Application and Comparison of Imaging Techniques for Data-Driven Disaster Debris Quantification

College of Engineering

Jasmine H. Bekkaye[1], Navid H. Jafari[1]

[1]Department of Civil & Environmental Engineering, Louisiana State University, Baton Rouge, LA, jbekka1@lsu.edu

Department of Civil & Environmental Engineering

Introduction

- Reasonable estimates of debris help communities better determine their debris management needs following a disaster; however, post-disaster waste data to validate debris estimates is often unavailable.
- This can be addressed by using imaging technology to quantify disaster debris promptly following a hazard.

Research Objectives

(1) Demonstrate and compare multiple imaging tools available for quantifying disaster debris using post-disaster data collected following Hurricane Ida in 2021.

(2) Establish a framework for selecting an imaging method based on the desired application and available resources.

Methodology

- Southeastern Louisiana (Fig. 1) chosen as a testbed due to tremendous amount of damage following Hurricane Ida and resulting debris generated.
- Image classification performed on pre- and post-Ida Sentinel-2 satellite imagery to assess large-scale vegetative debris transportation and quantities.
- NOAA high-altitude imagery analyzed to determine locations of vegetative debris on critical infrastructure.
- UAV & TLS surveys performed post-Ida at a TDMS in Grand Isle to calculate disaster debris volumes.
- Imaging methods were compared based on performance metrics and suitable applications were determined.

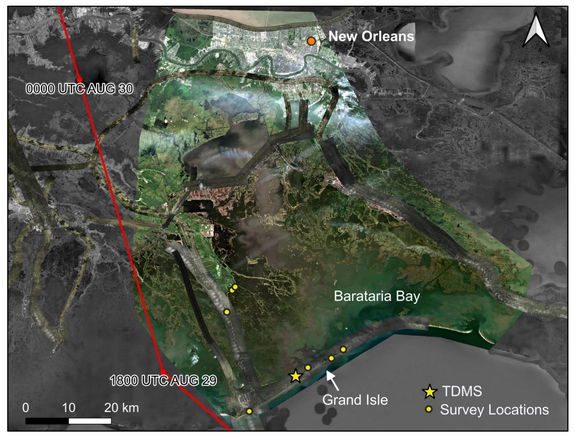

Figure 1. Location map of study area and data used.

Satellite & High-Altitude Imagery

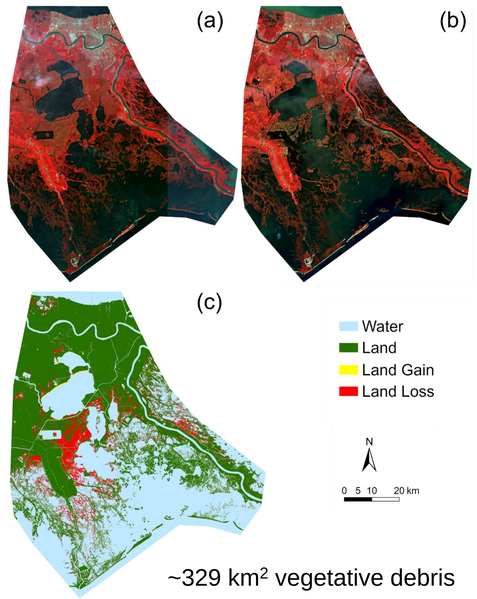

Figure 2. Sentinel-2 imagery[1]: (a) pre-Ida (08/05/21); (b) post-Ida (10/19/21); (c) change in land cover from 08/05/21 to 10/19/21.

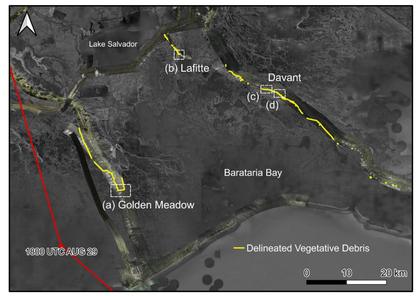

Figure 3. NOAA imagery[2] with vegetative debris locations.

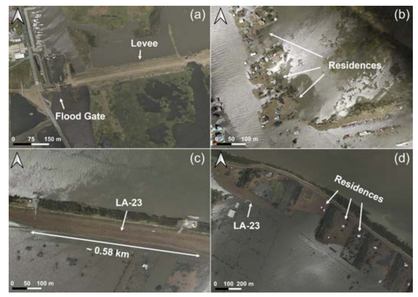

Figure 4. Areas within white boxes in Fig. 3, illustrating vegetative debris blocking critical infrastructure.

