THE USE OF REMOTE SENSING IMAGES IN FLOOD MONITORING

R. BERTICI[1], C. POPESCU[1], Adina HORABLAGA[1], Alina Lavinia CĂLUȘERU[2]
A. BORCA[1], Iulia OLTEANU[1], L. DRAGOMIR[1], D. DICU[1], M.V. HERBEI [1,*]

[1)] University of Life Sciences "King Mihai I" from Timisoara, Timișoara, 300645, Romania
[2)] National Agency for Environmental Protection Timis
[*]Corresponding author: mihai_herbei@yahoo.com

***Abstract**. Disaster management and the creation of hazard maps are activities that come to minimize the damage caused by disasters through processes to prevent the destruction and degradation of the environment. Floods represent one of the most dangerous disasters and are frequently encountered in different areas of the Earth's surface. The causes of these phenomena can be natural or the result of inappropriate exploitation of human activities. Among the most frequent causes of flooding are heavy rains, storms or melting snow. The present research evaluated remote sensing methods and techniques combined with the science of geographic information systems in the analysis of floods in the Western area of Romania, as well as in the estimation of the areas affected by these floods. The studied area is located near the town of Lugoj in Timis county - Romania. Radar images (SAR) taken from the Sentinel-1A remote sensing system were used to analyze and create maps of the flooded areas. The images are not influenced by weather conditions and can be taken both during the day and at night, which provides a good source of high-resolution datasets. In conclusion, this study can provide answers to the reason for the expansion of floods in the studied area and to a more rigorous planning in order to reduce and manage risks in periods of high flood risk.*

***Keywords**: GIS, images, remote sensing, SAR, Sentinel 1A*

INTRODUCTION

The land surface varies structurally and functionally in relation to natural and anthropogenic factors. Studies on terrestrial areas were carried out from ecological, economic and social perspectives, and the investigation methods based on remote sensing diversified over time. Studies based on satellite images are no longer recent, and techniques based on remote sensing and GIS are frequently used due to the facilities they offer.

In recent years, flood disasters have occurred frequently around the world, causing great damage. Satellite remote sensing technology is widely used in flood monitoring, because it can effectively and accurately observe the occurrence of flood events, facilitate rapid response to floods, and reduce unnecessary damage.

Ground observations can provide valuable information about the extent of surface water, but they are not always available, especially during flood events. Furthermore, it can also be difficult to obtain detailed and accurate spatial information on water extent using gauging stations alone. Satellite-based remote sensing technology is an affordable and easily accessible means of capturing near real-time inundation information with reasonable spatial resolution. This can be valuable for flood monitoring at a regional scale, of which many freely available sensors meet this requirement.

Compared with the traditional flow measurement methods for flood monitoring, remote sensing technology can quickly access a wide range of land surface spatial information in real-time for effective disaster prediction. Water information extraction is one of the most important uses of remote sensing for fast and accurate flood hazard assessment because satellites provide vast instantaneous coverage and periodic repeatability. Multiple water information extraction methods have been developed, including the thematic classification, single-band threshold, inter-spectrum relation, and water index methods.

MATERIAL AND METHOD

ArcGIS Pro was used to create thematic maps, in order to map the areas affected by the floods. ArcGIS Pro is the premier desktop geographic information system (GIS) application. Crafted with user-driven innovations, it offers unparalleled tools and capabilities that support your work. Users can maintain spatial data effectively; generate stunning 2D, 3D, and 4D visualizations; and conduct advanced mapping analytics.

Figure 1. ArcGis Pro.

The Study Area considered was around the Bega River flow, near Balint, Bethausen, Manastiur and Dumbrava Localities, Timis County, Romania.

