To: Dr. Santosh Rijal
From: Mary Silliman, Yang Wang, Zhenyu Yao, Mohammad Yunus Naseri
Subject: Geog 5084_Lab #8_Final Report
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INTRODUCTION

Geographic Information Systems (GIS) can be utilized to model the risk of flash flooding. Previous studies have used a myriad of physiographic variables to best predict risk, including precipitation, topography, soil hydrology, and runoff metrics (Knebl et al. 2005, Skelton & Panda 2009). All of these factors influence the presence, persistence, and quantity of [accumulated] water in a particular area. Considered variables can be reclassified by defining unique weights to determine the areas that are least and most prone to flood risk.

Widespread flooding was seen following Hurricane Matthew, a storm which impacted the Caribbean and southeastern United States in 2016. Flooding in the US occurred from October 4 to 11, 2016, however, Matthew made landfall near McClellanville, SC on October 8, 2016 as a category 1 hurricane (US Department of Commerce). Extreme rainfall and deadly flooding were observed throughout Georgia, South Carolina, North Carolina, and Virginia. There were 29 recorded deaths and an estimate of $10.3 billion in damages. In this study, we investigated the risk of flash flooding in the lower Catawba region.

STUDY AREA

The watershed we chose is called **Lower Catawba** 8-digit hydrologic unit code (HUC8). It is located between **North** and **South Carolina**, ranging from Blackstock, SC as the southern extent to Charlotte, NC on the northern end, with a geometric centroid at a latitude of 34.8728 degrees and a longitude of -89.9070 degrees. The area of the watershed is more than 3000 square km which is between the ranges specified in the problem statement. As water bodies, such as lakes, can create problems to the algorithm used in the analysis process, care has been given to **choose a watershed with the least number of water bodies.** There are six 10-digit hydrologic unit codes, HUC10, inside of the chosen watershed. On October 8, 2016, when Hurricane Matthew struck the east coast of the US, this watershed area was near the epicenter of the hurricane.

DATA COLLECTION

Types of Data (Variables)	Source
Land Cover (NLCD 2011)	• Geospatial data gateway
Watershed Region Hydrologic Unit (HUC 8 and HUC 10)	• Geospatial data gateway
Digital Elevation Grid	• 30-m DEM from geospatial data gateway
Soils	• Soil Survey Spatial and Tabular Data (SSURGO 2.2) from geospatial data gateway
NEXRAD Data Collection and Precipitation	• The National Center for Environmental Information (NCEI) NEXRAD Archive system. NOAA/NCDC NEXRAD

Table. 1. Data Collection and Source.

CORE METHODS

- ***NCLD***

Land cover data for 2011 was acquired from the USGS national database. The national land cover raster file was clipped to our study area using the **extract by mask** function in ArcGIS Pro. The resulting file was then re-projected to **NAD 1983 UTM Zone 17N*. Land cover descriptions were also inputted as a reference in the attribute table. In order to obtain a runoff curve number for each land cover type, land cover [numerical] values were multiplied by ten so that they could be used with soil data.

- ***Precipitation***

To fully consider the flash floods from Hurricane Matthew, examining physical processes and spatial numerical models, we firstly reviewed the NEXRAD data to ensure that there was enough rainfall to warrant investigating the watershed. After choosing the targeted watershed, we collected the NEXRAD data of rainfall for Hurricane Matthew. First of all, we found the nearest or most appropriate monitoring radar station from NOAA website. Next, we set the date to the start date of the hurricane, which was from 0:00 am in Oct 7 to 8:00 am in Oct 9. After downloading all these rainfall data files, we visualized the rainfall to see how the storm began and ended over the watershed. By following this procedure, we can have reasonable certainty for when the rainfall was heaviest over our watershed. We recorded the time when the rainfall was heaviest and then exported this single rainfall data file as raster file for future use in ArcGIS Pro. The following picture indicates the heaviest rainfall of Hurricane Matthew over the watershed. As you can see, the center of the storm was in the northeast of our watershed and the heaviest rainfall (the red part) also had a great influence in the watershed. Now we have a complete raster file for investigating the impact of Hurricane Matthew in the watershed.

