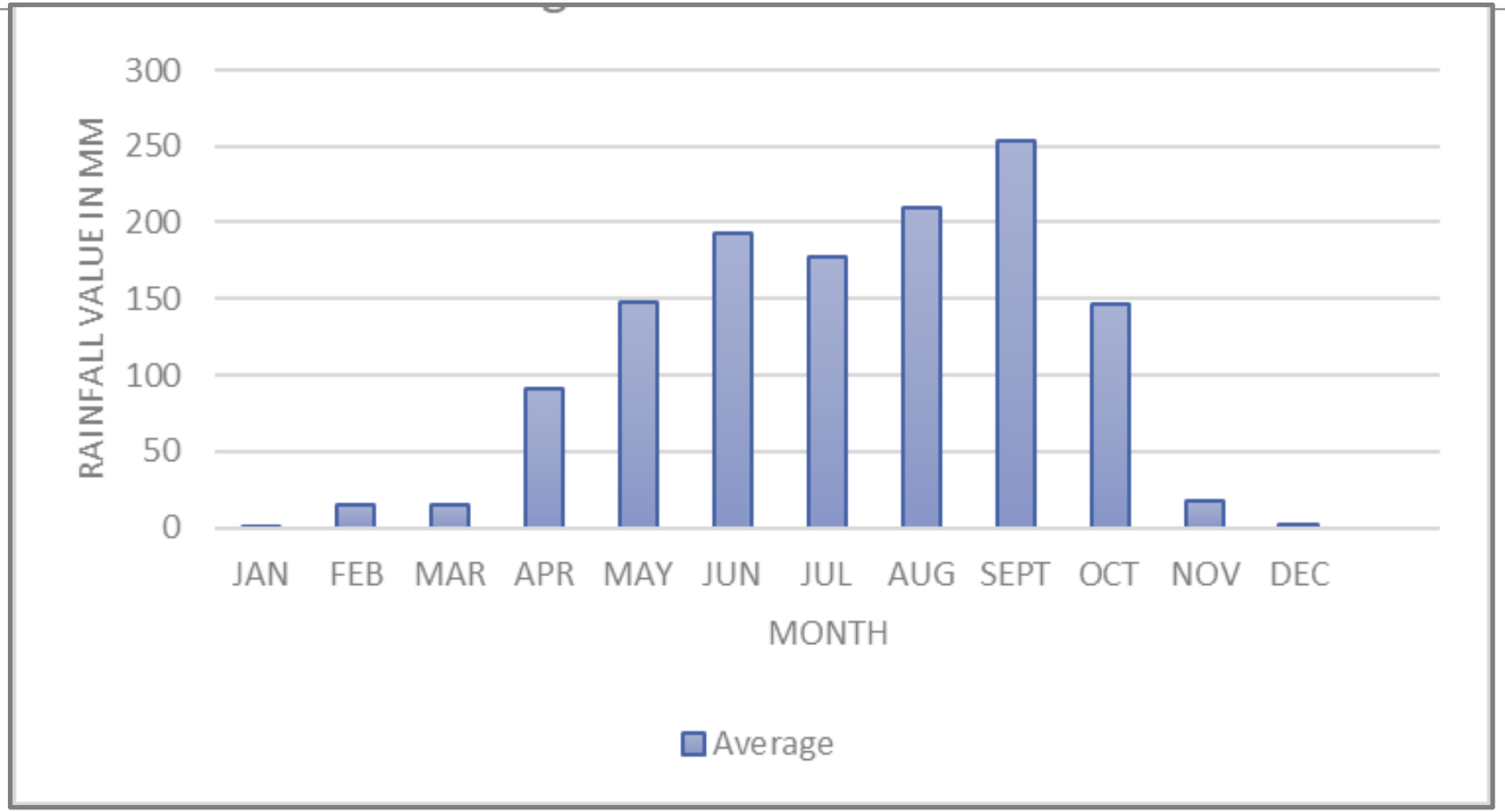


Data from the Nigerian Meteorological Agency (NiMeT)

Annual Rainfall Trend in Makurdi, Benue State (2012-2022)



Average Monthly Rainfall in Makurdi, Benue State (2012-2022)



Data from the Nigerian Meteorological Agency (NiMeT)

Results

Google Earth Engine

Training on using the Google Earth Engine to modify codes to select, analyze and display SAR data