- Satellite imagery useful for identifying vegetative debris generation and transportation across vast spatial areas.
- High-altitude aerial imagery well-suited for quantifying debris on critical infrastructure in response phase.

Unmanned Aerial Vehicle & Terrestrial Laser Scanning

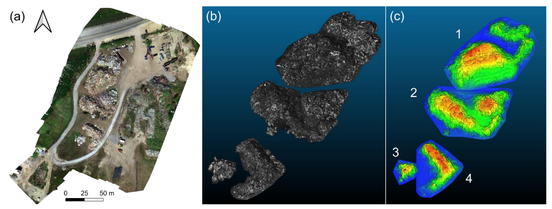

Figure 5. UAV Imagery: (a) orthomosaic; (b) segmented point cloud; (c) 3D meshes, labelled, and colored by relative elevation.

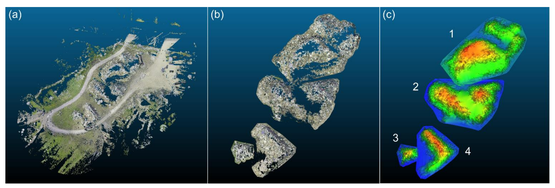

Figure 6. TLS Point Cloud: (a) composite; (b) segmented point cloud; (c) 3D meshes, labelled and colored by relative elevation.

- UAVs and TLS highly effective for quantifying debris and can provide precise volumes.
- Debris volumes from UAV and TLS surveys within 8% of each other (on average).

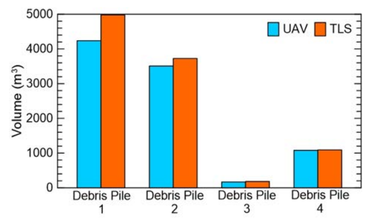

Figure 7. UAV and TLS debris volume comparisons

Comparison of Imaging Methods

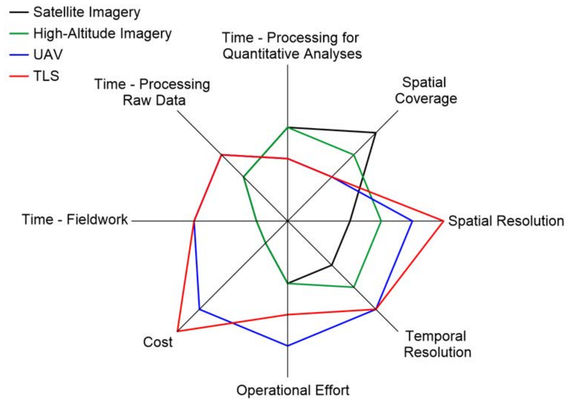

Figure 8. Summary of criteria for each imaging method for debris quantification.

- Publicly available satellite imagery is often limited by spatial and temporal resolutions.
- High-altitude imagery is limited spatially and temporally to interests of acquiring agency.
- UAVs & TLS highly effective but more expensive than satellite & high-altitude imagery and require more operational effort.
- UAVs may be a better option than TLS due to their lower cost and computational demand.

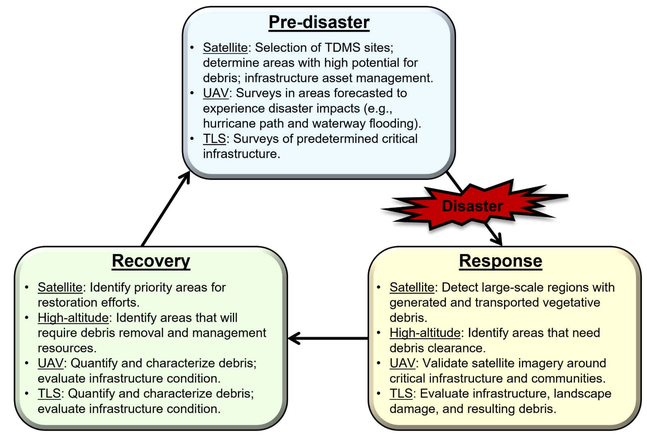

Figure 9. Suitable applications of imaging methods in different disaster management phases.

Summary and Conclusions

- Imaging tools can be employed for diverse applications with regard to disaster debris quantification.
- A framework was developed to evaluate imaging technologies and their efficacy in debris management. This will assist debris quantification efforts and decision making for waste managers.

References

[1] Copernicus. (2023). Copernicus Open Access Hub.
[2] NOAA. (2023). NOAA's Emergency Response Imagery.
[3] Bekkaye, J. H., and Jafari, N. H. (*under review*). "Application, Integration, and Comparison of Imaging Techniques for Data-Driven Disaster Debris Quantification." *Journal of Computing in Civil Engineering*.

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