Geomatics Support View in Flood Control and Watershed Management Within the Niger Delta Region of Nigeria

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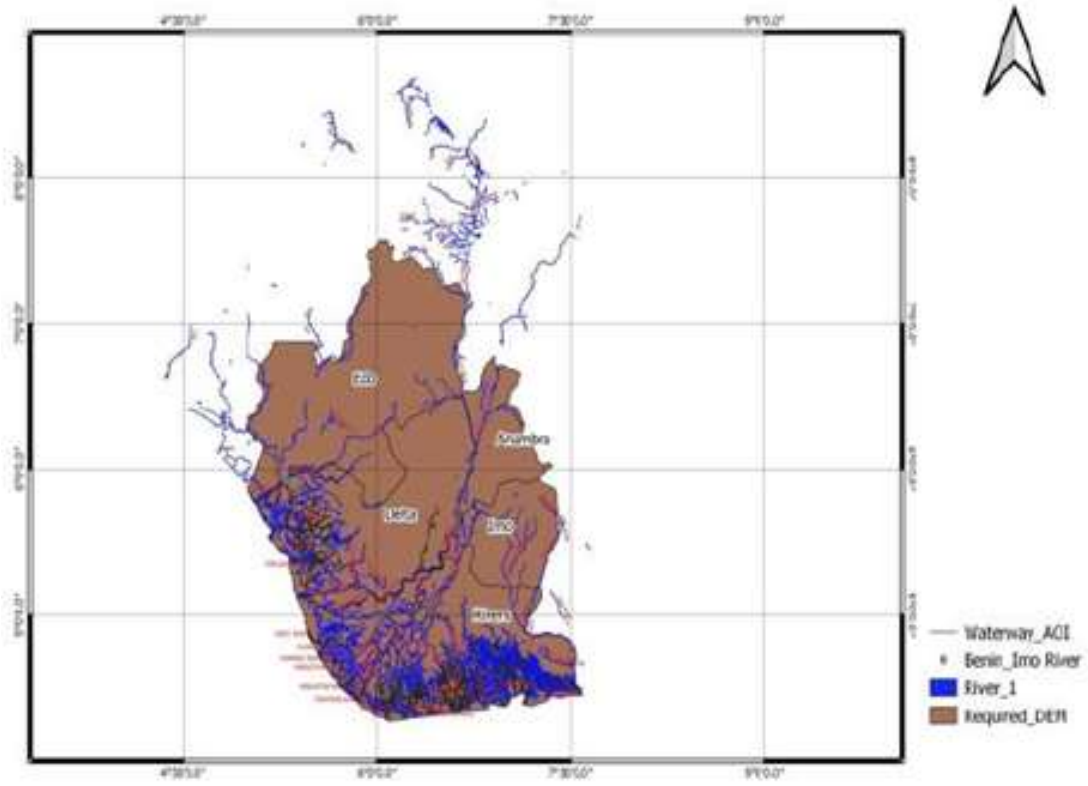
DESCRIPTION OF THE STUDY AREA

- The Niger Delta region is about 500km from the mouth of Benin River to Imo river in the East. This mangrove swamp is essentially vegetated tidal flat and best vegetation along the Nigeria Coast (Ibe 1995).
- The area spans over 20,000km2 and it has the largest wetland in Africa and among the three largest in the world. It is the second largest delta in the world. About 2,370km2 of the Niger Delta area consist of rivers, creeks and estuaries with stagnant swamps covering over 8,600km2 (Uyigue et al 2007).
- The region is divided into four ecological zones: Coastal inland zone, Mangrove Swamp zone, Fresh water zone and lowland rainforest Zone. The region is one of the ecological sensitive regions in Nigeria.
- Non-renewable resources such as sharp sand, gravel, oil and gas from the region are the main sources of revenue and environmental problems in Nigeria. The Niger Delta region is a low-lying area consisting of several tributaries of the Niger River and ending at the edge of the Atlantic Ocean



- The Niger Delta region is a low-lying area consisting of several tributaries of the Niger River and ending at the edge of the Atlantic Ocean. It consists of several creeks and estuaries as well as stagnant mangrove swamps.
- The region has an area of approximately 20,000 km2 and a 450m coastline. Nigeria's economy depends predominantly on oil and gas from the region as the main source of foreign revenue. Rise in sea level is a major problem for the Niger Delta as sea level rise creates inundation due to coastal flooding by incoming rivers.
- The Niger Delta region has been experiencing recurrent flooding especially in the low lying areas along the Niger River and its tributaries as well as far east to the Calabar river.
- The Federal Government attempted some mitigation measures after the 2012 flooding but these were only palliatives. Knowing these problems, it is necessary to embark on flood forecasting and develop watershed management programs.
- The aim of the study is to improve on the mechanism for the protection of people and properties from flood events and create a sustainable environment for the utilization of land and water resources.