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```
// OPTIONAL- Load the shapefile for your area of interest
var roi = ee.FeatureCollection("FAO/GAUL_SIMPLIFIED_500m/2015/level1").filter(ee.Filter.eq('ADM1_NAME', 'Benue'));
Map.addLayer(roi, {color: 'gray'}, 'Study Area',0);

// Set Google Terrain as the basemap
Map.setOptions('TERRAIN');

var collection = ee.ImageCollection('COPERNICUS/S1_GRD')
    .filter(ee.Filter.eq('instrumentMode', 'IW'))
    .filter(ee.Filter.eq('orbitProperties_pass', 'ASCENDING'))
    .filterMetadata('resolution_meters', 'equals' , 10)
    .filterDate('2022-09-01', '2022-12-31')
    .filterBounds(roi);
print(collection, 'Sentinel-1 Collection');
var collection_list=ee.ImageCollection(collection).toList(999);

var image1=ee.Image(ee.List(collection_list).get(4)).clip(roi);
var image2 =ee.Image(ee.List(collection_list).get(5)).clip(roi);
var sep_14 = ee.ImageCollection([image1, image2]).mosaic();
Map.centerObject(roi, 10);
Map.addLayer(sep_14.select('VH'), {min:-25,max:-5}, 'S1 Sep. 14, 2022 VH', 1);

var image3 =ee.Image(ee.List(collection_list).get(8)).clip(roi);
var image4 =ee.Image(ee.List(collection_list).get(9)).clip(roi);
var sep_26 = ee.ImageCollection([image3, image4]).mosaic();
Map.centerObject(roi, 10);
Map.addLayer(sep_26.select('VH'), {min:-25,max:-5}, 'S1 Sep. 26, 2022 VH', 1);

var image5=ee.Image(ee.List(collection_list).get(32)).clip(roi);
var image6 =ee.Image(ee.List(collection_list).get(33)).clip(roi);
var dec_19 = ee.ImageCollection([image5, image6]).mosaic();
Map.centerObject(roi, 10);
Map.addLayer(dec_19.select('VH'), {min:-25,max:-5}, 'S1 Dec. 19, 2022 VH', 1);


//////////////////////////++++++++++++Apply a speckle filter++++++++++++//////////////////
var SMOOTHING_RADIUS = 30;
var sep_14_filt = sep_14.focal_mean(SMOOTHING_RADIUS, 'circle', 'meters');
var sep_26_filt = sep_26.focal_mean(SMOOTHING_RADIUS, 'circle', 'meters');
var dec_19_filt = dec_19.focal_mean(SMOOTHING_RADIUS, 'circle', 'meters');
```

Inspector | Console | Tasks

Use `print(...)` to write to this console.

