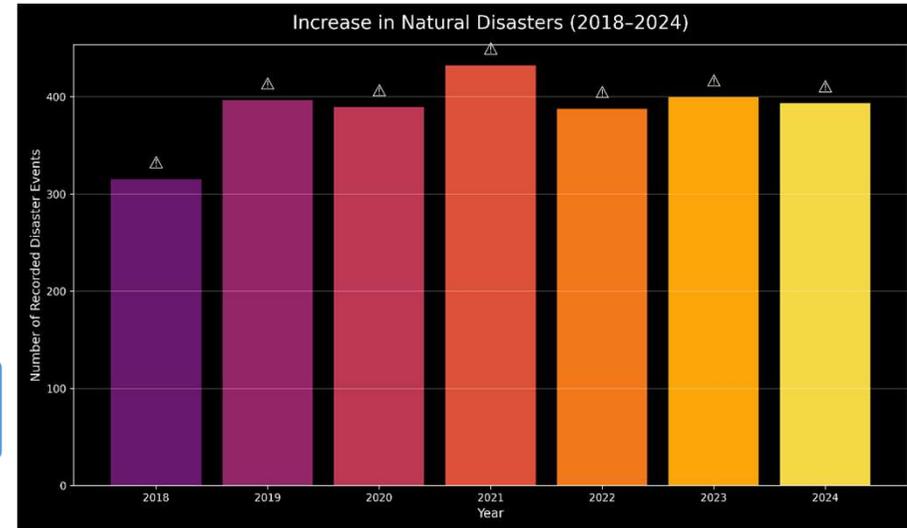


Dr. Surya Deb Chakraborty

Flood Analysis Using SAR Images

Disaster Monitoring

Disasters are increasing in frequency, intensity, and impact.
Earth Observation is no longer optional — it is essential



Why Flood Mapping is Critical

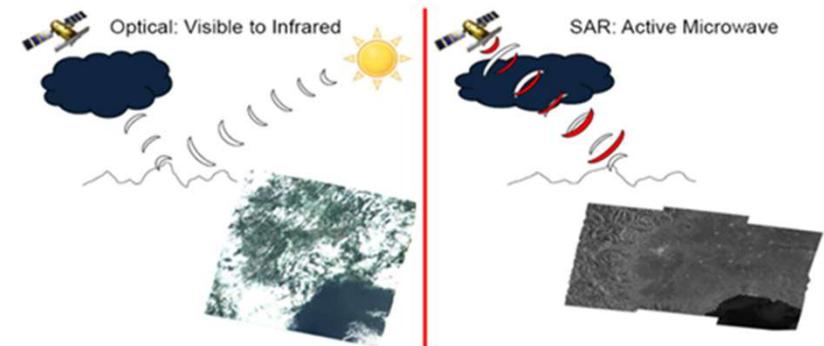
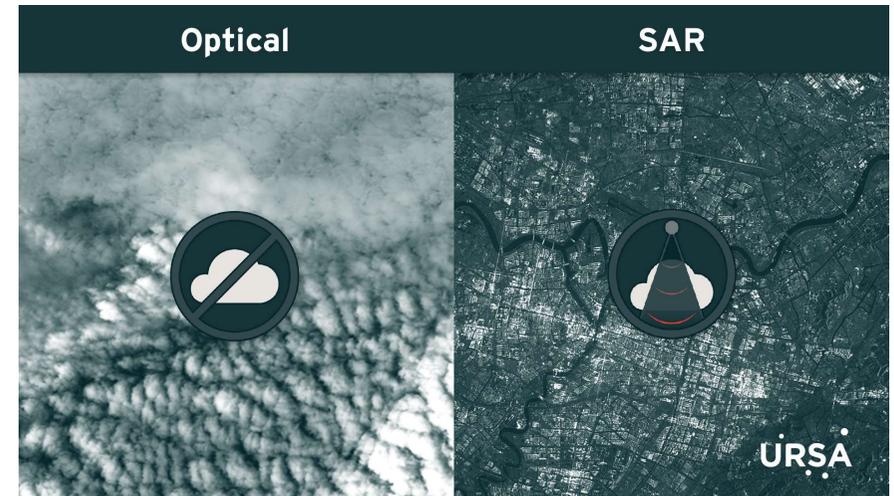
- Floods are among the **most frequent and destructive natural disasters**
- **Cause:**
 - Loss of life
 - Damage to infrastructure
 - Crop loss
 - Long-term socio-economic impact
- **Accurate and timely flood maps are essential for:**
 - Disaster response
 - Relief planning
 - Damage assessment



Challenges in Flood Mapping Using Optical Data

Limitations of Optical Satellite Data During Floods :

- Flood events usually occur with:
 - Heavy rainfall
 - Thick cloud cover
- Optical sensors:
 - Cannot see through clouds
 - Fail during night-time
- Result: **No usable data exactly when we need it most**

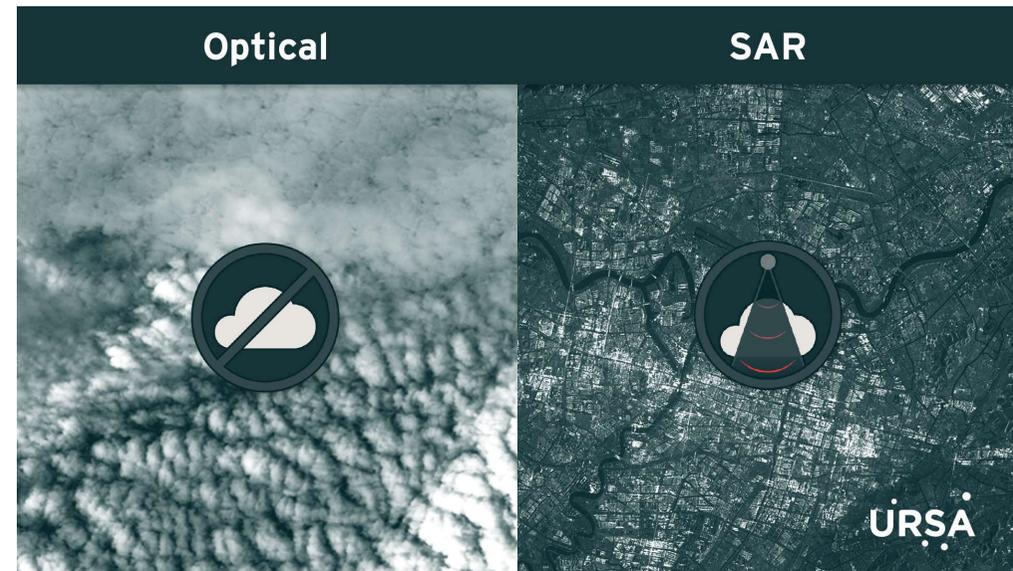
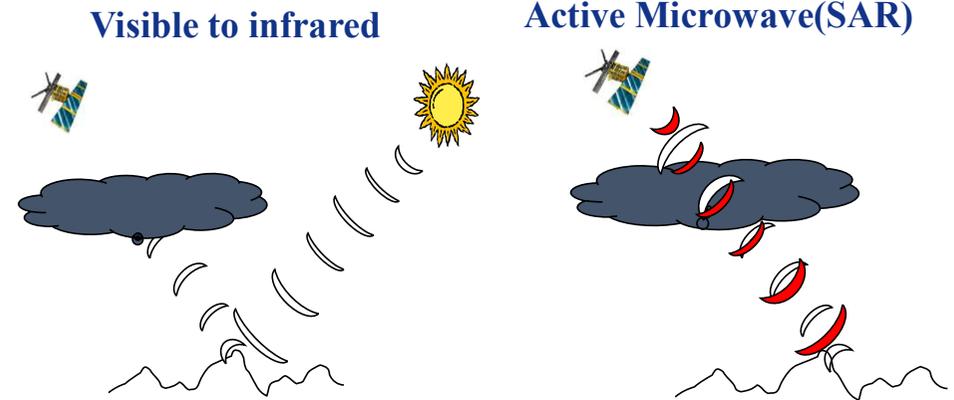


Why Synthetic Aperture Radar (SAR)?