- Rise in sea level is a major problem for the Niger Delta as sea level rise creates inundation due to coastal flooding by incoming rivers. Relative sea level rise values are usually higher in subsiding coasts like river deltas than the ones in stable coastal rivers (Musa et al, 2014)
- Although subsidence occurs relatively in deltas, in the case of Niger Delta, it is increased even more by oil extraction from underground sources (Erickson et al, 2006).
- Land subsidence lowers the topography of delta area with respect to the sea level and makes the area highly vulnerable to river floods.
- Other environmental problems include sediment reduction to the Niger Delta region as a result of the construction of Dams upstream of the Niger River.

FLOOD CONTROL AND WATERSHED MANAGEMENT USING GEOINFORMATION TECHNOLOGY

- Flood is among the most devastating natural hazards in the world claiming lives and properties more than any other natural phenomena (Alcira and Martha, 1991; Ologunorisa, 2006; Ehiorobo, 2012; Izinyon and Ehiorobo, 2014).
- Flood vulnerability mapping can offer appropriate security against floods. Rapid population growth create extra presure on land in urban areas, agriculture lands give way to housing development and roads without adequate drainage facilities give rise to flooding and erosion problems (Ehiorobo et al 2010).
- With climate change, heavy and damaging storms will continue to increase in frequency. Temperature also has an effect on vegetative materials which are used as mulching to control erosion (Ehiorobo and Izinyon, 2011)

FLOOD CONTROL AND MANAGEMENT

- Flood disaster management just as other disasters management can be grouped into
  - the preparedness phase where activities such as prediction and risk zone identification or vulnerability mapping are undertaken up long before the event occurs;
  - the prevention phase where activities such as forecasting, early warning, monitoring and preparation of contingency plans are done just before or during the event and
  - the response and mitigation phase where activities are undertaken just after the disaster and it includes image assessment and relief management (Van Western et al., 1993; Ehiorobo, 2012)
- To acquire information for flood management and control and identify areas that are vulnerable to flooding, reliable techniques of collecting and analyzing geospatial information are required.
- In this regard, an integrated approach of Remote Sensing (RS) and Geographic Information System (GIS) has proved to be the most effective and perhaps the only option to flood hazard preparedness and to reduce potential risk. This will be part of a larger, long term effort to gain a better understanding of communities vulnerable on the floodplains and low elevated areas to flood hazard. (Ehiorobo and Akpejiori 2016, Akpejiori and Ehiorobo 2017)

- Geo-informatics technology plays a major role in Humanitarian Emergency Response Management as well as Disaster Management. Map; positions and other attribute about region can be captured, stored, update and easily retrieved through the medium of the computer. The Global Positioning System (GPS), Remote Sensing and Geo-spatial information System (GIS) can be integrated for quick results and improved decision- making vis-ả-vis disaster management. (Ehiorobo and Audu, 2006)
- GIS technology is a valuable tool in developing environmental models and they include space and time as a common denominator and also possess advanced features for data storage, management analysis and display. Geoinformation technologies aside from being used to integrate various models also enable us to acquire information about the environment.
- Remote sensing technology provide land use and land cover images which when combined with ground survey data by GPS and Total station instrument enable us to model flood event and other environmental hazards. The integration of these various Geoinformation technologies does not only enable us to estimate soil loss but they provide the spatial distribution of the flood and erosion sites. Accurate erosion risks and sensitivity index maps can be generated by the system (Yuksel et al 2008, Ehiorobo et al 2010)