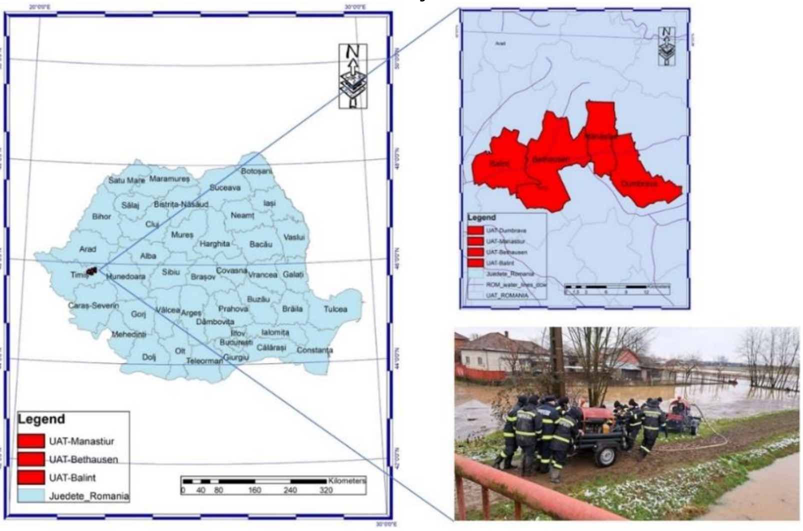

Figure 2. Map of flooded area.

For this project the main tool that was used to create and process the data is SNAP. The Sentinel Application Platform (SNAP) is a common architecture for all Sentinel Toolboxes. The software is developed by Brockmann Consult, Skywatch, Sensar and C-S.

The SNAP architecture is ideal for Earth observation (EO) processing and analysis due to the following technological innovations: extensibility, portability, modular rich client platform, generic EO data abstraction, tiled memory management, and a graph processing framework.

Figure 3. SNAP.

The images acquired were from the following dates: 20 June 2022 (Archive Image) and 27 February 2023 (Crisis Image).

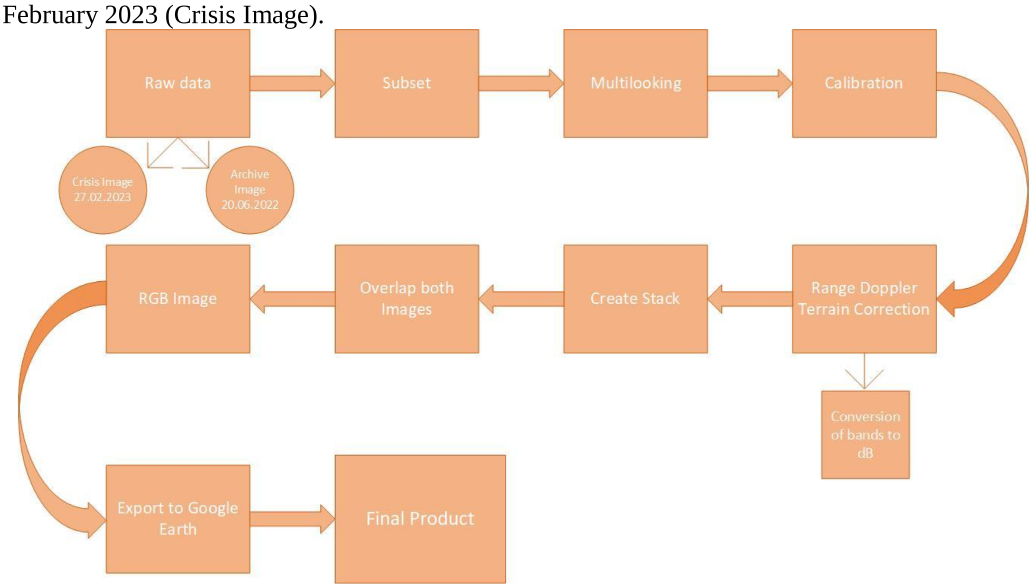

Figure 4. Workflow.

RESULTS AND DISCUSSIONS

First step of the project was to crop the images acquired from Copernicus Dataspace (Archive Image and Crisis Image), in order to streamline the processing time and the storage space occupied by the project, it was necessary to crop the image so that it includes only the area of interest. With the help of the SUBSET command, it was possible to reduce the memory from 1.6 GB to 350 MB for an image, and the processing time was reduced from 27 minutes and 47 seconds to 6 minutes and 2 seconds for an image.

