Mapping an island in Belize with a drone on the barrier reef

CITIZENS TO THE RESCUE IN BELIZE

RESIDENTS OF HOPKINS IN BELIZE RELIED ON ANECDOTAL OBSERVATIONS TO MANAGE FLOODING AND MAKE DECISIONS IN RESPONSE TO CLIMATE CHANGE. PETER LICALSI LOOKS AT A COLLABORATIVE EFFORT TO OBTAIN THE HIGHLY ACCURATE DATA THE VILLAGERS NEEDED

Belize is home to the second-largest coral reef system in the world. The villages along its coast, as well as Belize's myriad small islands, many of which lie several miles offshore, depend on the Belize Barrier Reef for their livelihood, as the natural beauty and wildlife of the region have become valuable tourism resources for the local economy.

The impacts of climate change have made flooding an imminent concern for communities living on the edge of dry land. In the small villages of places like Belize, where technology has not yet caught up with the public demands to adapt to a rapidly changing earth, the question of where is a crucial one

Damage caused by flooding, the collection of marine debris, and the need for coral reef protection are all critical concerns faced by the small coastal village of Hopkins. Its residents relied on anecdotal observations to manage these issues and have never had a truly data-driven way to make informed decisions in the realm of disaster management or conservation. So, in June 2016, Citizen Science GIS, a collaborative effort led by assistant professor Timothy Hawthorne of the US's University of Central Florida (UCF)'s GIS programme, along with the US National Science Foundation, the University of Belize, and the Hopkins Village Council, initiated an undergraduate research training programme to map disparities in debris, flooding, and disaster management and create the first high-resolution, open aerial imagery of vulnerable island environments. This project afforded Hopkins and the outlying islands location intelligence that would then be accessible via an online, interactive open data and mapping portal.

The data's in the details

The major challenges facing Hopkins Village were the lack of good data available on areas vulnerable to flooding or debris, and the fact that aerial imagery was almost non-existent or of poor quality. Even satellite imagery was poor.

"Unfortunately, we can't say for certain why high-resolution satellite imagery of Belize is not publicly available," says Nick Altizer, the lead graduate student on the project from UCF. "Resolution of the available satellite imagery tends to vary as it is gathered from multiple sources. For instance, the Worldview-4 satellite from DigitalGlobe has a resolution of 31cm but we are not seeing imagery in Belize approaching this level of detail; most imagery appears to be over 1m resolution with date of capture going back nearly 10 years."

The Citizen Science GIS team members sought to replace this with high-resolution imagery captured by affordable, consumer-level drones flown 150-200m above Hopkins Village and the outlying islands near the reef.

"We used DJI Phantom 4 Pro quadcopters capable of producing imagery resolution as low as 3.21cm," says Altizer. "A single battery for the Phantom 4 Pro typically provides 20 minutes of flight time but by exchanging the batteries we could fly areas as large as 1,100 acres, which can take as long as 4.5 hours. The small size of most islands in Belize meant each flight took about 15 minutes, with a resolution roughly around 4.15cm, but flight times varied widely depending on size."

Having captured the imagery, they could see a clearer picture of coastal and island vulnerabilities, boat docks and the damages they sustained, the existence of solar panels and other alternative energy sources on the islands, and sea walls (cement as well as temporary ones made of recycled materials like tires).

Drone2Map for ArcGIS was used to produce high-resolution orthomosaics. These were then directly uploaded to ArcGIS Online where they were made publicly available and digitised by the team. The digitised data was then placed in ArcGIS Online and publicly shared. The team digitised all of Hopkins and examined roads, culverts, and buildings. For structures, they looked at use (residential versus commercial) and proximity to flood-prone areas.

The results indicated that 211 out of 239 commercial structures lie outside flood-prone areas. Conversely, 241 out of 273 of the residential structures fall inside flood-prone areas.

For each digitised building in Hopkins, students and researchers did a field survey to identify its vulnerabilities: height above sea level, construction quality, vacancy, and distance from the coast. From their findings, they performed analyses on vulnerability based on structural data, and they also had residents draw a perception map for flood hot spots.

Drone-captured view of Hopkins Village with the Caribbean in the east and the lagoon in the west


Drone-captured high-resolution imagery of island and reef habitats on the barrier reef


Drone footage of Hopkins Village, showing severe flooding in the road

On the ground, by the sea

To compile this information, researchers asked individuals to map areas where they typically see flooding occur. Information was also recorded regarding the duration of the flooding in each area, how many people it affected, the land use, and personal thoughts on the cause and primary problems associated with it. The collected data on flooding hot spots compared with where residents perceived them to be were merged into a consensus map in ArcMap.

The results showed that new residential structures where families tended to live were being built closer to the lagoon – a more vulnerable, flood-prone area – since these plots were cheaper. The team was also able to create the first map of every culvert in the community, detailing its quality and the build-up that was leading to additional flooding.

Marine debris is also a huge problem in Hopkins. Using a sampling square made of pipe and rope, the team members sampled the beach along the strandline in 50m intervals using an iPad equipped with Esri's Collector app for ArcGIS to gather data offline along the coast.

Lain Graham, UCF PhD student of sociology and GIS and REU senior research mentor, explains: "When an accumulation of debris was identified as a hot spot, a new feature was initiated in Collector and attributes were entered in the field. The pairing of the offline capabilities in the Collector app and the external Bluetooth enabled Dual GPS device allowed for ±2.5m (CEP) accuracy in recording the data point's location. This combination allowed for the collection of hotspot attributes, such as relative size, dominate material type and allowed for the attachment of a photo taken from the tablet in the field and linked to the hot spot point and location. When our team returned to a WiFi-enabled location, the data collected was synced and was immediately visible online."

The team quickly learned that natural debris was just as important to Hopkins residents as man-made refuse. Cut coconuts and Sargassum (a brown algae that many locals refer to as seaweed or seagrass), along with other natural debris, were added to the list of attributes as a result of local collaboration. Citizen Science GIS also learned that while local efforts to manage waste are promising, exotic debris proves to be particularly challenging. The data collection along the beach identified plastics as the most abundant material, and when local perceptions were gathered, most people surveyed confirmed plastics to be most problematic.

The future

Data and action are the keys to stewardship of the community's ecosystem. Efforts like the Village Council's beach clean-up project can use the marine debris to not only identify priority areas for clean-up but also use the map as a maintenance log, updating the database for future projects. Over time, the impacts of this work can be measured, and persistent problem areas can be identified.

"What we kept hearing when we started this work was that the community in Hopkins Village tends to be left behind when resources are allocated or distributed," says Hawthorne. "Now, they have data to support some of the structure improvement initiatives they want to do, like road repairs or clean culverts."

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