SAR Advantages

- It sends its own energy and records the backscatter
- Key advantages:
 - Works **day & night**
 - All weather capabilities (clouds, rain, and haze)
 - Penetration capabilities
 - **Active and passive sensor**

Hence, SAR is **ideal for flood monitoring**



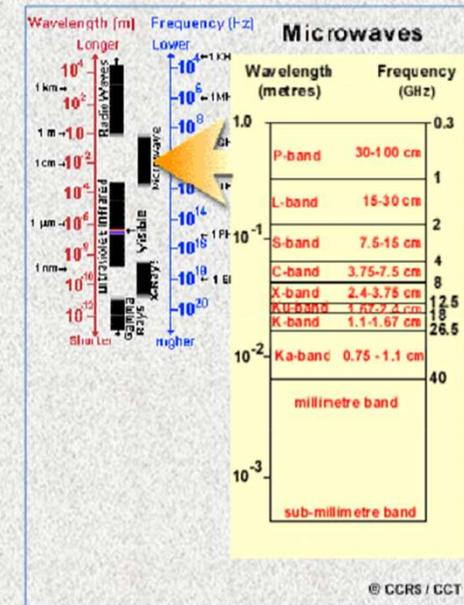
Microwave Radar Bands

Wavelength Range of Microwaves

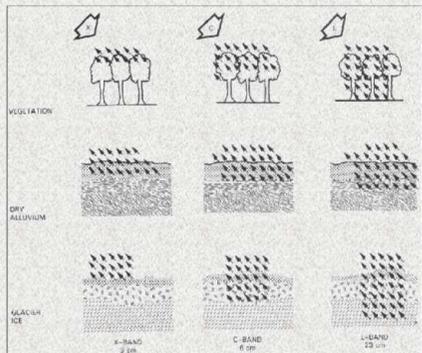
Band	Wavelength range (cm)	Utility
Ka, K, Ku	0.8 – 2.4	Early airborne radar systems
X	2.4 – 3.8	Military reconnaissance, terrain mapping
C	3.8 – 7.5	Flood mapping, agriculture, forest, marine/oceanic research
S	7.5 – 15.0	medium-range meteorological applications (ex. rainfall measurement, airport surveillance and specialised tracking tasks)
L	15.0 – 30.0	Forestry, Oil spills, boat/ship identification, glacier/ice, geology
P	30.0 – 100.0	Geology, study of vegetation canopies, glacier/sea ice and soil

- Electromagnetic radiation in microwave wavelength region
- Range - about 1 cm to 1 m
- Main advantages:
 - Can penetrate through cloud cover, haze, dust, and moderate rainfall
 - Data can be collected at any time

What are Microwaves?



Interaction with Target



Properties of Microwaves

Characteristic that control Radar energy / Target interaction

1. System parameter

- Wavelength
- Polarization
- Look angel
- Resolution

2. Target parameter

- Surface roughness
- Moisture Content
- Slope and orientation

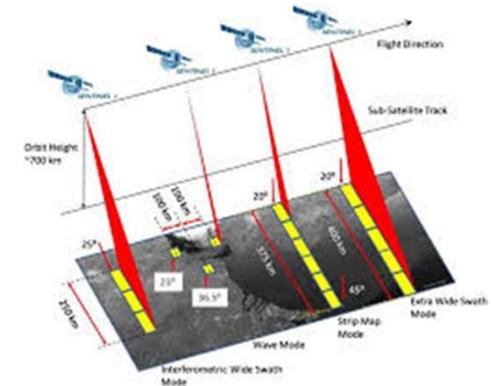
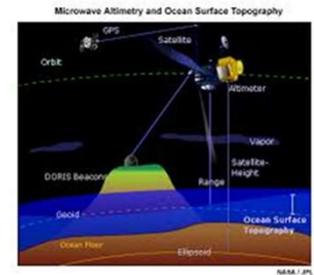
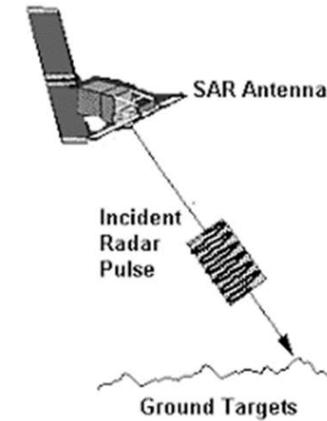
Incidence Angle

The angle perpendicular to the imaged surface and the direction of the incident radiation

1- Steep beam position
2- Shallow beam position

Backscatter varies with incidence angle.

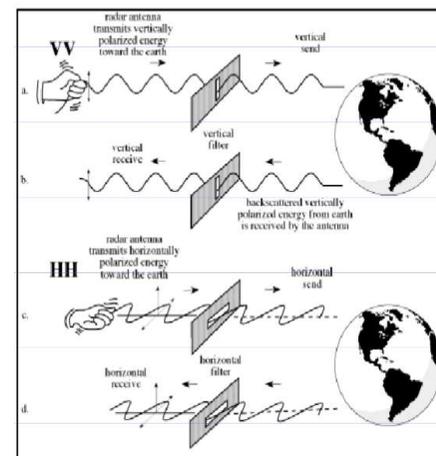
29



Polarisation

Properties of Microwaves - Polarisation

- Polarization refers to the orientation of the electric field
- Most radars transmit microwave radiation either horizontally polarized (H) or vertically polarized (V)
- Similarly, the antenna receives either the horizontally or vertically polarized backscattered energy; some radars can receive both
- There are four combinations of transmit and receive polarizations:
 - HH - for horizontal transmit and horizontal receive,
 - VV - for vertical transmit and vertical receive,
 - HV - for horizontal transmit and vertical receive, and
 - VH - for vertical transmit and horizontal receive