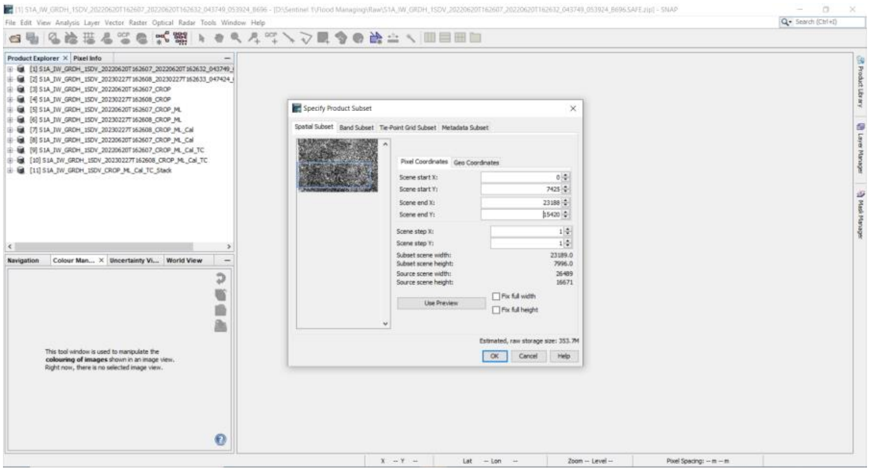

Figure 5. Step 1.

The second step was to apply Multilooking, another method to make time more efficient but also to reduce speckle. Time this process take is 51 seconds. The process is repeated for both images.

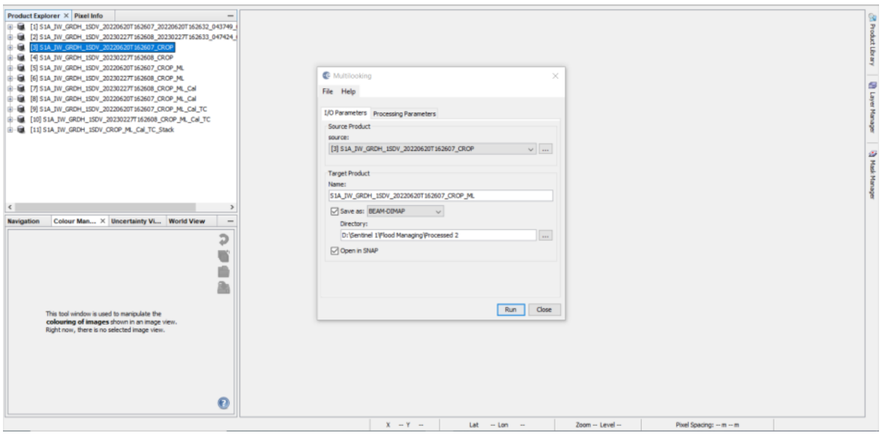

Figure 6. Step 2.

The third step is Calibration, it takes 5 seconds and is done for both images.

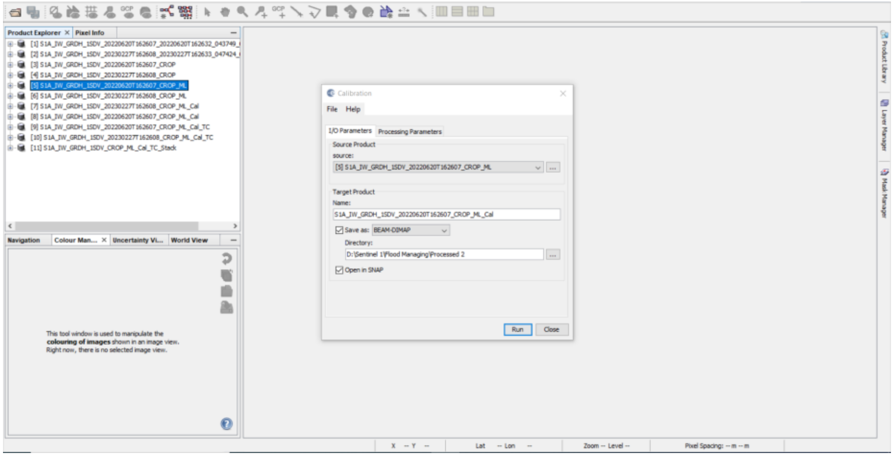

Figure 7. Step 3.