- ***Digital Elevation Grid***

The **elevation data** was downloaded from the Geospatial data gateway with a 30-m resolution in the form of a DEM. As the watershed included a vast area, four different terrains (i.e., elevation) data layers were downloaded for it. The downloaded DEM layers were then merged with each other using the 'Merge' function in ArcGIS Pro. Then, the DEM layer was mosaicked with the watershed boundaries using the 'Mosaic to New Raster' function. The DEM layer was necessary for our analysis as later on in the project we used the data layer to find the flow direction and accumulation.

- ***Soil***

Before we start researching and analyzing soil conditions through ArcGIS Pro, we need to make sure all the data projections are unified: **Geographic Coordinate System:** **NAD 1983 UTM Zone 17N.* **Soil data** was downloaded via **SSURGO 2.2**, https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. After unzipping, we double-clicked the Access database. Once Access was opened, we entered a directory path (folder path) for the tabular data - type in the folder path for the soil **tabular** data folder and click OK. In ArcMap, we added six counties for **"component" data** by add data button. Similarly, all soil layers were merged into one single layer, **i.e.,** Mecklenburg (NC), Union (NC), Chester (SC), Fairfield (SC), Lancaster (SC), and York (SC) Counties Lines shapefiles. A map unit was considered a polygon area that has an associated set of soils and soil characteristics. It should note that there was a field called MUKEY. We then merged the final "component" data that can be joined with the six county shapefiles in a new shapefile to create a new layer by MUKEY. Next, we clipped the six counties for soil descriptions by the study area (i.e., we excluded soil information that was not related to the study area).

- ***Runoff Curve Numbers (CN)***

To calculate the runoff curve number, information from both the land cover and soil layers were used. A new field was added to the land cover attribute table, data was obtained by using the calculate field function, and values (from the value field) were multiplied by 10. This was done so that the various land cover types could be used in conjunction with the hydrologic soil groups to obtain a runoff number. A new field was also added to the soil attribute table, where hydrologic soil group A classifications received a 1, B received a 2, C received a 3, and D received a 4. Any classification with X/D received a classification of 4 and a null classification received a value of 4. Soil group A represents soils with the lowest runoff potential, such as sand, and soil group D represents soils with the highest runoff potential like clay. The land cover and soil layers were then joined together. A new field was added to the combined attribute table and the calculated land cover value was added to the equivalent numerical hydrologic soil group. To determine runoff curve numbers, the resulting values were obtained using the reclassify function.

COMBINE DIFFERENT PARTS

After collecting and processing the raster data, we developed a raster total storm precipitation layer covering the watershed. **First,** we examined the 1-year storm data in the watershed. In order to do this, we went to the NOAA website and located the watershed area to find the PDS-based precipitation frequency for different durations. For our investigated watershed, the precipitation frequency is about **3.49**, which is recorded for future use.

Second, after getting soil and land cover results, we used the raster calculator to compute a soil retention (S) layer incorporating the curve numbers. After calculating each pixel, we found that the soil retention layer is from 0 to 52.5. Next, we used the S layer along with the P value (the precipitation raster layer from NEXRAD) to compute a Q layer, which is a cell by cell runoff layer from the 1-year storm. After getting the Q layer, we also computed the flow accumulation from the 1-year storm with Q layer as the weight and this result will be treated as the baseline flow level for comparison.

Third, in addition to the above results of 1-year storm, the predicted flow accumulation surface were obtained for comparison. In order to get this, we calculated the new S layer and Q layer with the 1-year storm constant value rather than the previous actual rainfall totals (P value) from Hurricane Matthew. After repeating all the steps in the second procedures, the flow accumulation from the 1-year storm constant with Q layer as weight was obtained.