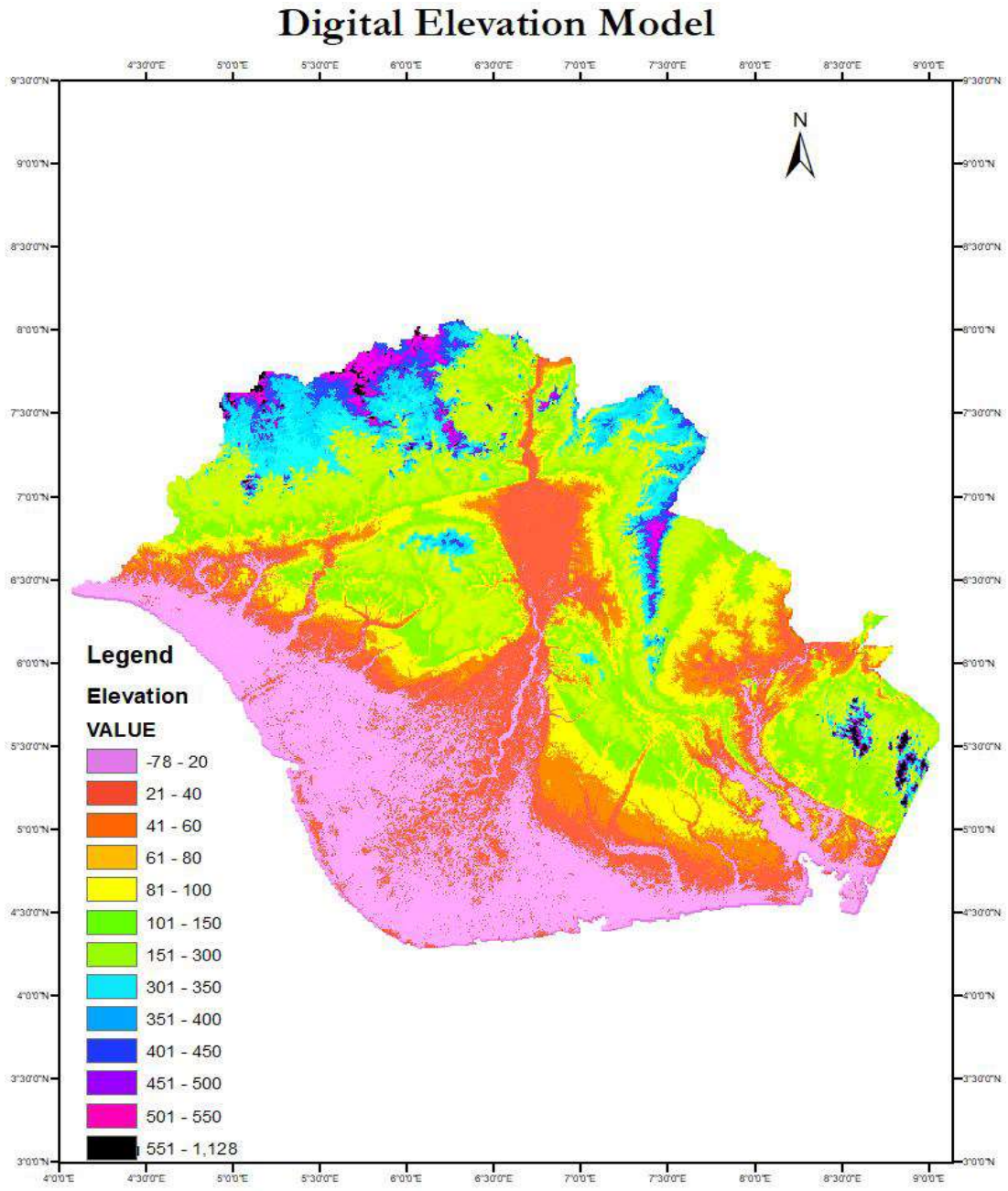
WATERSHED MANAGEMENT

- Watershed management are increasingly reliant on information Technology. Recent advances in data acquisition through remote sensing, Global Navigation Satellite System (GNSS), data utilization through GIS and data sharing and communication through the internet and the use of models would provide managers with the needed tools for informed decision.
- New technologies such as interferometric Synthetic- Aperture Radar (IFSAR) are providing data with greater spatial resolution now increase our capacity to analyze and predict water resources phenomena.
- Effective watershed decision making requires the integration of Data, expert judgment, knowledge and simulation model to solve practical problems. A decision support system that integrate Database Management System (DBMS). GIS, Simulation model, Decision models and Computer interface are needed. Digital Elevation model (DEM) are used as input for the spatial decision support system.