The fourth step is to convert the bands from a linear value to a Decibel (dB) value. This is done to preview the values, but the bands remain virtual, and to easily manipulate pixel values and eliminate errors.

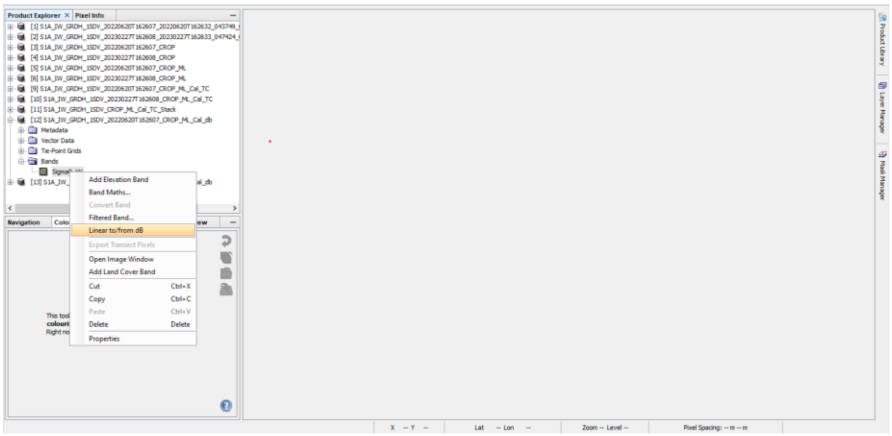

Figure 8. Step 4.

Side by side comparasion between linear scale band and logarithmic scale band.

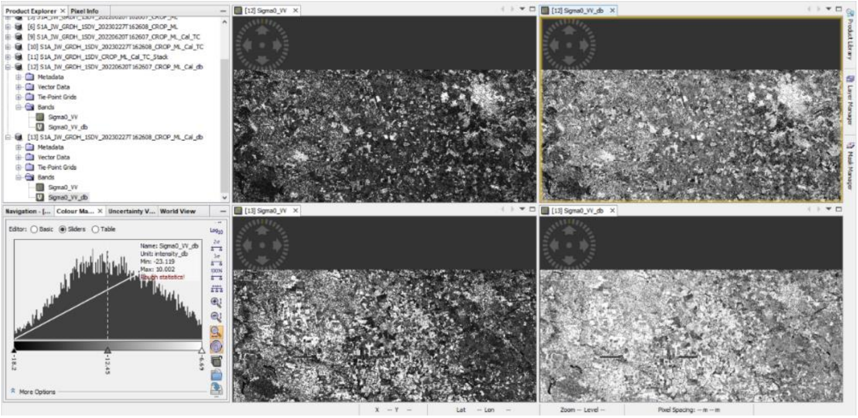

Figure 9. Comparasion.

The fifth step is to project the pixels onto a projection system (WGS84) using Range Doppler Terrain Correction.

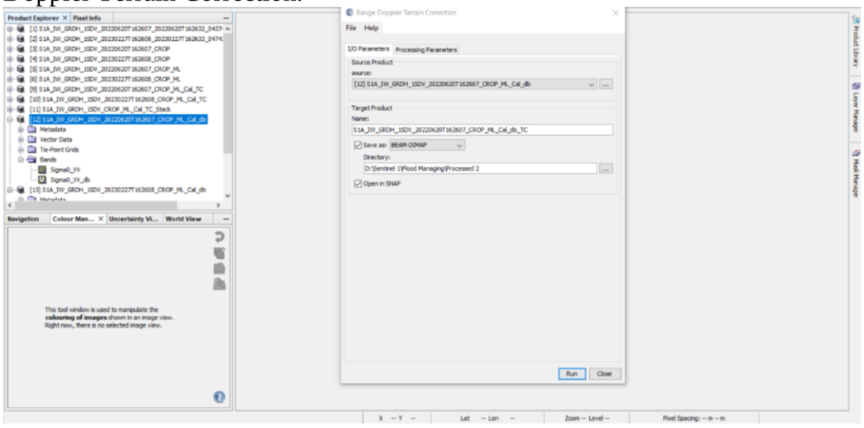

Figure 10. Step 5.

The sixth important step is converting the bands from a linear value to a Decibel (dB) value. In this step, the tapes are saved from the virtual tapes and written to the file.