Fourth, in order to limit both 1 year and the actual flow accumulations, flow accumulation below 1000 was reclassified as 0. Then, we calculated the percentage of the 1-year flow accumulation at all locations over the watershed. Finally, we reclassified the percentages into five different intervals with different labels, such as “No Probability” for the lowest percentage and “Very High Probability” for the highest percentage.

RESULTS

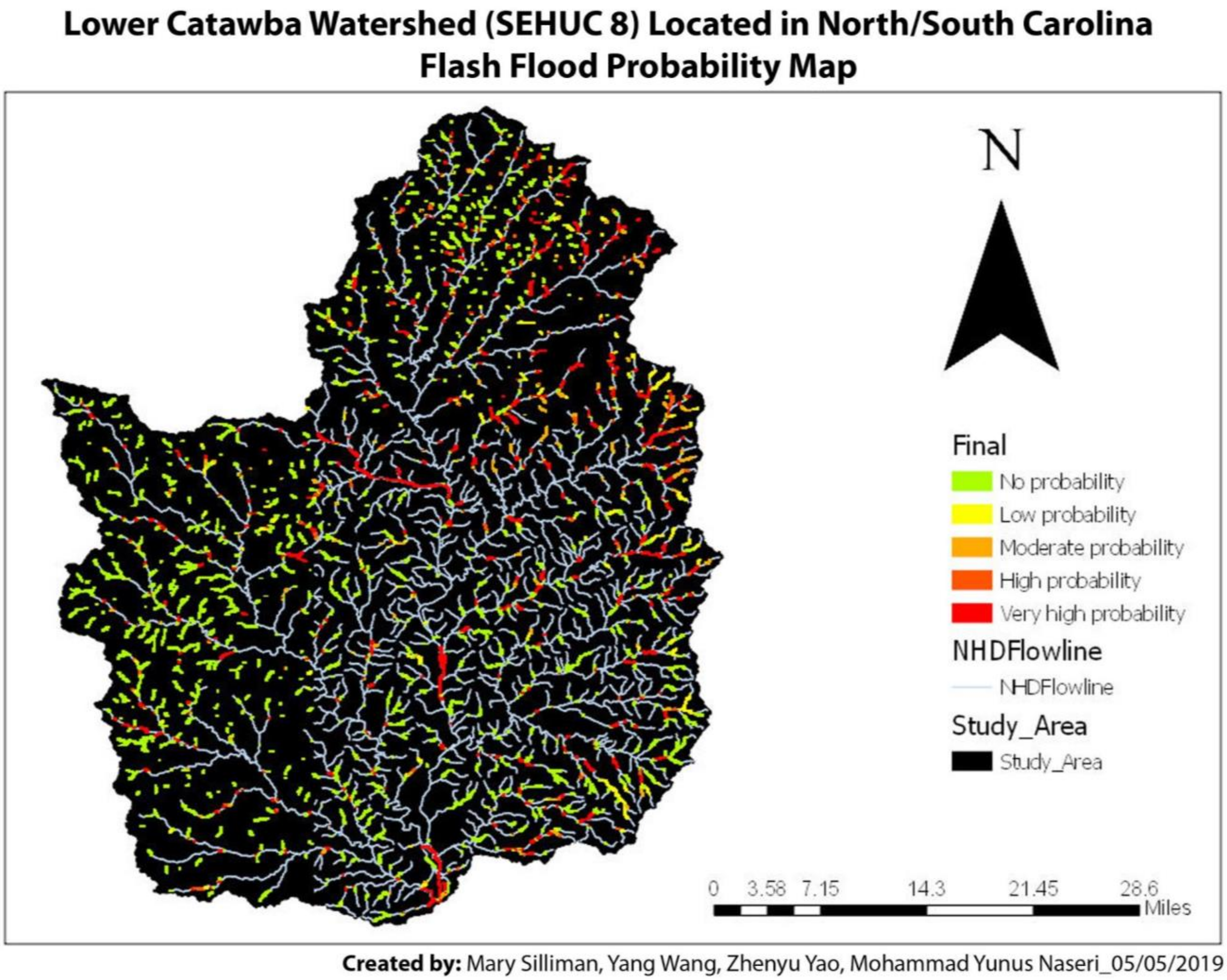

Fig. 1. A Map of the Flash Flooding Probability in Lower Catawba Watershed, North/South Carolina.