```
▾ ImageCollection COPERNICUS/S1_GRD (36 elements)                    JSON
    type: ImageCollection
    id: COPERNICUS/S1_GRD
    version: 1687940684963146
    bands: []
  ▾ features: List (36 elements)
    ▸ 0: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220902T173729_20220902T…
    ▸ 1: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220902T173754_20220902T…
    ▸ 2: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220907T174542_20220907T…
    ▸ 3: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220907T174607_20220907T…
    ▸ 4: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220914T173729_20220914T…
    ▸ 5: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220914T173754_20220914T…
    ▸ 6: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220919T174541_20220919T…
    ▸ 7: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220919T174606_20220919T…
    ▸ 8: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220926T173729_20220926T…
    ▸ 9: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20220926T173754_20220926T…
    ▸ 10: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221008T173729_20221008…
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    ▸ 12: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221013T174542_20221013…
    ▸ 13: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221013T174607_20221013…
    ▸ 14: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221025T174542_20221025…
    ▸ 15: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221025T174607_20221025…
    ▸ 16: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221101T173729_20221101…
    ▸ 17: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221101T173754_20221101…
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    ▸ 19: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221106T174607_20221106…
    ▸ 20: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221113T173729_20221113…
    ▸ 21: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221113T173754_20221113…
    ▸ 22: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221118T174542_20221118…
    ▸ 23: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221118T174607_20221118…
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    ▸ 25: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221125T173754_20221125…
    ▸ 26: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221130T174541_20221130…
    ▸ 27: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221130T174606_20221130…
    ▸ 28: Image COPERNICUS/S1_GRD/S1A_IW_GRDH_1SDV_20221207T173728_20221207…
```
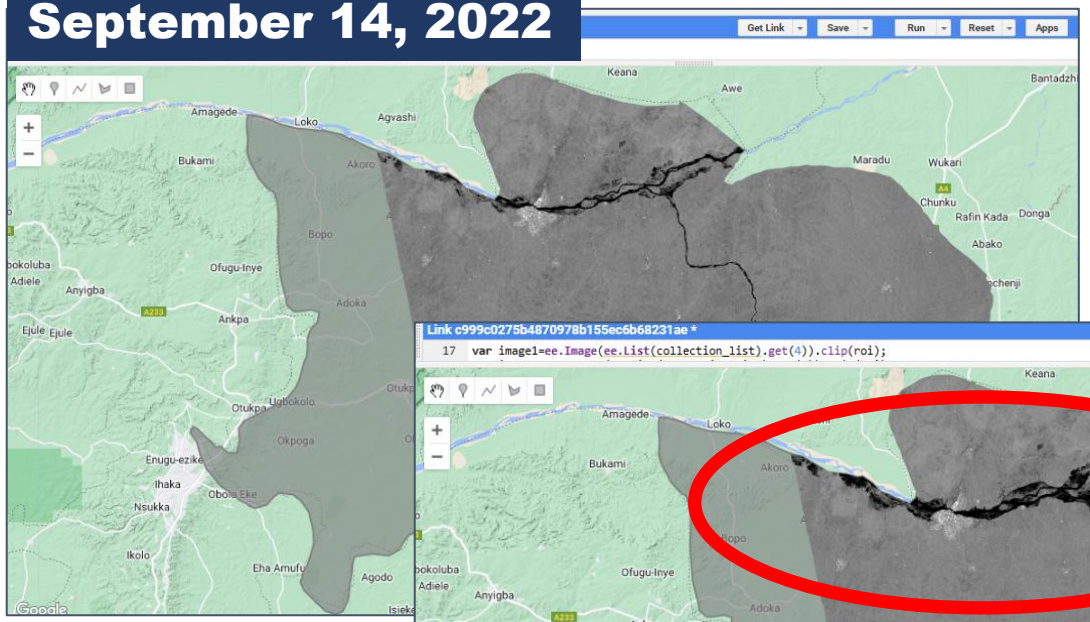
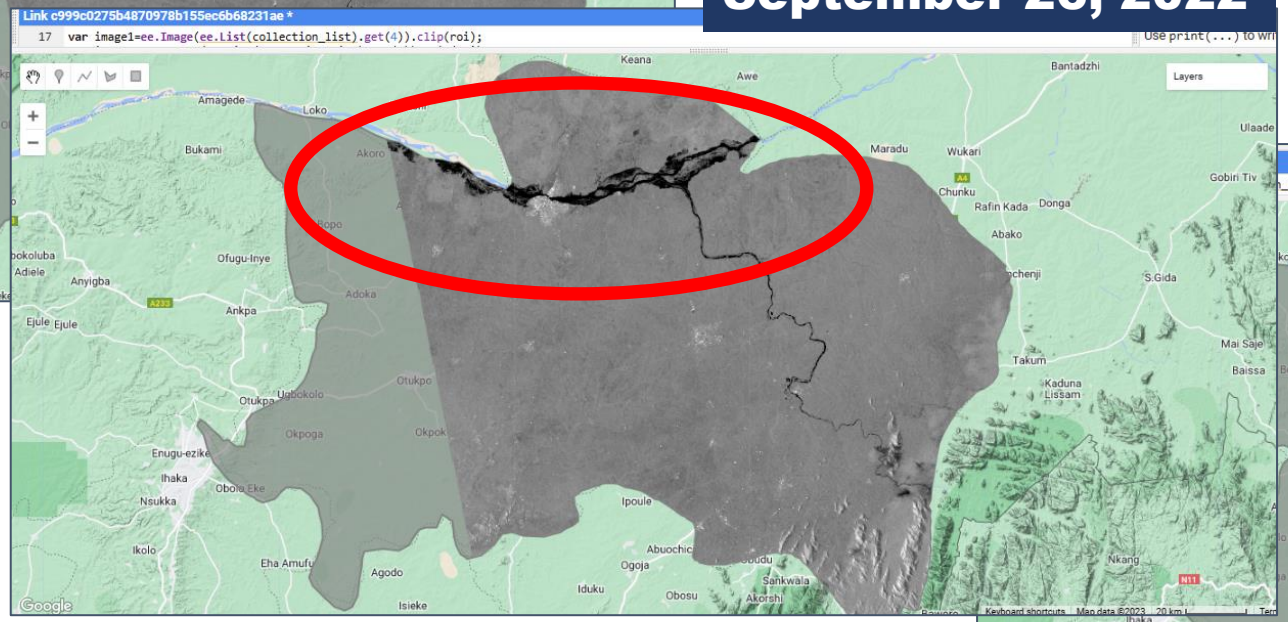

Results

Pre-Flood
September 14, 2022



Flood
September 26, 2022



Post Flood
December 19, 2022

Results

Training on using the Google Earth Engine to modify codes to prepare flood maps

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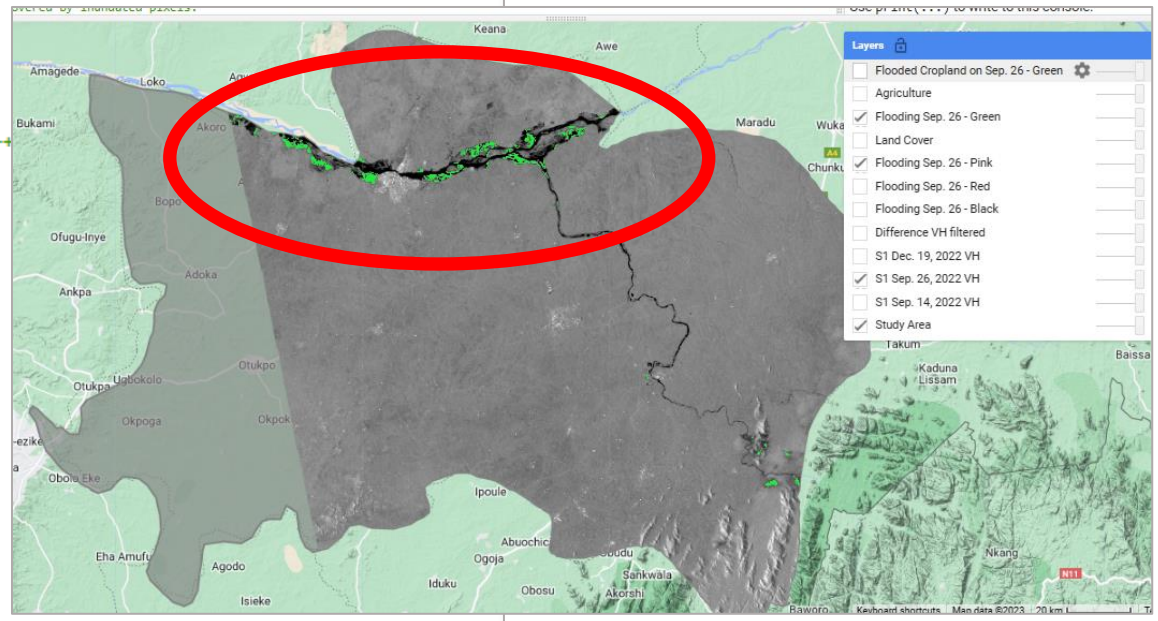
```
//////////////++++++++++++Create difference images from before and after the event++++++++++++/////////
//NOTE: In order to substract logarithmic values (dB) - you must perform a division
var sep14_sep26_diff= sep_26_filt.select('VH').divide(sep_14_filt.select('VH'));
Map.addLayer(sep14_sep26_diff, {min: 0,max:2}, 'Difference VH filtered', 0);