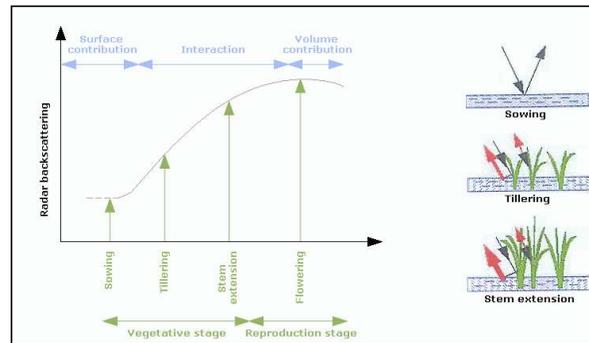
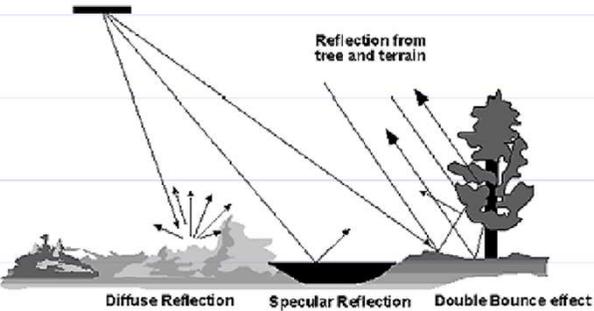
Polarization

HH - for horizontal transmit and horizontal receive
 VV - for vertical transmit and vertical receive
 HV - for horizontal transmit and vertical receive
 VH - for vertical transmit and horizontal receive

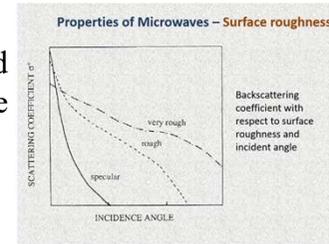


What does SAR measure

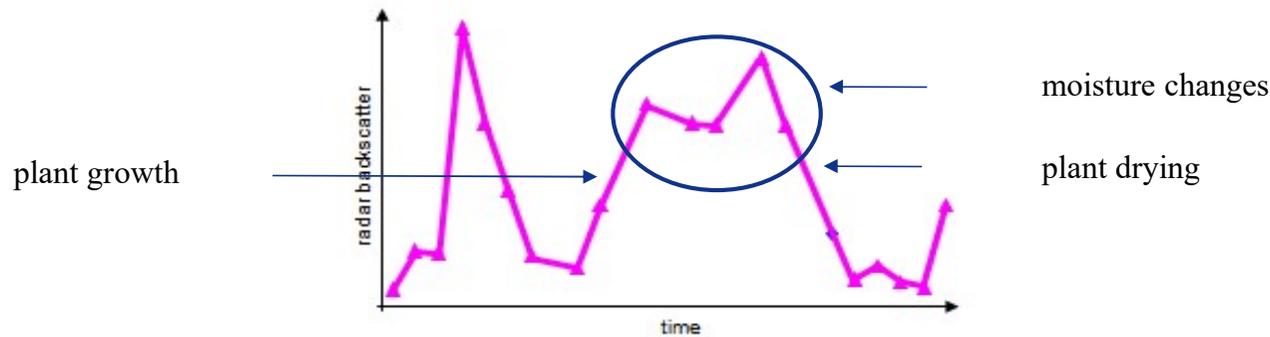
- **Roughness** – The higher the object’s roughness, the larger the fraction of the energy reflected back to the radar.



Increase of plant height does correspond to an increase in roughness, hence reflected energy.



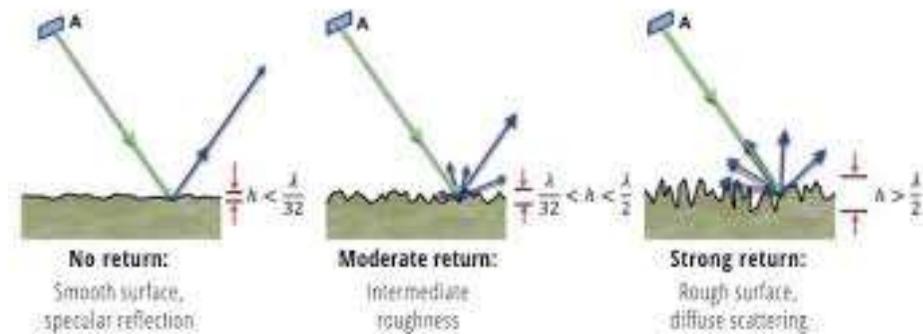
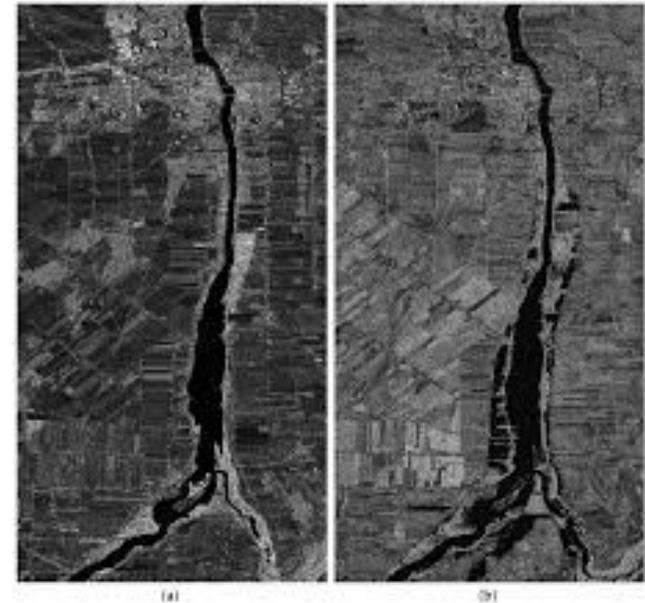
- **Moisture** – The moisture content in the plant translates into relevant variations of the backscattered energy.



How SAR Sees Flooded Areas

SAR Backscatter Behaviour During Floods

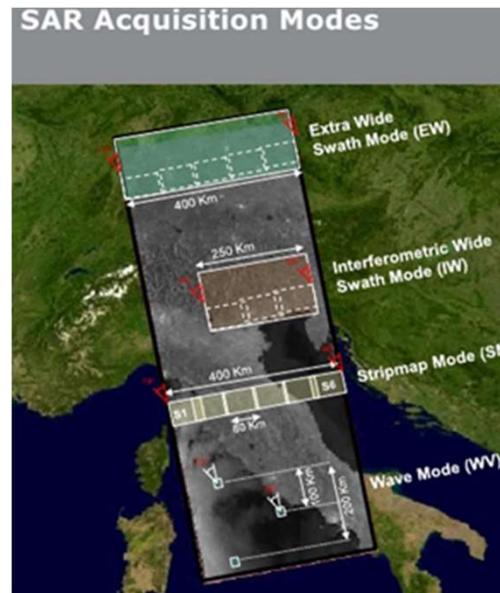
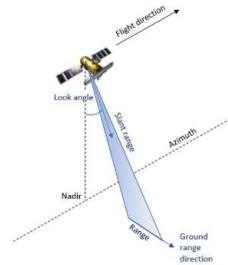
- Smooth water surface → **low backscatter**
- Appears **dark** in SAR images
- Flooded areas show:
 - Sudden change in backscatter compared to pre-flood condition
- This change is the **key to flood detection**



Why Sentinel-1 for Flood Analysis

Advantages of Sentinel-1 SAR Data

- Free & open-access (Copernicus Program)
- C-band SAR, ideal for water detection
- Revisit time:
 - 6–12 days
- Widely used by:
 - Disaster agencies
 - Researchers
 - Operational flood services