CONCLUSIONS AND DISCUSSION

As hydrologic modeling is a challenging task, this study has taken a simplified approach. This research has confirmed that Geographic Information Systems (GIS) can be used to simulate the risk of flooding. The study has compared the hurricane rainfall over the watersheds using NEXRAD rainfall totals data with the normal rainfall in a 1-year storm and we computed and rated the areas of likely flooding from the hurricane. **First,** the flood-prone areas of the catchment area are mainly located in the northeast due to this area is also a relatively high terrain region. **Second,** the outcome is very obvious which is that some areas will never flood, and some will flood commonly (Fig. **2**). For instance, a mountain ridge will never flood as there is no land above it to provide rain runoff to the location (i.e., the bright green area on the map is not flooding). **Third,** a narrow channel valley at a lower elevation, on the other hand, may flood often because so much rain falling on the land upslope that will be channeled through it. For example, the location of the dark red color in the middle of the catchment.

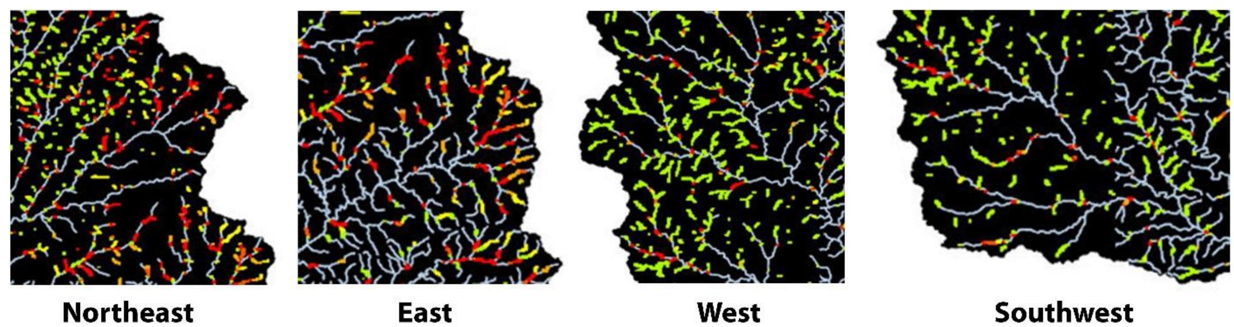

Fig. 2. Direction of northeast and east are very high probability the risk of flooding; direction of west and southwest are not probability the risk of flooding.