//////////////++++++++++++Apply a threshold - based on the difference image values ++++++++++++////////
var UPPER_THRESHOLD = 1.25;
var inundation_sep14_sep26 = sep14_sep26_diff.gt(UPPER_THRESHOLD)
Map.addLayer(inundation_sep14_sep26.updateMask(inundation_sep14_sep26),
{palette:"070908"},'Flooding Sep. 26 - Black',0);

//////////////++++++++++++Refine the flood map results with additional datasets++++++++++++
// Calculate pixel connectivity and remove those connected by
//8 pixels or less.
var connections = inundation_sep14_sep26.connectedPixelCount();
var inundation2_sep14_sep26 = inundation_sep14_sep26.updateMask(connections.gte(8));

Map.addLayer(inundation2_sep14_sep26.updateMask(inundation2_sep14_sep26),
{palette:"ee360c"},'Flooding Sep. 26 - Red',0);

// Remove misclassified pixels in areas where the slope is greater than
//5% using an SRTM DEM
var srtm = ee.Image('USGS/SRTMGL1_003');
var terrain = ee.Algorithms.Terrain(srtm);
var slope = terrain.select('slope');
var inundation3_sep14_sep26 = inundation2_sep14_sep26.updateMask(slope.lt(5));
Map.addLayer(inundation3_sep14_sep26.updateMask(inundation3_sep14_sep26),
{palette:"ec11d1"},'Flooding Sep. 26 - Pink',0);

// Remove misclassified pixels in areas where there is pernament open water using
// the Copernicus Global Land Service (CGLS) land cover map (100m)
var global_landcover = ee.Image("COPERNICUS/Landcover/100m/Proba-V-C3/Global/2019").select('discrete_classification');
var landcover_roi = global_landcover.clip(roi);
Map.addLayer(landcover_roi, {}, "Land Cover", 0);

// Extract only water pixels from CGLS using class value equal to 80 or 200
//var water = landcover_roi.eq(80,200);
var water = landcover_roi.eq(80).or(landcover_roi.eq(200));
var watermask = inundation3_sep14_sep26.where(water,0);
var inundation4_sep14_sep26 = watermask.updateMask(watermask);
```



Results

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```
  bestEffort: false
  });

// Convert inundated extent to hectares
var inundation_area_ha_sep26 = inundation_stats_sep26.getNumber("VH").divide(10000).round();
print(inundation_area_ha_sep26, 'Hectares of Inundated Area for Sep. 26');

//////////////////////++++++++++++Calculate Flooded Cropland++++++++++++//////////////////
// Use the Copernicus Global Land Service (CGLS) land cover (100m) map to identify cropland
// Extract only cropland pixels from the CGLS. The cropland class value is equal to 40
var crop = landcover_roi.eq(40);
var cropmask = landcover_roi.updateMask(crop);

// Calculate the affected cropland using the flood layer from Sep. 26
var cropland_affected_sep26 = inundation4_sep14_sep26.updateMask(cropmask);
// Calculate the pixel area where there are crops and it is flooded
var crop_pixelarea = cropland_affected_sep26.multiply(ee.Image.pixelArea());
// Sum pixels of affected cropland layer
var crop_stats = crop_pixelarea.reduceRegion({
  reducer: ee.Reducer.sum(), //sum all pixels with area information
  geometry: roi,
  scale: 10,
  maxPixels: 1e9
  });
// Convert area to hectares
var crop_area_ha_sep26 = crop_stats.getNumber("VH").divide(10000).round();
// Print results
print (crop_area_ha_sep26, 'Hectares of Inundated Cropland on Sep. 26');

// Add crop layer to map
Map.addLayer(cropmask, {}, 'Agriculture', 0);

// Add flooded crop area to map
Map.addLayer(cropland_affected_sep26, {palette:"22ec3b"}, 'Flooded Cropland on Sep. 26 - Green', 0);
```

Inspector | Console | Tasks

Use print(...) to write to this console.

```
ImageCollection COPERNICUS/S1_GRD (36 elements)
  type: ImageCollection
  id: COPERNICUS/S1_GRD
  version: 1687940684963146
  bands: []
  features: List (36 elements)
Sentinel-1 Collection

24725
Hectares of Inundated Area for Sep. 26

8558
Hectares of Inundated Cropland on Sep. 26
```

Training on using the Google Earth Engine to modify codes to estimate Inundated Cropland

Summary of Results

The study observed that:

- The monthly series analysis of ground measured rainfall data from 2012 to 2022 revealed an inconsistent rainfall pattern.
- The maximum annual rainfall occurred in 2019, even though the worst flood incident was recorded in 2022. Furthermore, although the greatest amount of rainfall in 2022 was recorded by NiMET in August, the flood incident was most pronounced in September. Thus indicating that the flood occurrence is not due only to rainfall. The release of water from the Lagdo Dam in neighbouring Cameroon is also a major cause of flood in Benue State.
- The flood maps prepared with the Google Earth Engine revealed that most of the flooded areas were located along the river line.
- About 35% of the flooded area in Benue State in 2022 was crop land.