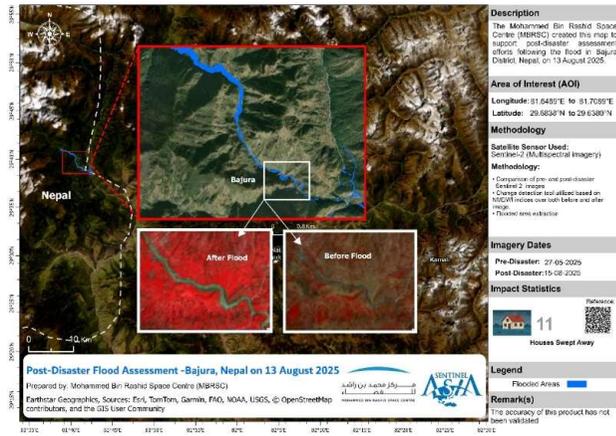
Flood Disaster monitoring

Different types of Flood

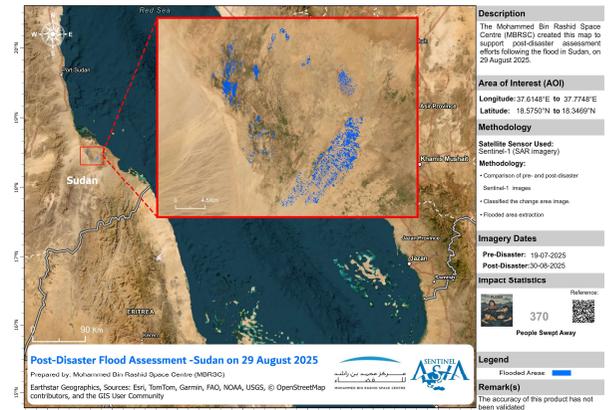
Cyclonic flood in LAOS



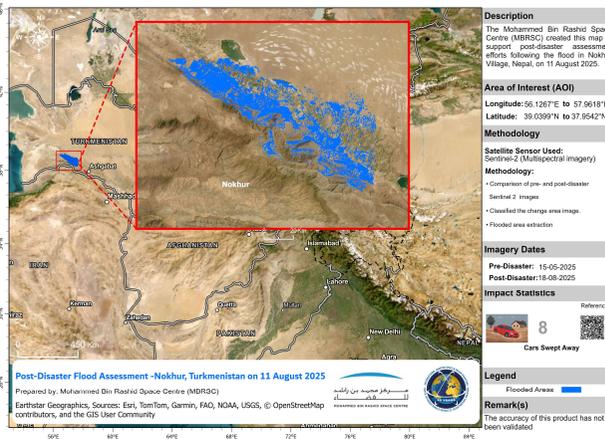
Flash flood in Nepal



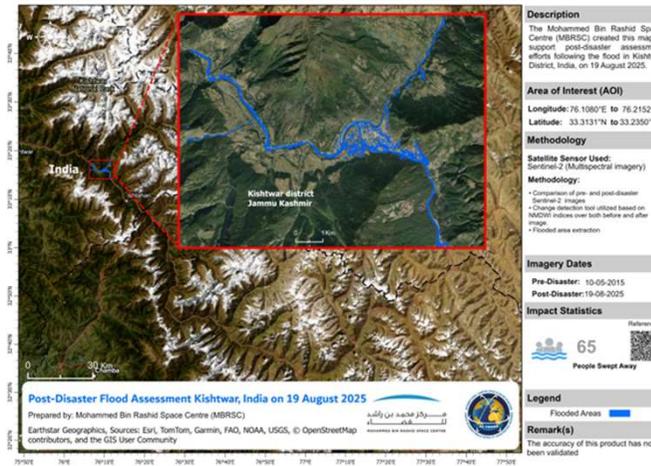
Landslide due to Flood in Sudan



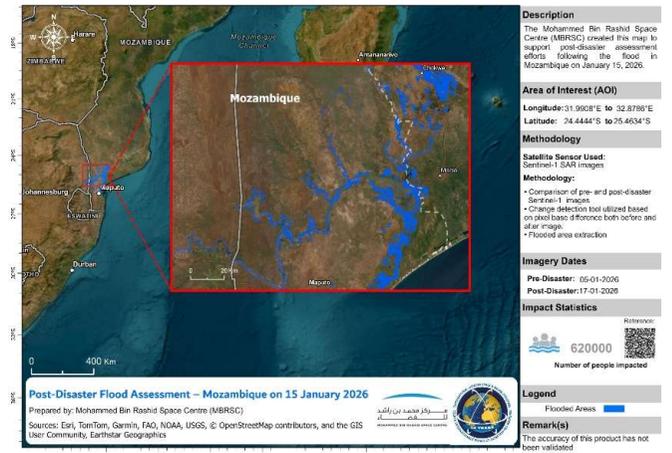
Mud flow due to Flood in Turkmenistan



Cloud Blust flood in India



Flood in Mozambique

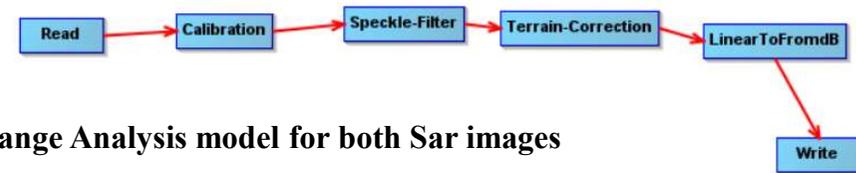


Overall Flood Mapping Workflow

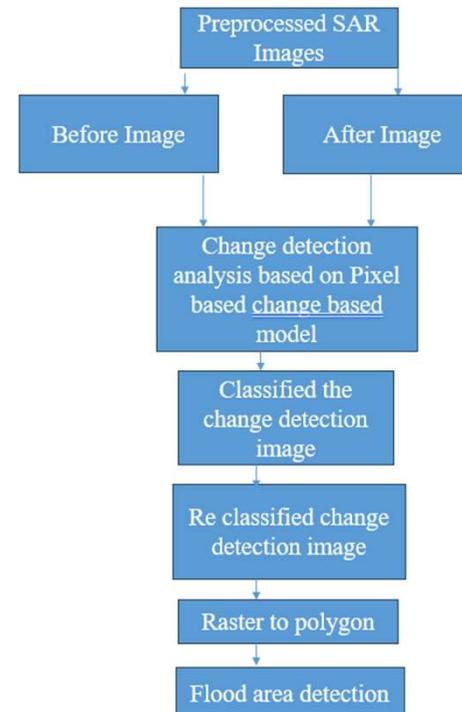
End-to-End Flood Mapping Workflow Using SAR

