Hydrological Characterization of the Nigeria's 2012 and 2022 Floods using the Floodwater Depth Estimation Tool (FwDETv2.0).

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Background

- Over the years, satellite observations have been demonstrated as invaluable in flood monitoring, inundation mapping, exposure, and risk assessments in ungauged basins.
- Some of these ungauged basins located in flood prone regions also experience devasting floods recurrently.
- In this work we evaluated the hydrological characteristics of the 2012 and 2022 floods in the Lower Niger River Basin in Nigeria using satellite observations.

Table 1*: Some Descriptions of the 2012 and 2022 Floods.*

Year	States Affected of 36	Deaths	Displaced People	Causes	Floodwater Level
2012	33	363	2.1 million	Heavy rainfall/Dam release	12.84 m (42ft)
2022	33	612	2.8 million	Heavy rainfall/Dam release	13.22m (43ft)

- While Nigeria experiences seasonal flooding during the rainy season, the decadal interval between these two catastrophic flood events and the similarities between the natural and anthropogenic conditions responsible for their occurrence prompted this study.
- Using the Floodwater Depth Estimation Tool (FwDET 2.0), we estimated and compared the flood depths for the 2012 and 2022 floods in Idah, Nigeria. FwDET 2.0 computes the flood depths using a Digital Elevation Model and a flood inundation map.

