DETERMINING VULNERABLE SITES TO FLOOD RISK USING LiDAR, GIS, AND DATA MINING: AN EXAMPLE OF FORT PLAIN FLOOD OF JUNE 28TH, 2013

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Introduction: On Friday, June 28th, 2013, Fort Plain, New York, was severely flooded. Flood is a frequent event at Mohawk River. The 2013 flood was due to seasonal, persistent rains and caused damage to homes, businesses, and altered Fort Plain's environment. Recorded peak water-surface elevations and discharges have shown a strong correlation during floods (Tsakiri et al., 2014). On June 26th 2006, a major flood has affected extended areas surrounding the Mohawk River basin in New York State, while previous documented floods such as in March 1977 and in January 1996 the recorded peak water-surface elevations and discharges recorded from selected USGS stream-gaging stations were also related (Suro et al., 2009). The purpose of this study is to enhance a resilient infrastructure build of the study area by predicting vulnerable sites of future flood hazards through reconstruction and simulation of previous floods.

Methodology: A methodology is described and has been applied at a study area where data were available. A lab and a field data technique was used to approach high accuracy of a flood water level and coverage simulation. The first technique utilized public available pictures of the flooding in Fort Plain from June 28th, 2013. Pictures were obtained from Google and then ten geographic locations were inferred and mapped on ArcGIS (Fig. 1). The pictures correspond to locations that range in an area from 15 Herkimer St., Fort Plain, NY 13339, to Lock 15, which is southeast of the starting point, to 12 Abbott St., Fort Plain, NY 13339, which is west of Lock 15. This region totals in 1.5 miles in length. All digitized points showing the water level of the flood are located at the western side of the Mohawk River and along the Otsquago Creek. Mapped locations were imported into a GIS software. Light Detection and Ranging (LiDAR) data were used to produce a digital elevation model (DEM) to provide flood simulations and other channel characteristics (e.g. slope, longitudinal profile and elevation gradient). A 3D-LiDAR digital elevation model (DEM) of the town infrastructure has been constructed, and a flood simulation was able to show the intersection between the water surface of the flood and the georeferenced locations from the pictures. The second technique utilizes field obtained data to simulate the flood. A high accuracy GPS survey of points collected from the field at the study area and differentially corrected to provide accurate water levels of the flood. This allowed us to analyze

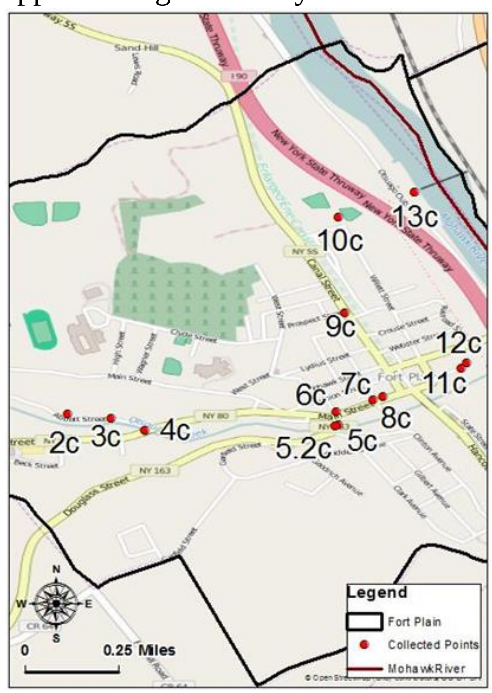

Figure 1: An aerial view of the study area (from ArcGIS) showing the locations of the obtained pictures from Google. Study area is shown with a black polygon, the Mohawk River with a red polyline, and the GPS points gathered in the field represented with red dots.

the data more thoroughly rather than by looking at online images and simulate the flood in the 3D-LiDAR DEM. A geo-collector Trimble Geo 7X, with a capability of a horizontal and vertical accuracy of 0.1 m, with an external antenna Trimble Tornado mounted on a 2m pole was used. 60 points were obtained from each location under 0.3 m preliminary post-processed accuracy. Post-processing correction took place in Trimble extension integrated in ArcMap, and a permanent station with less than 100 km radius (ONEONTA, NYON permanent GPS station of 5sec interval) from our GPS antenna was used. A data mining software, Knime, was used to evaluate hydrological and atmospheric variables that contribute to flooding and enhance an immediate response and efficient decision making. A previous methodology (Tsakiri et al., 2014) has been used to decompose different time scale components that may contribute to increasing water discharge values.

Results: At the study area, the longitudinal profile of the river shows a slope of 0.3°, by using Global Mapper. The slope of the eastern side of the river increases by 3.3°. The eastern side of the river is outside the well-developed flood plain, hence why there are no flood observation points on this side of the river. On the contrary, the western side increases only by 0.3°. This area has a lower elevation and gentle slope, and corresponds to the point bar deposits. These numbers were obtained from LiDAR. Shuttle Radar Topography Mission (SRTM) data (approximately of 30 meters spatial resolution) provided a coarser resolution and very erroneous results and for this reason any results was disregarded. The existing Air-LiDAR data (0.3 meters spatial resolution) provided a more accurate slope.