APPENDICES

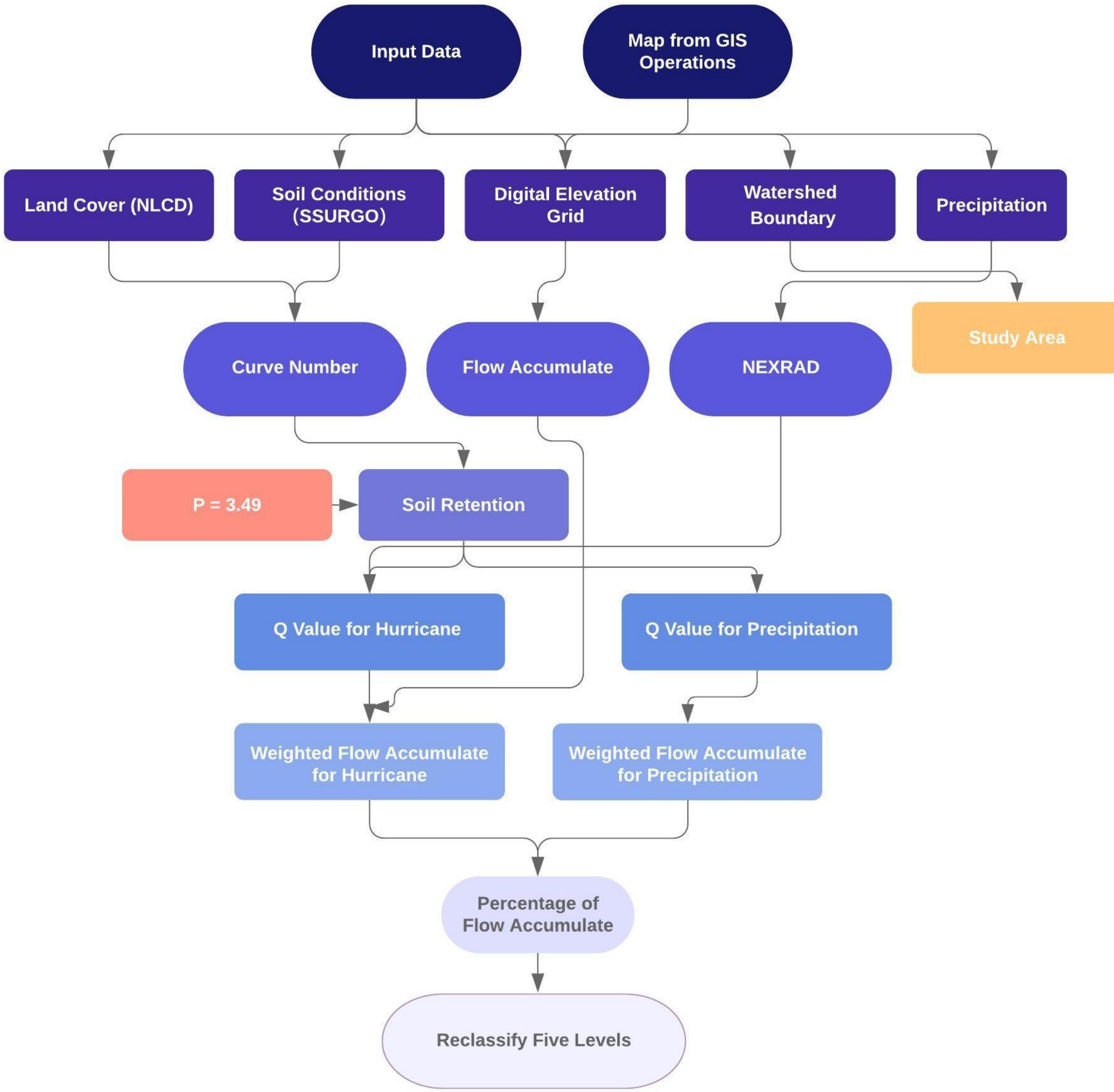

Fig. 3. Model Flowchart.