Figure 11. Step 6.

The seventh step is to create a stack of the two images.

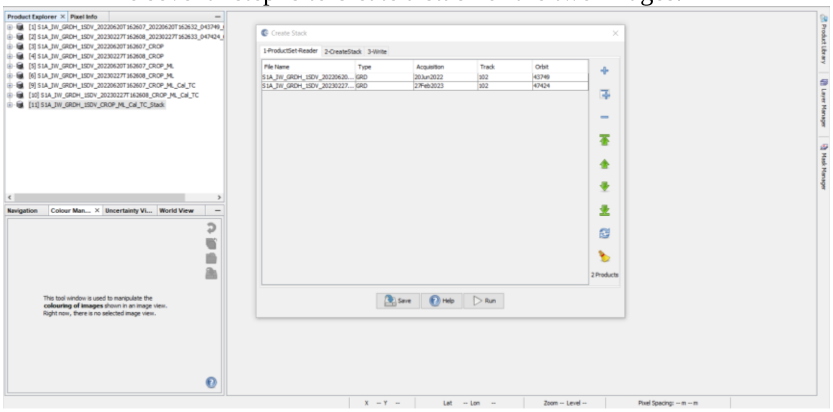

Figure 12. Step 7.

The eighth step is to overlap the images.

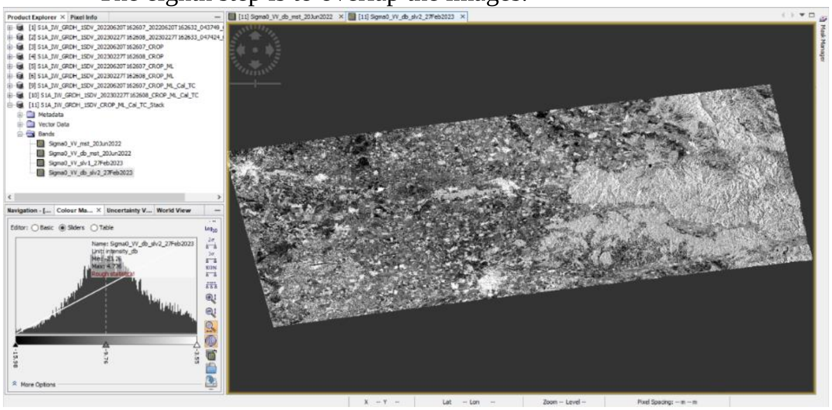

Figure 13. Step 8.

The ninth step is to create the RGB image.

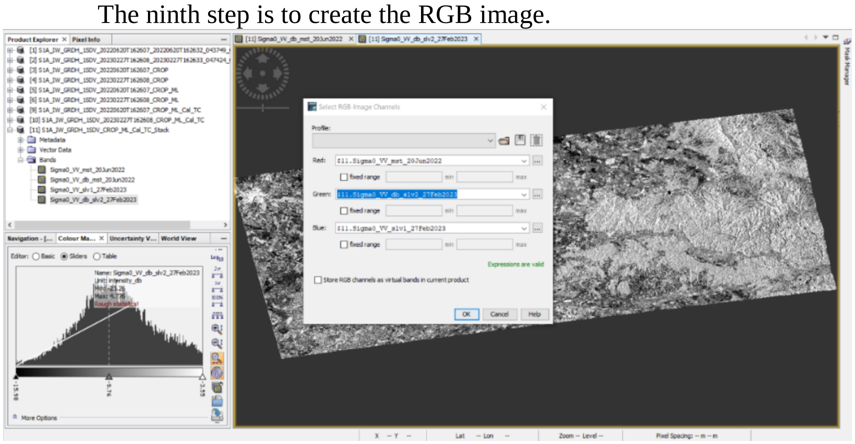

Figure 14. Step 9.