- A major advance in data generation, preparation and management is in the use of Geospatial technologies such as Geographic Information System (GIS), Global Navigation Satellite System (GNSS), and Remote Sensing.
- In term of watershed modelling, a typical model preparation would include the use of Remotely Sensed data for the extraction of Terrain Canopy data or the use of Digital Terrain Model (DTM) or Digital Elevation Model (DEM) data for extraction of hydrologic catchment properties such as Elevation Matrix and Flow direction Matrix, ranked elevation matrix, flow accumulation matrix.

- When Digital data are used for hydrologic modelling, they offer the following data evaluation procedures to improve accuracy and usability (Edsel et al 2011)
  - They help check what percentage of the area that has slope of 0%
  - Use of the surface flow routing to check whether water will flow across the watershed area if arbitrary point source is selected
  - Check of the orientation and interconnection of the stream network
  - Use of stream as ”cut out” across DATUM and check whether the slope of a longitudinal section towards the lowest exit node is continuous.

- In many instances in places such as the Niger Delta region, there is limited or no data available for the watershed. GIS automated tools based on geostatistical interpolation techniques for instance using inverse distance weighting or Kriging after improved options for generating new DEMs, data sets from points and contour data sets.
- As a first step in the study, the Digital Elevation Model (DEM) for the study area was obtained from the Shuttle Rader Topography Mission database (SRTM) at a spatial resolution of 30m with the use of Google Earth Engine interface. This was then used to delineate the sub-watershed of the lower Niger Delta River Basin and extract major streams within the area (using ArcHydro extension in ArcGIS).
- The DEM with the defined streams and the delineated sub watersheds is shown in the figure