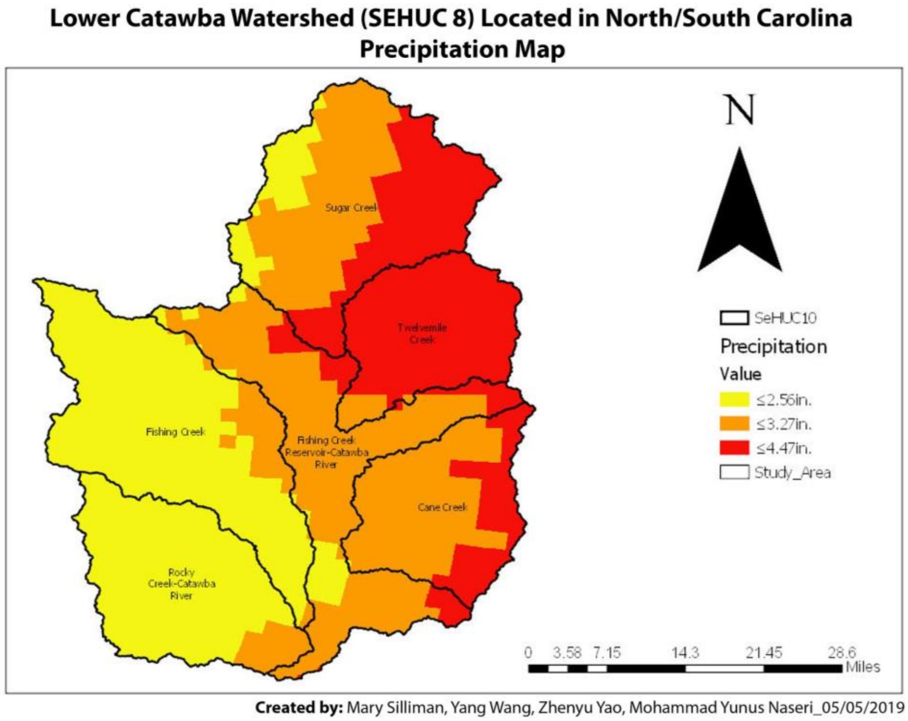

Fig. 4. A Map of the Precipitation in Lower Catawba Watershed, North/South Carolina.

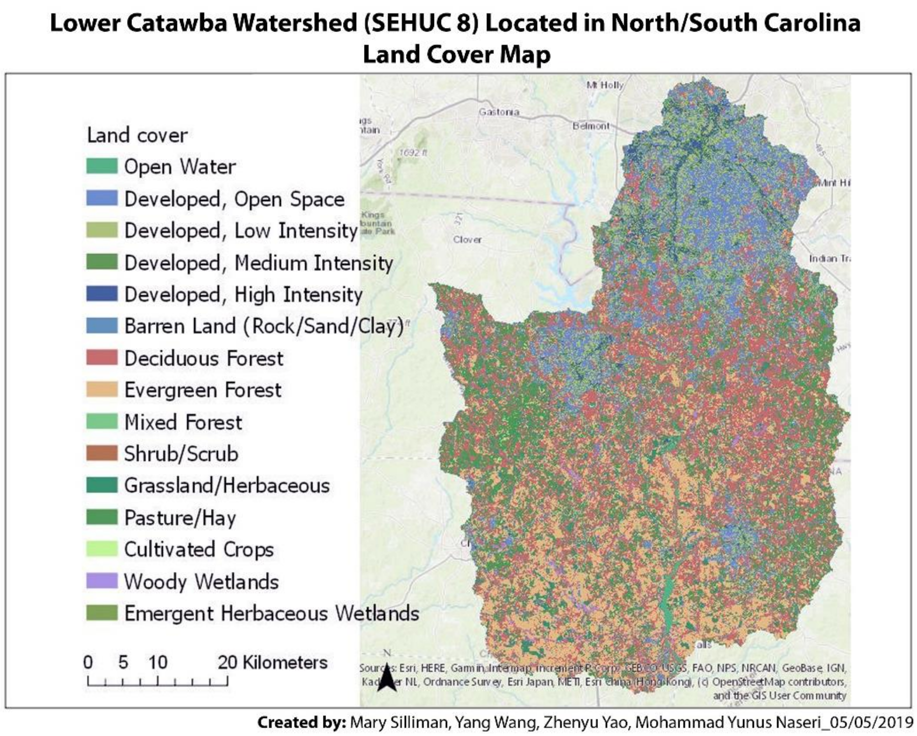

Fig. 5. A Map of Land Cover in Lower Catawba Watershed, North/South Carolina.