Virtual Presentation by She Space Nigeria, during the Final Call for She Space International

Spatio-temporal analysis of the impact of 2022 flood incident on the "Food Basket State" of Nigeria

Presentation by

She Space Nigeria

5:38 / 2:00:50

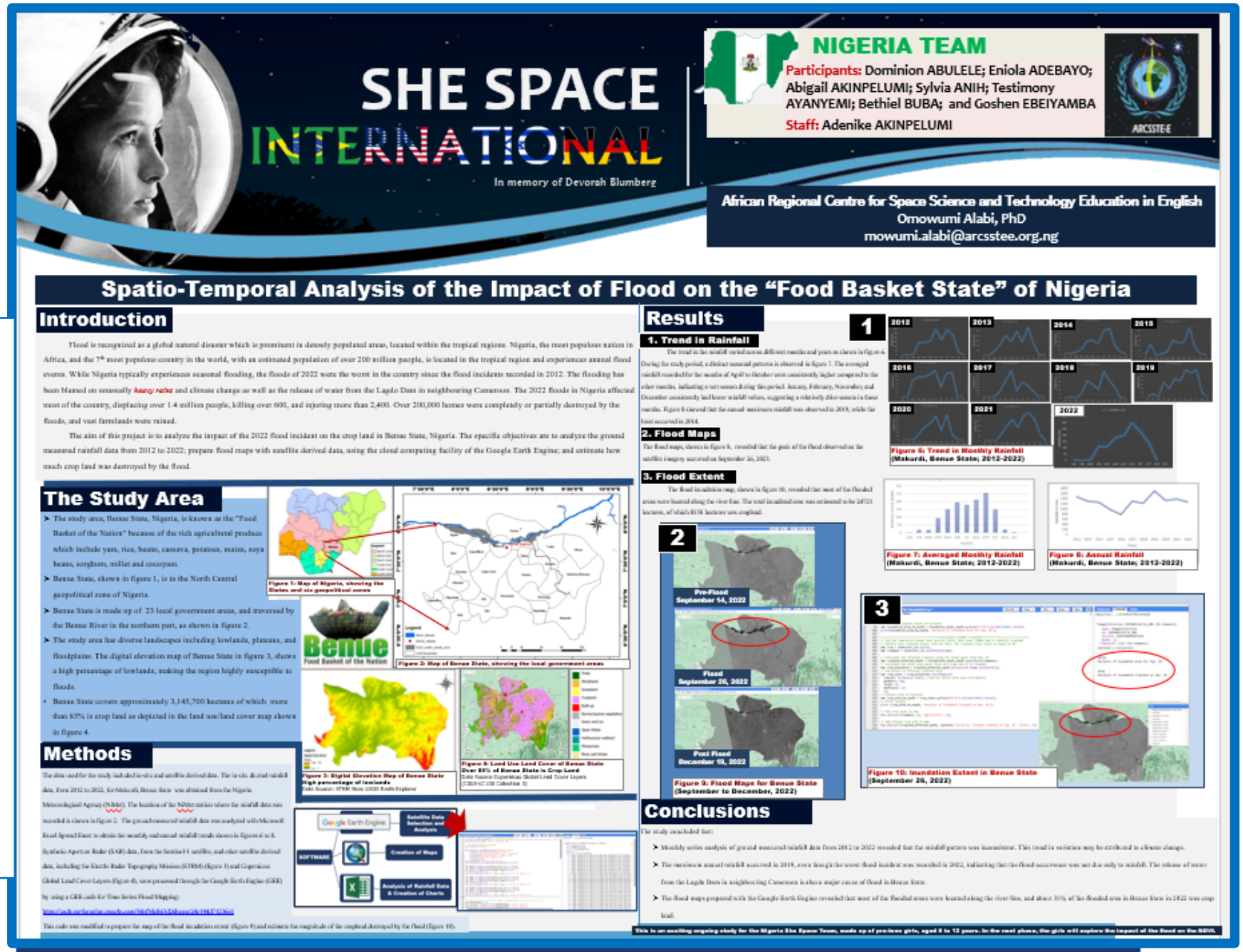
Phase One

Skills Acquisition (Software)

Microsoft Excel
- Analyze NiMeT rainfall data

ArcGIS (ArcMap)
- Prepare Map of Study Area

Google Earth Engine
- Create Flood Maps using Synthetic Aperture Radar (SAR) data from the Sentinel-1
- Estimate how much crop is destroyed