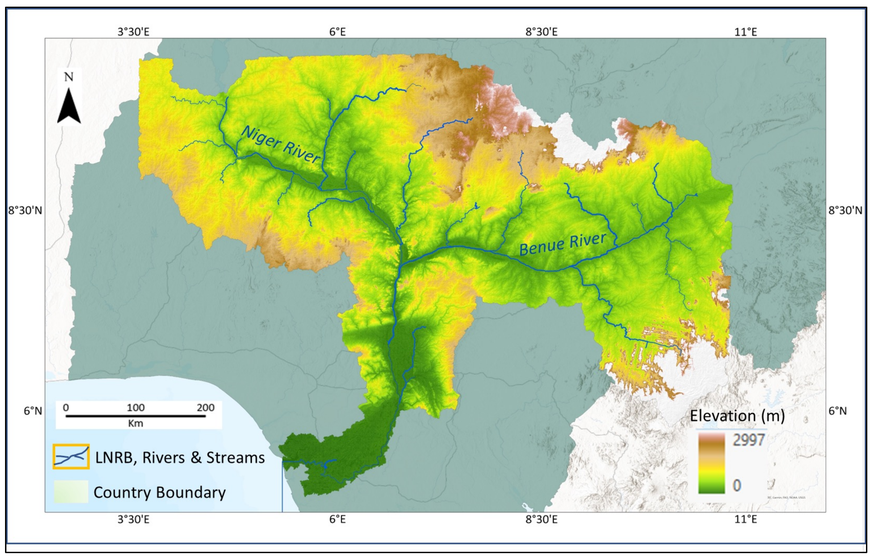

Figure 1: *Map of the Lower Niger River Basin (LNRB) in Nigeria.*

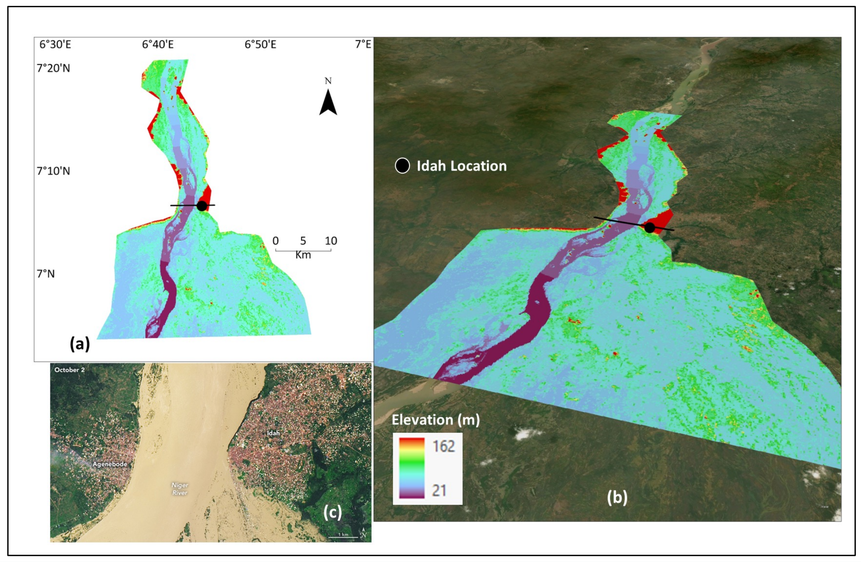

Figure 2: *Map showing the location of Idah in the LNRB in Nigeria.*

Data

Table 2: *Dataset sources and description.*

S/N	Dataset	Spatial Resolution (m)	Source
1	Moderate Resolution Imaging Spectroradiometer (MOD09Q1.061)	250	NASA EarthData Appeears
2	Height Above Nearest Drainage Model	30	Donchyts/Deltares (Donchyts et al. 2016) awesome-gee-community-catalog
3	NASA Digital Elevation Model	30	NASA / USGS / JPL-Caltech
4	Precipitation	30 (downscaled)	Global Precipitation Climatology Center

Method

- Step 1 — Identifying Boundary Cells
- Step 2 — Extracting the Elevation of the Boundary Cells
- Step 3 — Assigning the Boundary Cells Elevation to the Domain Cells
- Step 4 — Floodwater Depth Calculation
- Step 5 — Smoothing

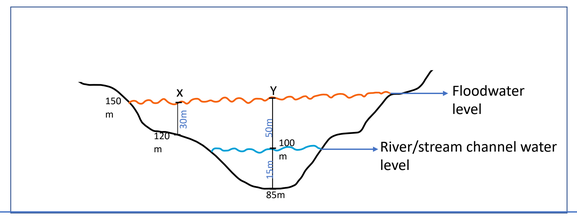

Figure 3: *Schematic representation of the Flood Depth Estimation concept (Modified after Cohen et al. 2018).*

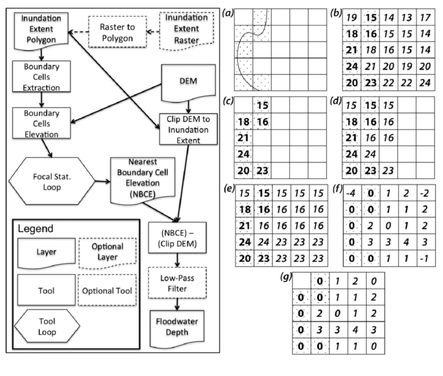

Figure 4: *Workflow process summary for the FwDET calculation (Cohen et al. 2018).*

Preliminary Result

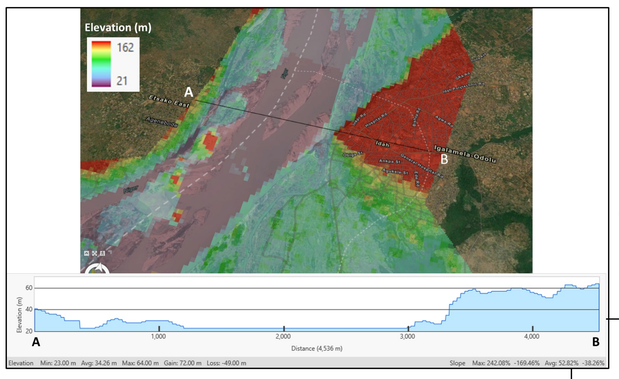

Figure 5: *Elevation of a section of the Niger River. Profile line A-B across a section of the Niger River in Idah, Nigeria. Cross-section representing the topography along the profile line A-B in Idah, Nigeria. The minimum elevation along the profile line A-B is 23m while the maximum elevation is 64m.*

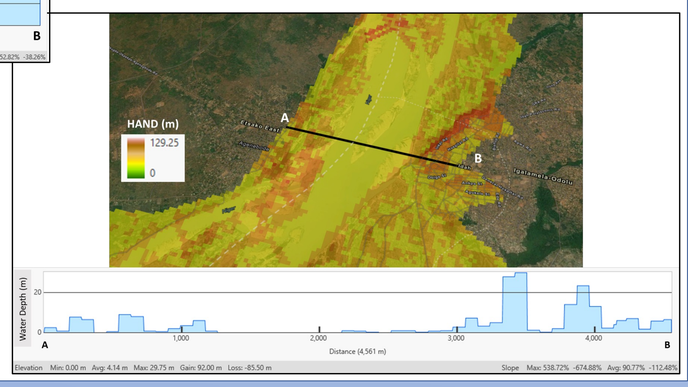

Figure 6: *Water level estimations from the Height Above Nearest Drainage model along a section of the Niger River. The profile line A-B across the Niger River in Idah, Nigeria. Cross-section representing water depth along the profile line A-B in Idah, Nigeria. The minimum water depth is 0m while the maximum water depth is 29.8m.*