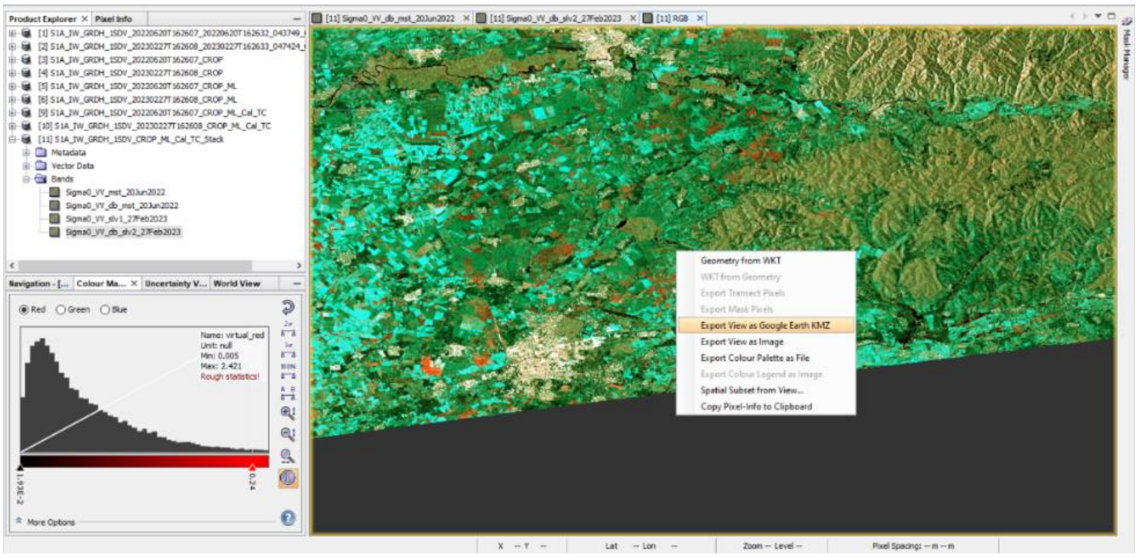

Figure 15. Exporting to Google Earth format.

The final image shows the red colored areas that represent the flooded areas. The image is loaded in Google Earth for a good reference of the area.

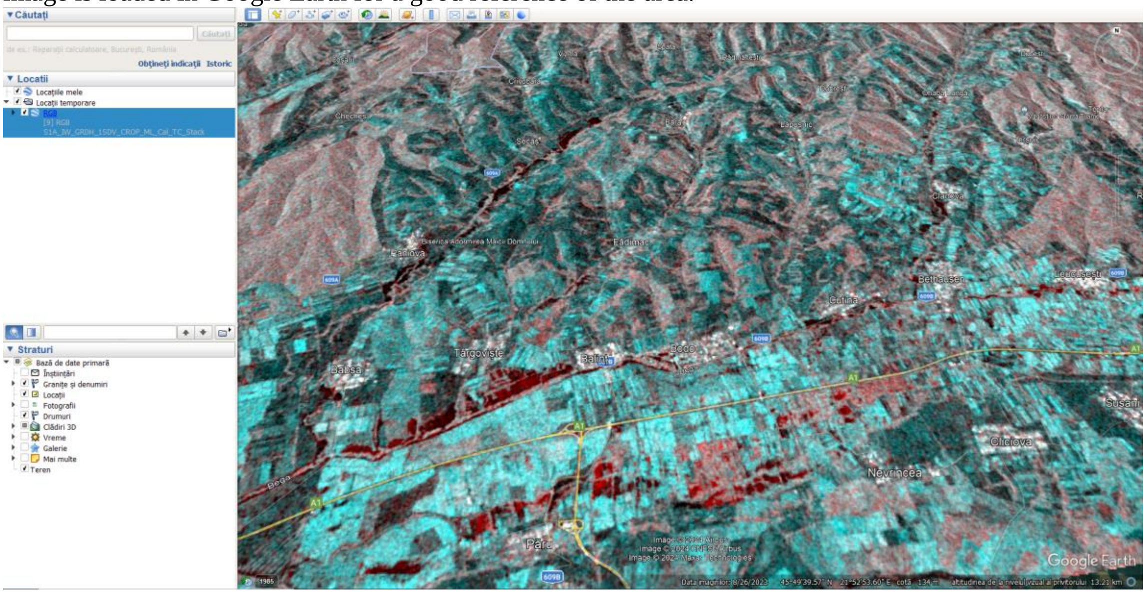

Figure 16. Final Image of Flooded areas.