1. SAR data download
2. SAR preprocessing
3. Change detection
4. Classification
5. Flood extraction
6. Final flood map

Model developed for SAR data preprocessing



Flood Change Analysis model for both Sar images



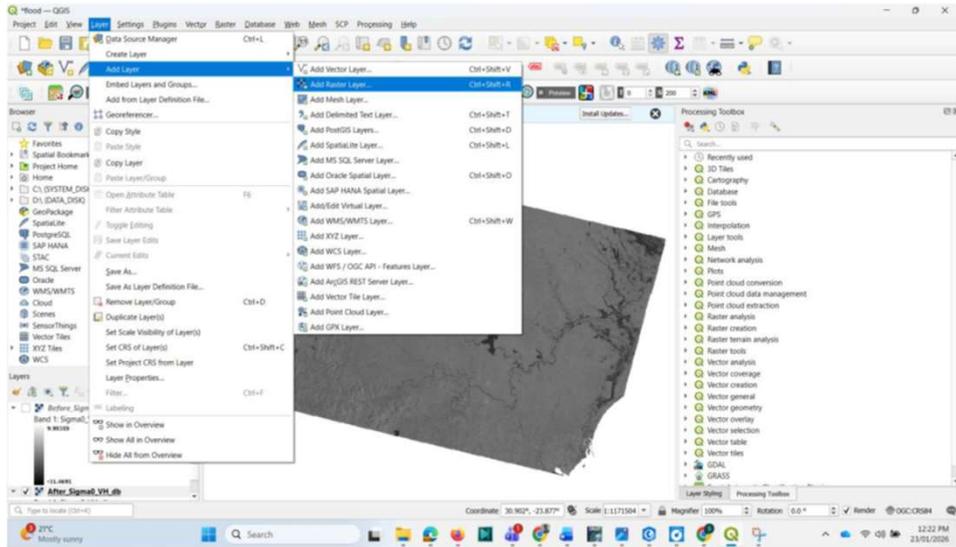
SAR data processing in SNAP

The image illustrates the SAR data processing workflow in SNAP through four sequential screenshots:

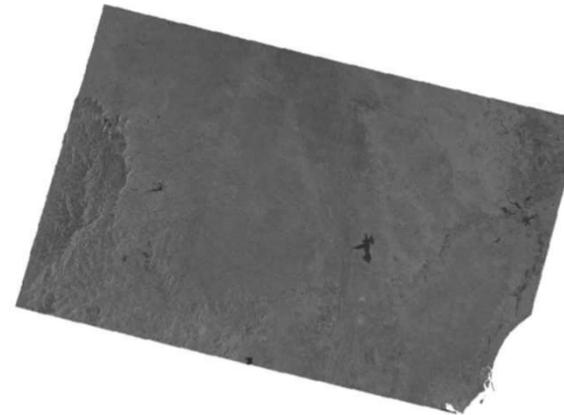
- Graph Builder:** Shows a workflow graph with steps: Read → Calibration → Speckle Filter → Terrain Correction → Linear To Fractal → Write. A blue arrow points from this window to the main processing window.
- Main Processing Window:** Shows the main interface with a SAR image. A blue arrow points from the 'Tools' menu to the 'Batch Processing' dialog.
- Batch Processing Dialog:** Shows the 'Batch Processing' dialog with a table for I/O Parameters. The table contains the following data:

File Name	Type	Acquisition	Track	Orbit
S1A_IW_GRDH_1SDV_20201117T031847_20201117T031912_062801_07808_849	GRD	17Jan2018	79	62801
S1A_IW_GRDH_1SDV_20201117T031848_20201117T031913_062802_07808_850	GRD	09Jan2018	79	62802
- Execution:** Shows the main processing window with the SAR image and a 'Batch Processing' dialog box open, indicating the execution of the graph.

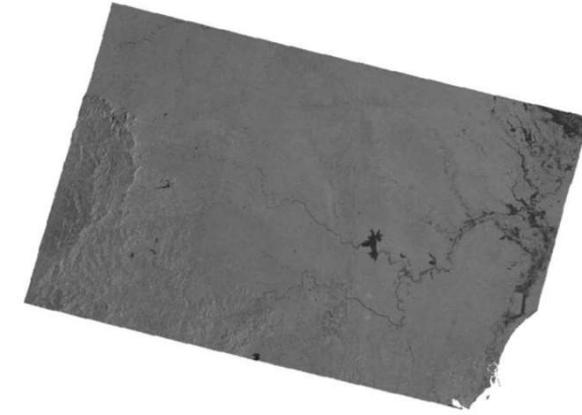
Flood analysis in QGIS



An update to the QuickMapServices plugin is available. Install Updates...



An update to the QuickMapServices plugin is available. Install Updates...



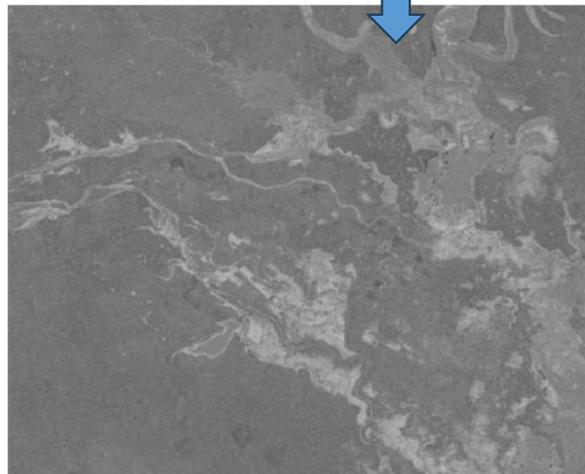
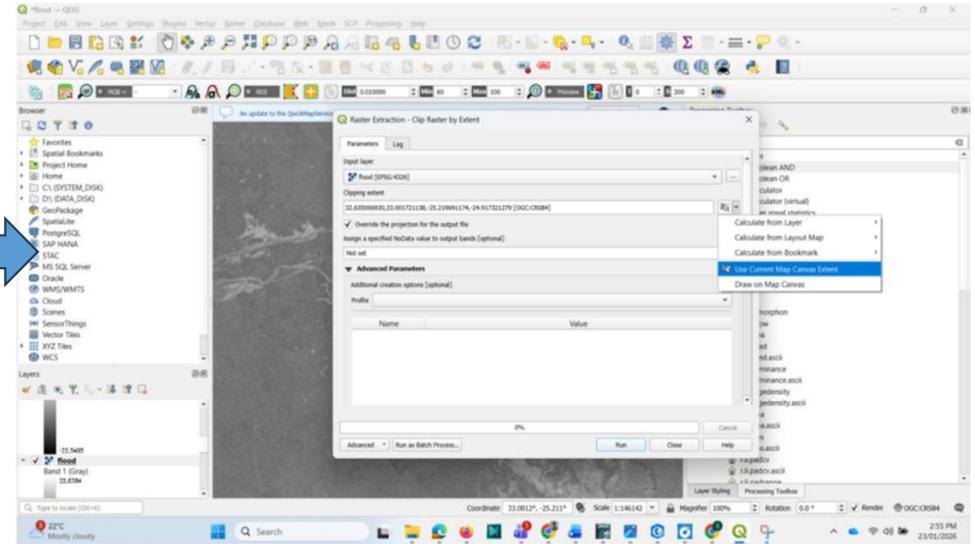
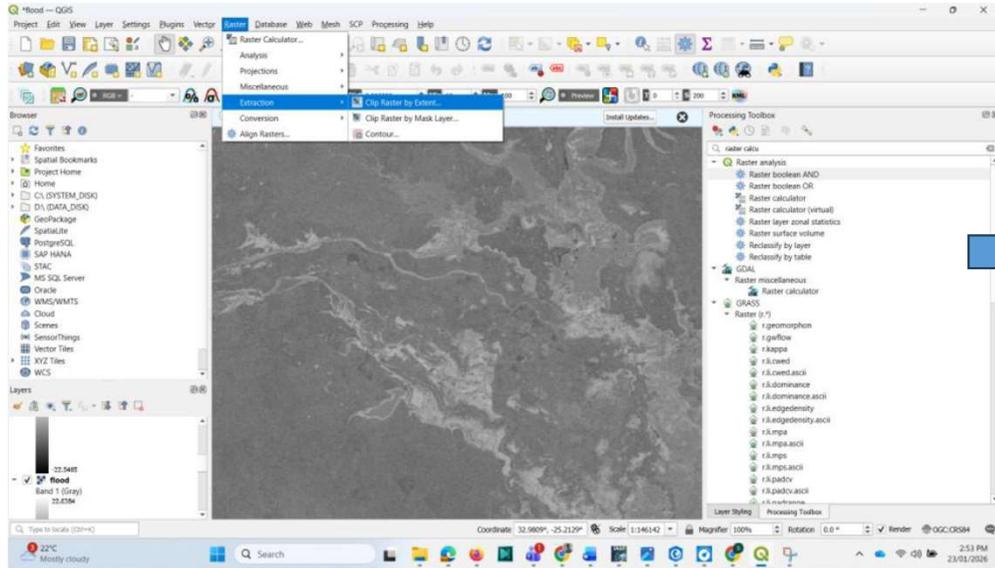
Flood area highlighting in QGIS