The determined water levels of the 3D simulated flood in the GIS software were calculated in the computer laboratory (Table 1). GPS high accuracy elevations were obtained from the field and were post-processed with a differential correction of the GNSS (Global Navigation Satellite System) sessions. The maximum water level of the flood, from the 3D LiDAR DEM and available pictures showing high water marks, was 101.6 meters. The maximum water level of the flood, determined from the Trimble Geo 7X and the subsequent post-processing, was 105 meters. The differential correction has increased accuracy from the previous, uncorrected vertical elevation values from the range of 4.37 meters to 13.71 meters. The differential corrected GPS elevation values range from 0.27 meters to 1.33 meters.

		Coordinates		Elevation (meters)		Accuracy (meters)				
No.	Address	Latitude	Longitude	GPS Data (MSL)	Simulation & Pictures	Simulation Estimated Error	GPS Uncorr. Horiz.	GPS Cor. Horiz.	GPS Uncorr. Vert.	GPS Cor. Vert.
02C	22 Abbott St	42° 55' 47.951" N	74° 38' 9.148" W	103.35	101.6	± 0.3	±7.14	±1.47	±13.71	±1.33
03C	12 Abbott Street	42° 55' 47.463" N	74° 38' 3.032" W	101.73	100.2	± 0.3	±6.68	±0.26	±9.65	±0.42
04C	Abbott Street Bridge	42° 55' 45.732" N	74° 37' 58.376" W	105.00	N/A	N/A	±4.44	±0.28	±7.29	±0.79
05.2c	Red Mill Bridge	42° 55' 46.288" N	74° 37' 31.74°8" W	102.62	N/A	N/A	±4.56	±0.17	±7.49	±0.36
05C	Red Mill	42° 55' 46.567" N	74° 37' 31.243" W	92.39	96.6	± 0.3	±6.94	±0.85	±12.49	±0.82
06C	Valero	40 59' 4.235" N	73 51' 10.013" W	96.57	95.8	± 0.3	±6.72	±0.28	±9.49	±0.58
07C	New York Pizzeria	42° 55' 49.919" N	74° 37' 26.392" W	93.06	96.9	± 0.3	±4.91	±0.12	±8.19	±0.27
08C	Kathy's Attic Shop	42° 55' 50.402" N	74° 37' 25.019" W	96.88	96.6	± 0.3	±4.88	±0.30	±5.30	±0.58
09C	181 Canal Street	42° 56' 2.216" N	74° 37' 30.398" W	93.39	94.4	± 0.4	±6.61	±0.22	±7.08	±0.28
10C	Agway Feed Center	42° 56' 15.543" N	74° 37' 31.220" W	93.61	94.5	± 0.3	±4.00	±0.15	±4.37	±0.46
11C	Daylight Donuts	42° 55' 54.351" N	74° 37' 14.061" W	92.48	94.3	± 0.3	±6.48	±0.46	±8.76	±0.58
12C	Lock 15	42° 56' 22.8820" N	74° 37' 27.2073" W	N/A	92.3	± 0.3	N/A	N/A	N/A	N/A
13C	Lock 15	42° 56' 18.945" N	74° 37' 20.648" W	92.87	N/A	N/A	±3.71	±0.25	±4.51	±0.30

Table 1: Water levels of the flood determined from the Global Mapper 3D mode in the laboratory, and the corresponding pictures of the flood event. GPS data (mean sea level elevations; MSL) were collected from the field.

Discussion: When simulating the flood, it was taken into account that terrain features obstruct water flow, like buildings, and trees. This function also determines how a flood plain would increase when the area is enlarged by some depth. There were two clusters obtained from the GPS data. One clustered above 100 m, and the other centered on 90 m. The flood simulation focused on the most reliable data, which was the cluster of 90 m. However, a possible binomial clustering is common to occur when flood occurs in different elevations along the same river, especially when GPS data are taken from an extensive segment of a river's steep longitudinal profile.

The specific location was chosen by the availability of web-based public available pictures from a previous flood to demonstrate a methodology of simulating floods and inform the community for possible vulnerable sites of high flood damage. Flooding causes contamination to occur, while debris and other forms of waste can travel to unwanted areas. This technique of flood simulating and identification of vulnerable sites may help Fort Plain for quick recovery or enhance the societal resilience against floods. When the study area was visited for GPS survey on February 20-21st, 2016, recovery was still underway. Some houses were completely gone, while others were still under construction. This research was conducted in order to present a methodology of assessing vulnerable sites for flood hazard, and to prepare and alert the community for vulnerable sites of flood.

Works Cited

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