CONCLUSIONS

Based on the analysis conducted using SNAP, SENTINEL-1, and ArcGIS Pro regarding the flood that occurred near Balint, Romania, on February 27, 2023, several conclusions can be drawn:

1. Extent of Flooding: The combination of SNAP and SENTINEL-1 data allowed for the precise mapping of the flooded areas. By analyzing the satellite imagery, we were able to determine the extent of the floodwaters and identify the most severely affected regions.
2. Temporal Analysis: Utilizing the temporal capabilities of SENTINEL-1 data, we were able to track the progression of the flood over time. This analysis provided valuable insights into the dynamics of the event, including the rate of water accumulation and the duration of inundation in different areas.
3. Vulnerability Assessment: ArcGIS Pro facilitated the integration of various spatial datasets, enabling us to conduct a comprehensive vulnerability assessment of the affected areas. By overlaying flood extent maps with demographic, infrastructure, and land use data, we identified vulnerable communities and critical infrastructure at risk.
4. Emergency Response Planning: The timely availability of accurate flood maps generated using SNAP, SENTINEL-1, and ArcGIS Pro was instrumental in facilitating emergency response efforts. Emergency responders were able to use these maps to prioritize evacuation routes, deploy resources to the most affected areas, and coordinate rescue operations effectively.
5. Long-Term Resilience Planning: In addition to immediate response efforts, the data and analysis generated from this project are crucial for long-term resilience planning. By identifying flood-prone areas and understanding the underlying factors contributing to vulnerability, policymakers can implement measures to mitigate future flood risks, such as improved land use planning, infrastructure upgrades, and early warning systems.
6. Importance of Remote Sensing and GIS: This project underscores the importance of remote sensing technology and Geographic Information Systems (GIS) in disaster management and risk reduction. The integration of satellite imagery, advanced processing tools, and spatial analysis capabilities provided a powerful toolkit for understanding and responding to the flood event.

In conclusion, the collaboration between SNAP, SENTINEL-1, and ArcGIS Pro proved invaluable in assessing the impact of the flood near Balint, Romania, and informing both immediate response efforts and long-term resilience planning initiatives. By leveraging the capabilities of these technologies, we can enhance our ability to mitigate the impacts of future flood events and build more resilient communities.

ACKNOWLEDGEMENT

The authors thanks to the GEOMATICS Research Laboratory, ULS "King Mihai I" from Timisoara, for the facility of the software use for this study.

BIBLIOGRAPHY

Zhang, Yuwei, Peng Liu, Lajiao Chen, Mengzhen Xu, Xingyan Guo, and Lingjun ZHAO. “A New Multi-Source Remote Sensing Image Sample Dataset with High Resolution for Flood Area Extraction: GF-FloodNet.” International Journal of Digital Earth 16, no. 1 (2023): 2522–54. doi:10.1080/17538947.2023.2230978.

YUAN, C. ET AL. (2019) ‘Accuracy evaluation of flood monitoring based on multiscale remote sensing for different landscapes’, Geomatics, Natural Hazards and Risk, 10(1), pp. 1389–1411. doi: 10.1080/19475705.2019.1580224.

TICEHURST, CATHERINE, AND FAZLUL KARIM. “Towards Developing Comparable Optical and SAR Remote Sensing Inundation Mapping with Hydrodynamic Modelling.” International Journal of Remote Sensing 44, no. 9 (2023): 2912–35. doi:10.1080/01431161.2023.2211714.

https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview

https://www.esri.ro/ro-ro/home

https://www.copernicus.eu/en/access-data
https://sentinels.copernicus.eu/web/sentinel/copernicus/sentinel-1
https://earth.esa.int/eogateway/tools/snap
https://dataspace.copernicus.eu/
https://dataspace.copernicus.eu/browser/
https://lugojexpres.ro/blog/despagubiri-pentru-localitatile-bethausen-margina-dumbrava-balint-si-manastiur-afectate-de-inundatii/
https://www.opiniatimisoarei.ro/se-umfla-apele-in-timis-cod-rosu-de-inundatii-au-fost-transmise-mesaje-in-sistemul-ro-alert/27/02/2023
https://www.igsu.ro/
https://www.nasa.gov/