She Space International 2023 Poster by the Nigeria Team

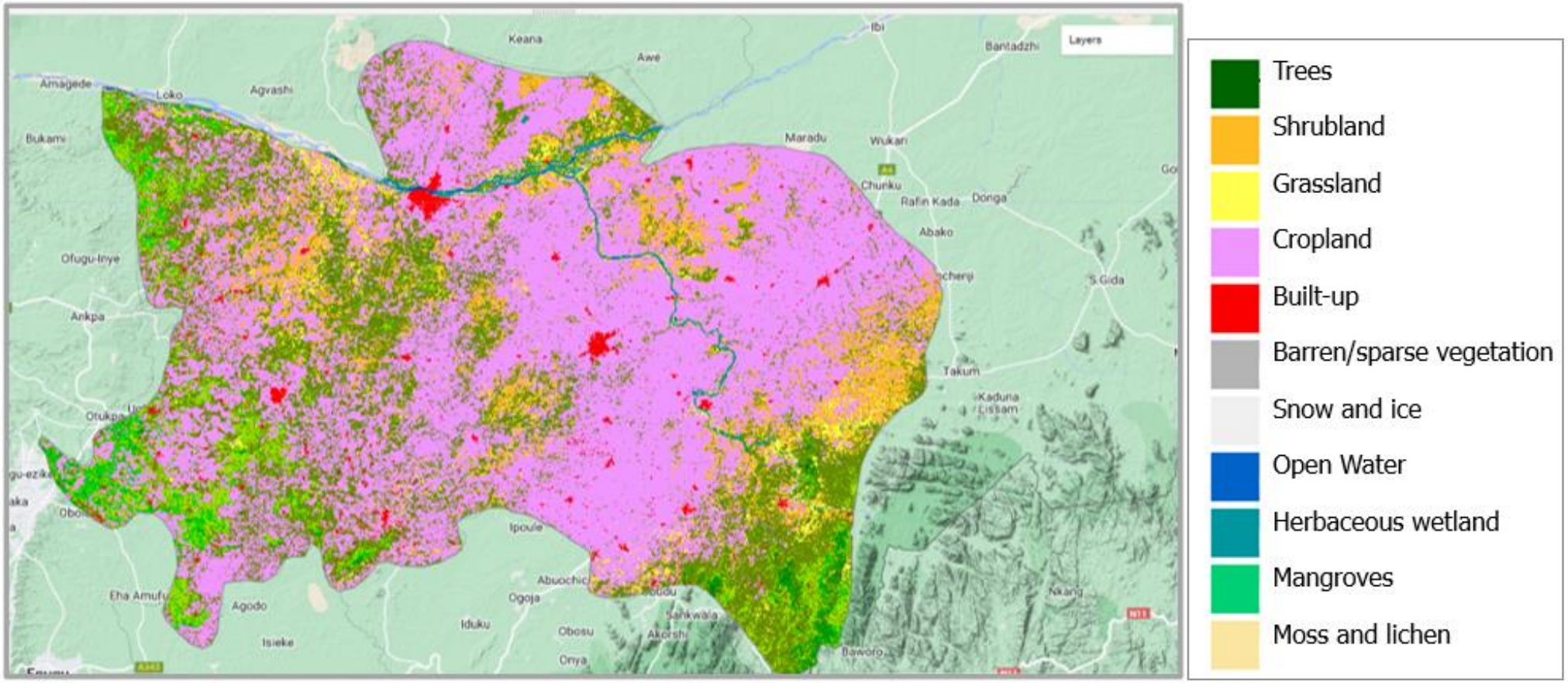
Phase Two

Use Satellite data to monitor impact of flood on Cropland: **NDVI Analysis**

Google Earth Engine

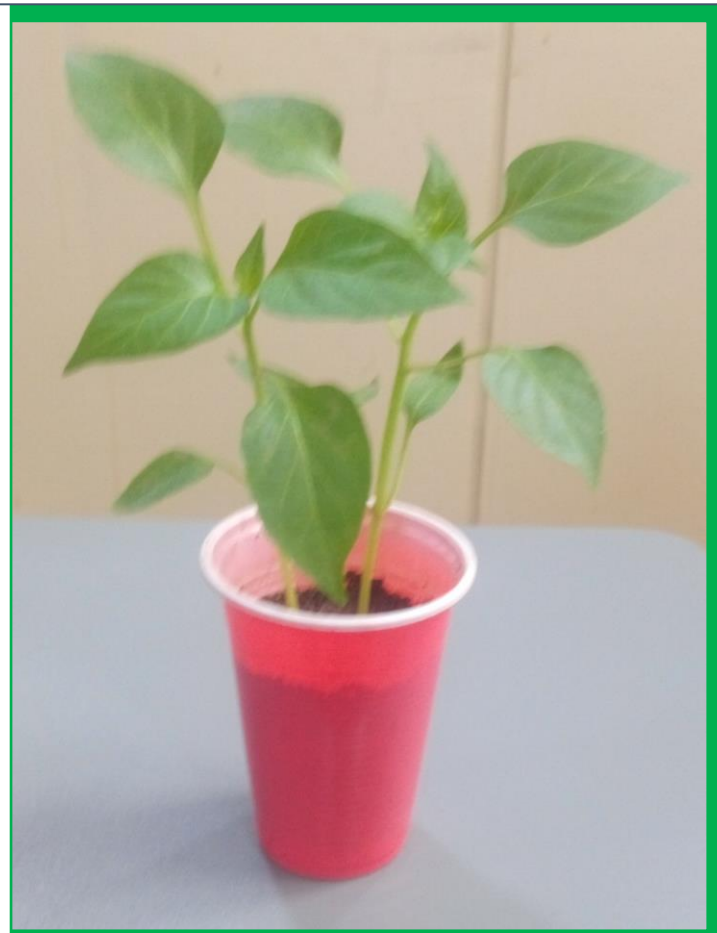
Land Use Land Cover of the Benue State, Nigeria

Data Source:Copernicus Global Land Cover Layers (CGLS-LC100 Collection 3)



Practical Session:
Monitor Plant Growth

- Transplant the Yellow Pepper Plants (8 weeks old) at home.
- Take care of the plants and collect data to monitor the growth.
- The plant will produce the yellow pepper that mummy will use to prepare fried rice during Christmas!
- Collecting data to observe the different phases of growth in this ground monitoring practical session will help the girls to understand how satellite-derived data can be used to monitor plant growth and the impact of flood on cropland



Encouraging the Girls to learn STEM in a fun-filled environment

Celebrating the Girls

My Personal Experience

- She Space Nigeria Team
- Space for Women Mentee
- Space for Women Mentor

MY PERSONAL EXPERIENCE

My name is Eniola Adebayo. I am ten (10) years old and I am the representative for the North Central Nigeria. I am from Kogi state but I currently live in Calabar with my family. I attend Kids N' Us School. I am in Primary six (6).

I made new friends and I enjoyed my stay in Ife. I also love my mentors for teaching and encouraging my friends and me to work hard in order to succeed and I have learnt a lot from both of them. They have inspired me! I joined She Space International because I want to learn how to use remote sensing, satellite data and how to collect data to analyze a problem.