The image displays the QGIS software interface. On the left, the main window shows a map with a dark, irregularly shaped area highlighted, representing a flood zone. The 'Raster' menu is open, and the 'Raster Calculator...' option is selected. A blue arrow points from this menu item to the 'Raster Calculator' dialog box on the right. The dialog box is titled 'Raster Calculator' and contains the following sections:

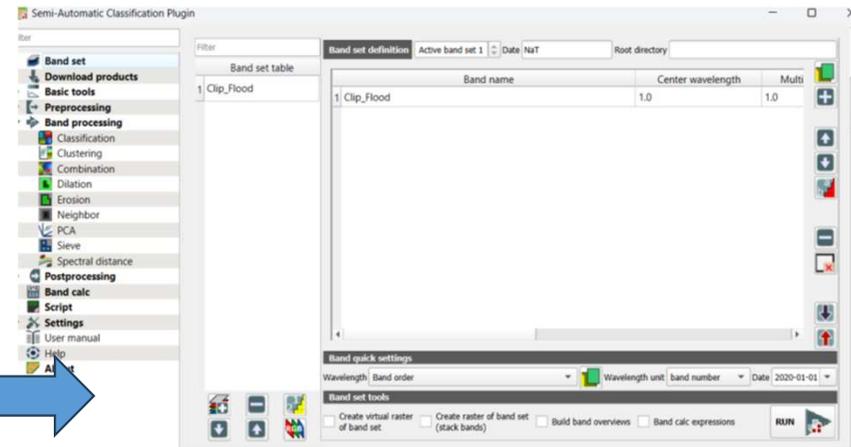
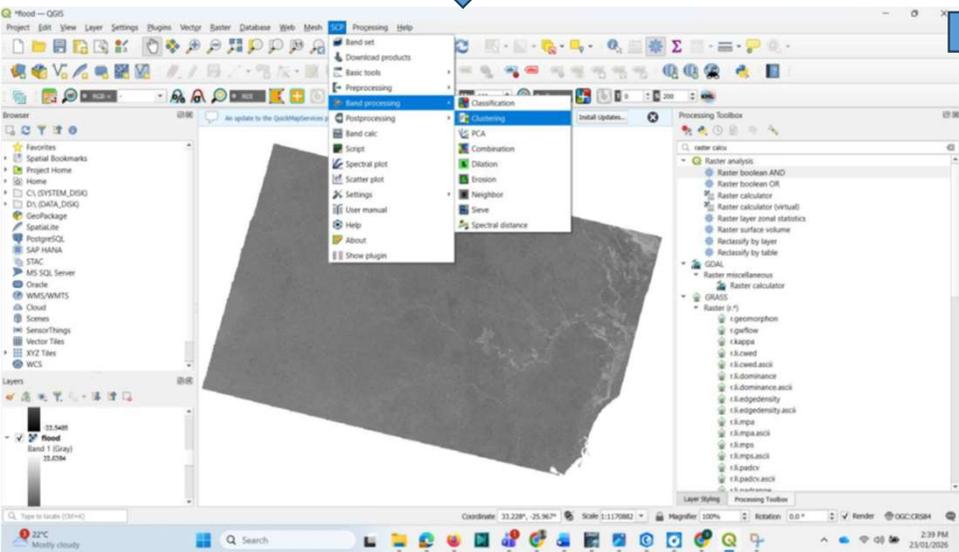
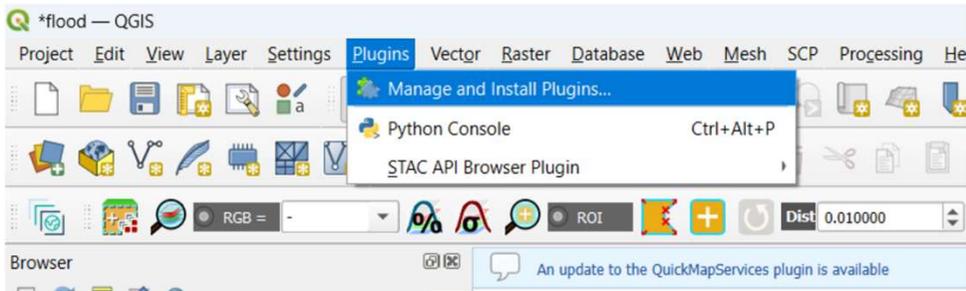
- Raster Bands:** A list of input bands including '2Re_classify_Flood@1', 'Classify_Flood@1', 'Clip_Flood@1', 'Re_classify_Flood@1', 'Before_Sigma0_VH_db@1', 'After_Sigma0_VH_db@1', and 'flood@1'.
- Result Layer:** Options for 'Create on-the-fly raster instead of writing layer to disk', 'Output layer', and 'Output format' (set to 'GeoTIFF').
- Spatial Extent:** 'Use Selected Layer Extent' is checked. X min: 30.32682, X max: 33.25102, Y min: -26.05297, Y max: -23.96492.
- Resolution:** Columns: 32552, Rows: 23244.
- Output CRS:** OGC:CRS84 - WGS 84 (CRS84).
- Operators:** A grid of mathematical and logical operators including '+', '*', '(', 'min', 'IF', 'cos', 'acos', '-', '/', ')', 'max', 'AND', 'sin', 'asin', '<', '>', '=', 'abs', 'OR', 'tan', 'atan', '<=', '>=', '!=', '^', 'sqrt', 'log10', and 'ln'.
- Raster Calculator Expression:** The expression entered is: `("Before_Sigma0_VH_db@1" - "After_Sigma0_VH_db@1")`

A second blue arrow points from the 'Raster Calculator' dialog box back to the map view, indicating the result of the calculation. The map view shows the same dark area as before, but with a slightly different appearance, suggesting the application of the calculated expression.