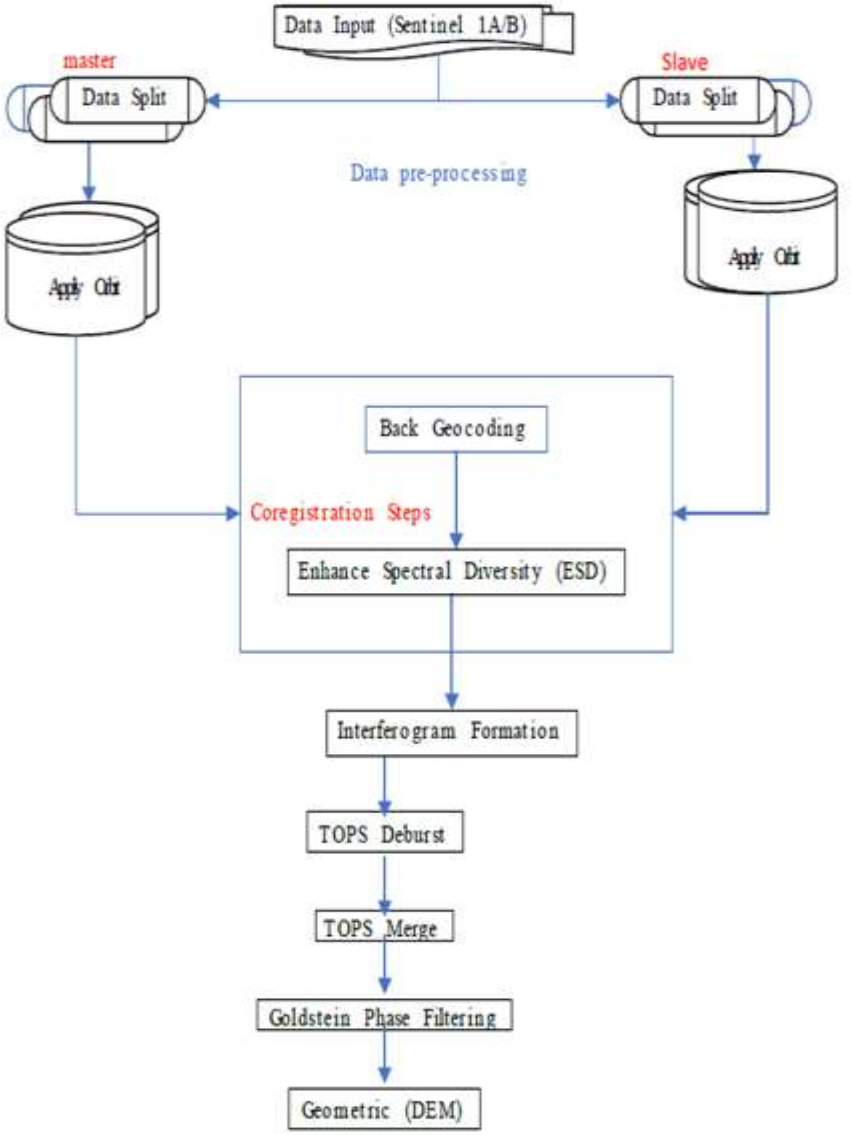


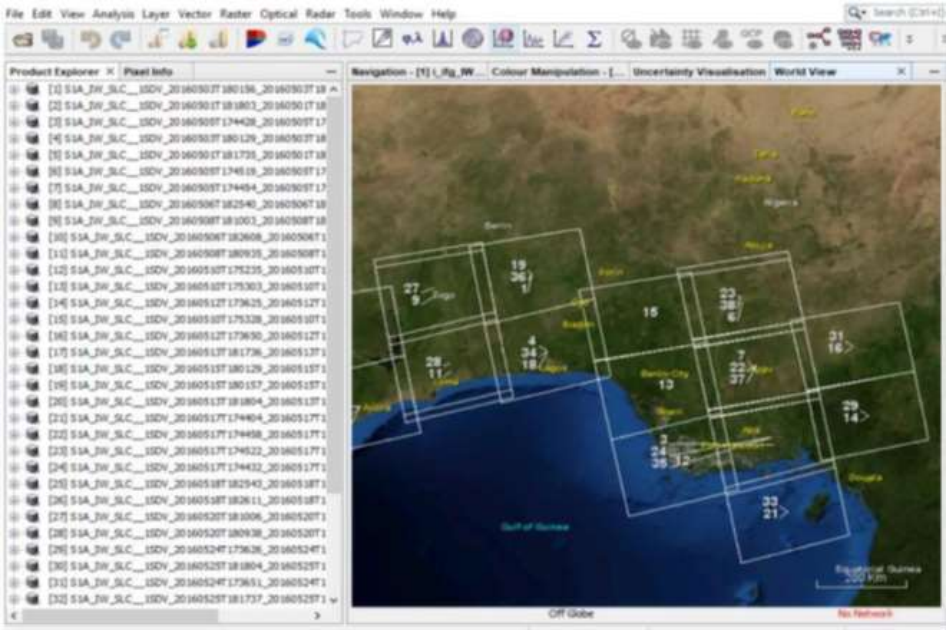
ACQUISITION, PROCESSING AND GROUND THRUTHING/ VALIDATION OF IFSAR IMAGERIES FOR WATERSHED DELINEATION AND FLOOD MANAGEMENT

- Thirty-seven (37) interferometric pairs of the Sentinel 1A/B acquired from January 2016 to September 2019 (4years) obtained from the European Space Agency (ESA) were used in this study.
- The design procedure is guided by the aim of the project, study area and data coverage/type. The months of January and September were chosen as periods with low and high-water levels across the study area and used in the processing.
- The number of RTK GNSS control points for DEM Ground Truthing/validation established per States is presented in Table for Edo, Delta, Bayelsa and Rivers states

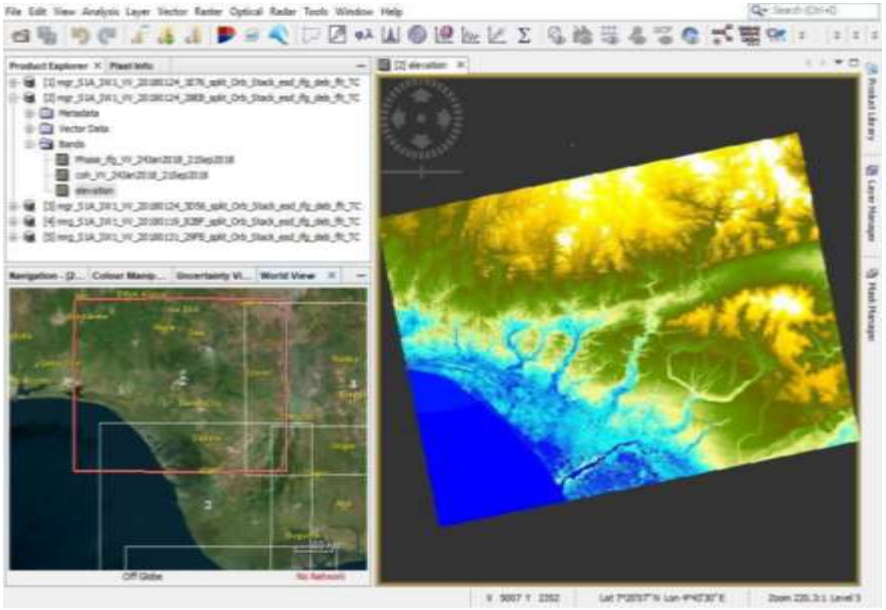
State	No. of points
Edo	16
Delta	20
Bayelsa	25
Rivers	20