In the course of the training, I learnt how to use ArcMap and Google Earth Engine to create maps, show features and legends, collect data and code on Google Earth Engine. This afforded me the opportunity to apply my knowledge of coding. The classes where very interesting and I really enjoyed break times because we always had something delicious to eat like; small chops, chicken, egg rolls, juice, biscuits, fries and ketchup.

Moreover, we had an in-house presentation where we rehearsed for the international presentation. Parents were present for the in-house presentation. After listening to us, they told us what we had to improve on and gave us thumbs up for the things we were very good at. At the International presentation, the Nigerian team was the youngest team and after we finished our presentation, the hosts and other teams were shocked that girls our age could do such things. We were really commended on our hard work.

The last day of the training was a fun day! We walked to the zoo, where we saw different animals like; lions, ostriches, crocodiles, sea turtles, snakes, a hyena and a crowned crane. It was a wonderful experience. On that same day, we surprised our mentor with a small birthday party. She was very happy.

In conclusion, my experience during the She Space program is great.

Conclusion: Viable Methods of promoting gender equality in the space sector

- "The Catch them Young approach"
  - Outreach programs to schools to identify brilliant girls, mentor the girls through a multi-disciplinary, project-based learning program. This could be an academic research, using satellite derived and other types of remotely sensed data, to address local environmental issues

- Mentorship Programs originating at the local level to feed into national and international mentorship programs. For example, She Space Nigeria, to She Space International and Space4Women Mentorship Program of UNOOSA

- Competitive Grants to support Mentors and Advocates with viable projects to promote gender equality in the space sector