Flood area clipping in QGIS



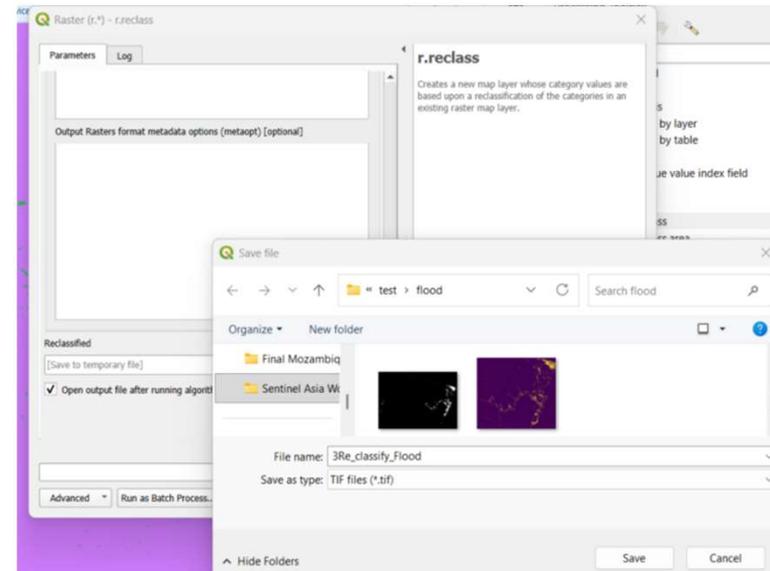
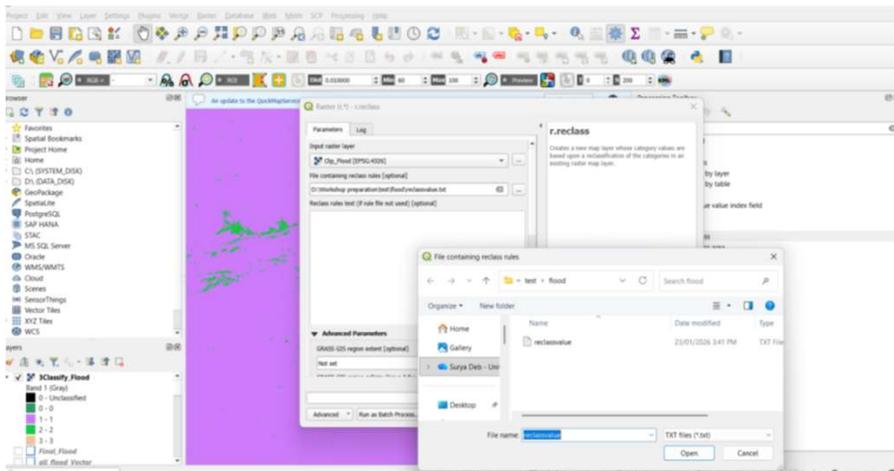
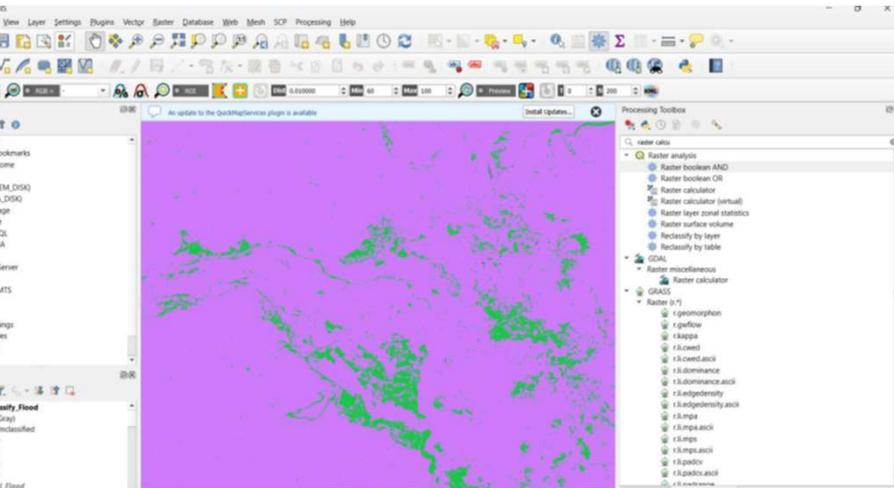
Classification of Flood Area