- The Multi-date data processing technique was adopted because of coverage of the Interferometric Wide swath (Khosravi et al., 2019).
- This is because of the temporal analysis or change detection over the area of interest.
- The processing workflows are provided in the flowchart
- The next figures show pictures of the final output which is the DEM of the study area in the software environment presented below

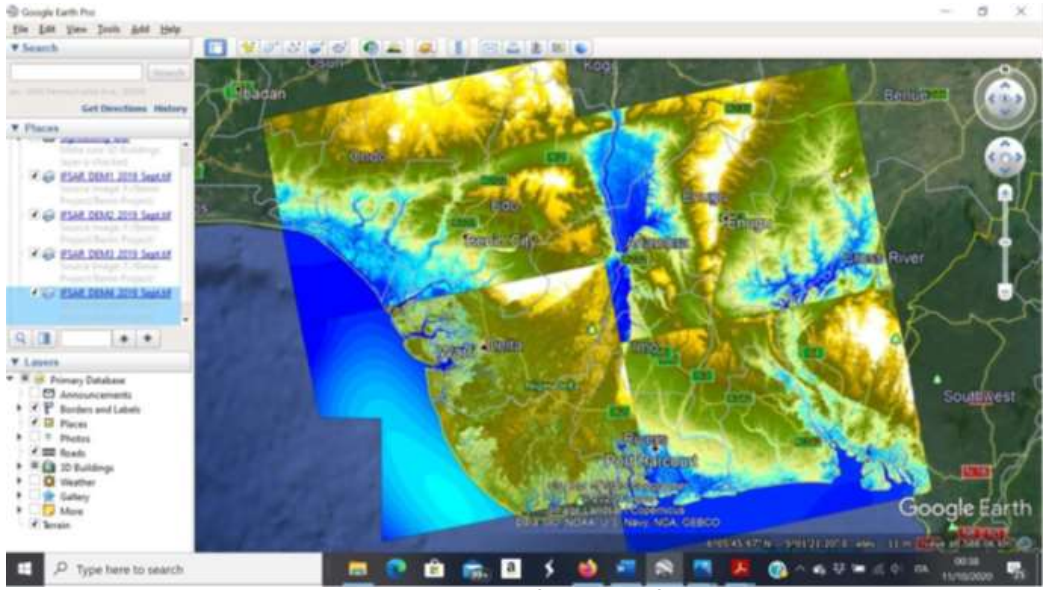




Data input



The DEM of the study area in the software environment.



September 2019 DEM of the Study area imported into Google Earth

CONCLUSIONS

- The Niger Delta region is a low lying area crisscrossed by series of Creeks and Rivers. As a result of sea level rise, there is inundation of the coastal area and this give rise to coastal flooding.
- This has resulted in environmental disaster within the study area resulting in loss of lives and properties. It has become therefore expedient to carryout continuous studies of the area and develops measures for flood control and watershed management.
- Geoinformation Technology (Geomatics) consisting of a combination of Satellite Remote Sensing, GIS and Ground Survey methods using GNSS are important tools for such studies. Flood Zone Mapping and Watershed Delineation using DEM generated from SRTM obtained from Google Search engine were used for preliminary watershed delineation.

- Further work is ongoing in the continuous IFSAR imageries to generate more accurate DEM for the study area. The DEM and Flood Zone maps will help in carrying out flood control, Flood preparedness and management as well as appropriate watershed delineation for effective planning and management. As part of the watershed management process, water sampling need to be carried out and the sampled points need to be Geo-referenced.
- Land use and land cover maps need to be produced for watershed development planning. It is anticipated that this study will help significantly in improving the socio-economic wellbeing of the people living within the study area. Geomatics support is an essential and veritable tool necessary for flood control and watershed management within the study area.

THANK YOU FOR LISTENING