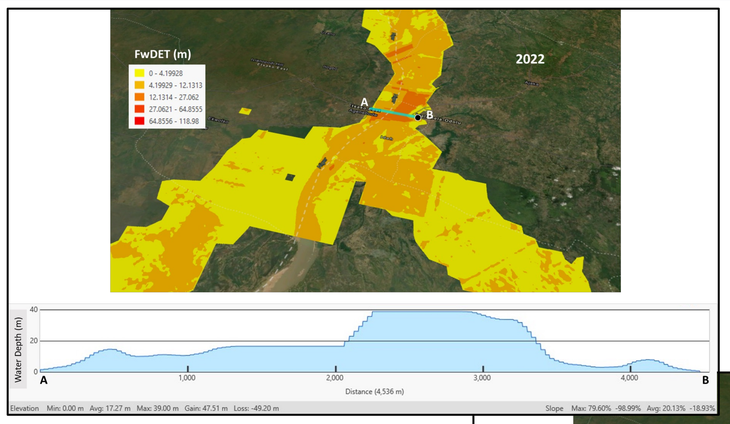

Figure 8: *FwDET estimation for a section of the Niger River Basin in October 2012. Profile line A-B across the Niger River at Idah, Nigeria. The cross-section for profile line A-B across the Niger River in Idah, Nigeria shows a minimum water depth of 0m and maximum water depth of ~ 58m.*

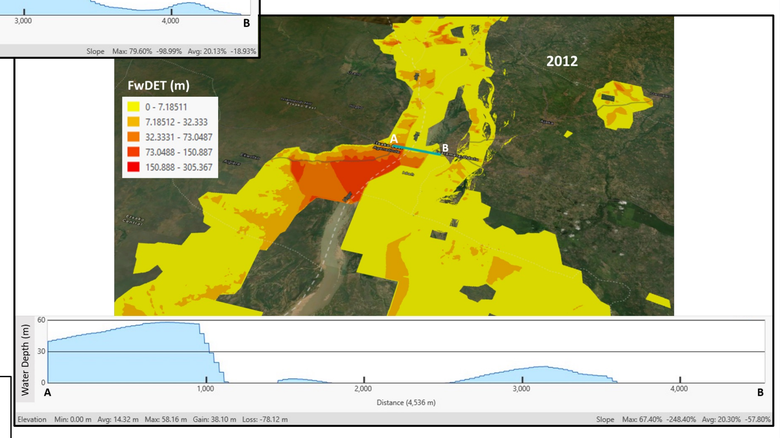

Figure 7: *FwDET estimation for a section of the Niger River Basin in October 2022. Profile line A-B across the Niger River at Idah, Nigeria. The cross-section for profile line A-B across the Niger River in Idah, Nigeria shows a minimum water depth of 0m and maximum water depth of 39m.*

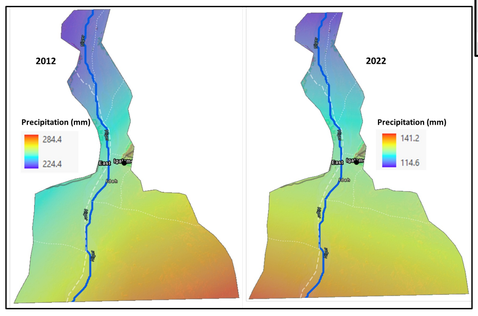

Figure 9: *Precipitation in millimeter per month (mm/month) within a section of the Niger River Basin for October 2012 and 2022. The Global Precipitation Climatology Center spatial resolution is 1° X 1° (111km X 111km) downscaled to 30m X 30m. The difference between the minimum and maximum precipitation for October 2012 and 2022 are 109.8 mm/month and 143.2 mm/month respectively implying more precipitation in October 2012.*

Preliminary findings

- FwDET calculated the water depth along the profile line A-B in Idah, Nigeria for October 2012 and 2022.
- Water depth by the HAND model gave an insight to the expected range of water depth calculated by FwDET.
- Though the 2012 flood had less damages reported compared to the 2022 flood, the amount of monthly precipitation was more for October 2012 with higher values of water depth along the profile line A-B.

Limitations

- FwDET output (water depth) depends on the quality of the flood extent map and the quality of the DEM.
- Water Depth estimation by FwDET will vary with different DEM.
- Depending on DEM spatial resolution, water depth might be undetectable by FwDET.

Future Work

- Flood disaster damage assessment for 2012 and 2022.
- Flood risk assessment for the Lower Niger River Basin.
- Flood frequency analysis to:
  a. Predict the possible flood magnitude over 10 years.
  b. Estimate the frequency with which the flood magnitude may occur.

References

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