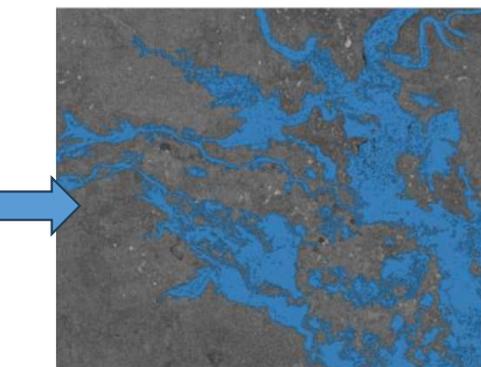
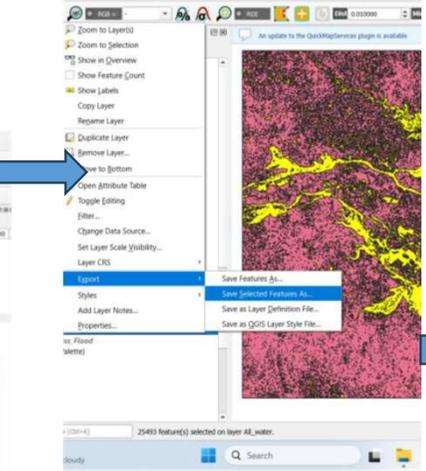
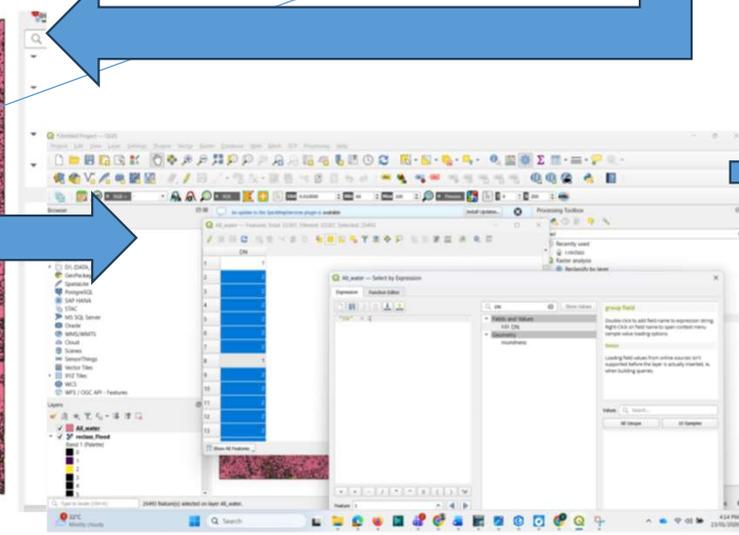
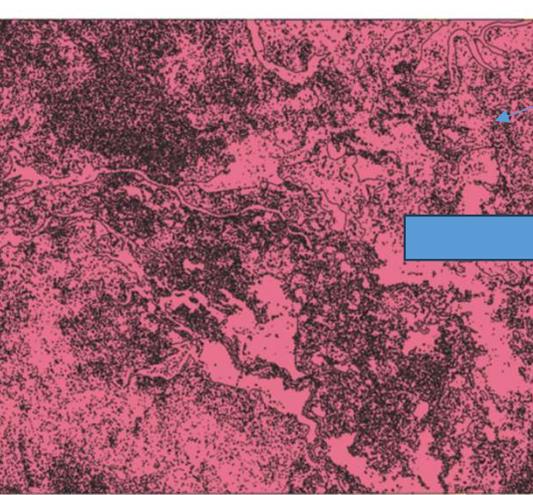
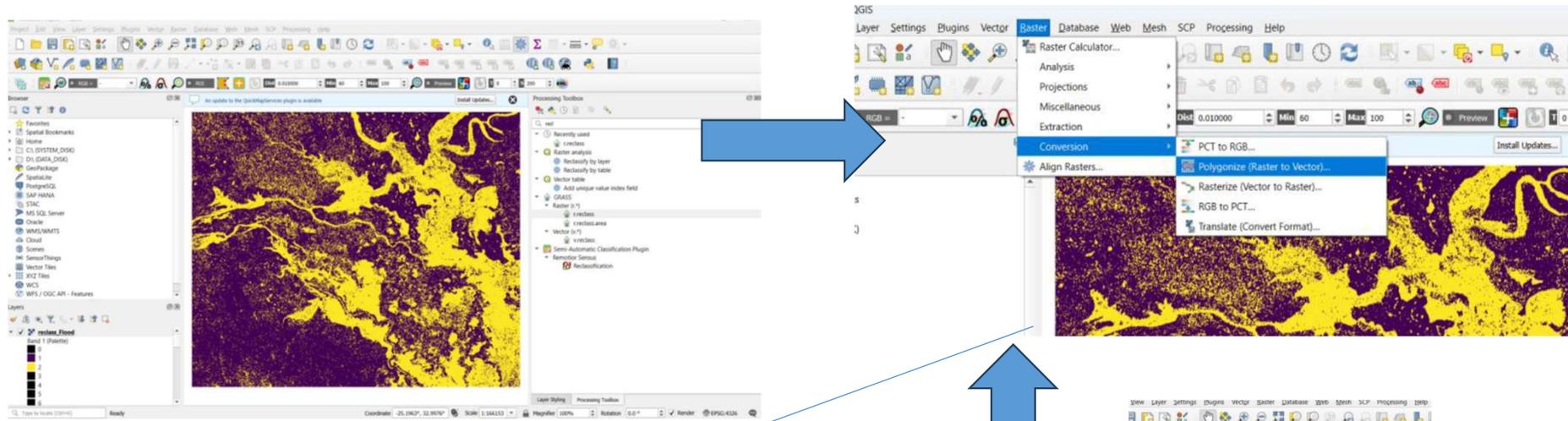
Mozambique Flood Monitoring

1. Open the **Processing Toolbox**.
2. Search for the **Reclassify** tool.
3. Use a predefined reclassification table:
 - Original values **0 and 1** → **Class 1 (Non-water)**
 - Original values **2 and 3** → **Class 2 (Water)**

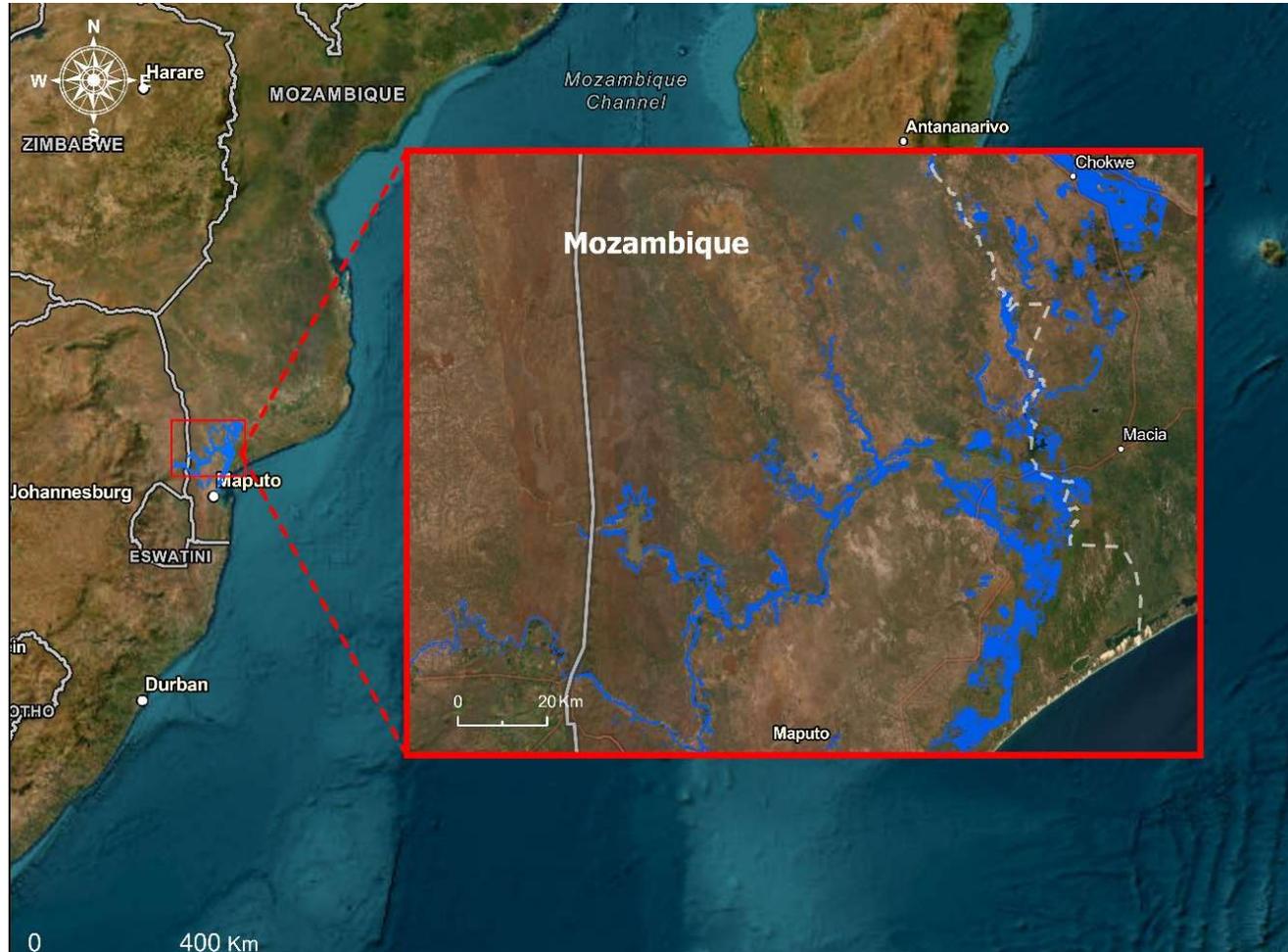
0 thru 1 = 1
2 thru 3 = 2



Re classification and Final Flood area extraction



Mozambique Flood Monitoring



Thank You