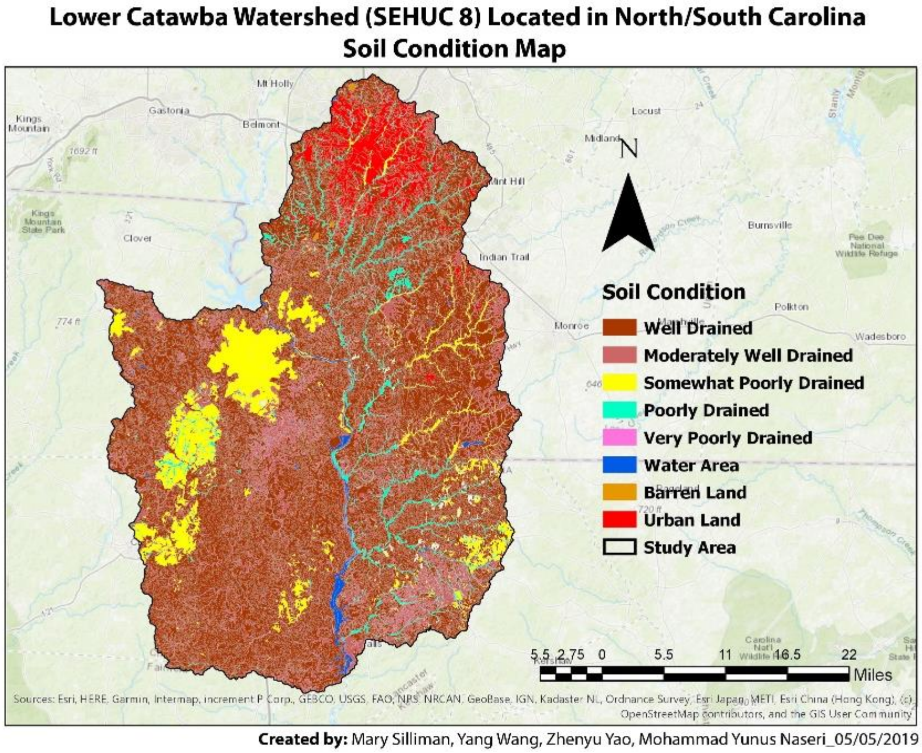

Fig. 6. A Map of Soil Condition in Lower Catawba Watershed, North/South Carolina.

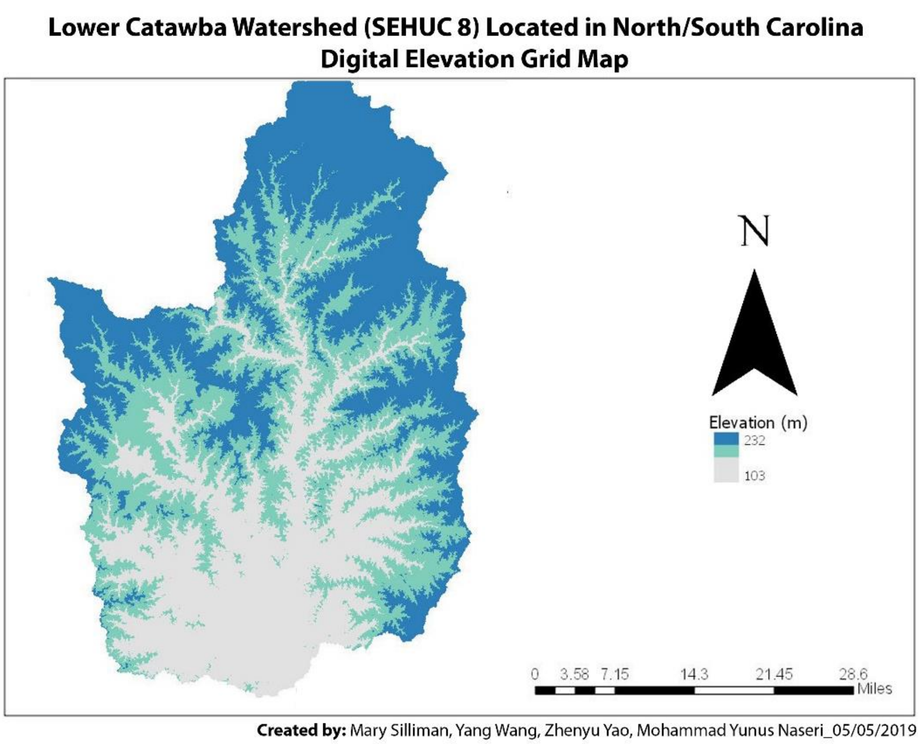

Fig. 7. A Map of the Digital Elevation Grid in Lower Catawba Watershed, North/South Carolina.

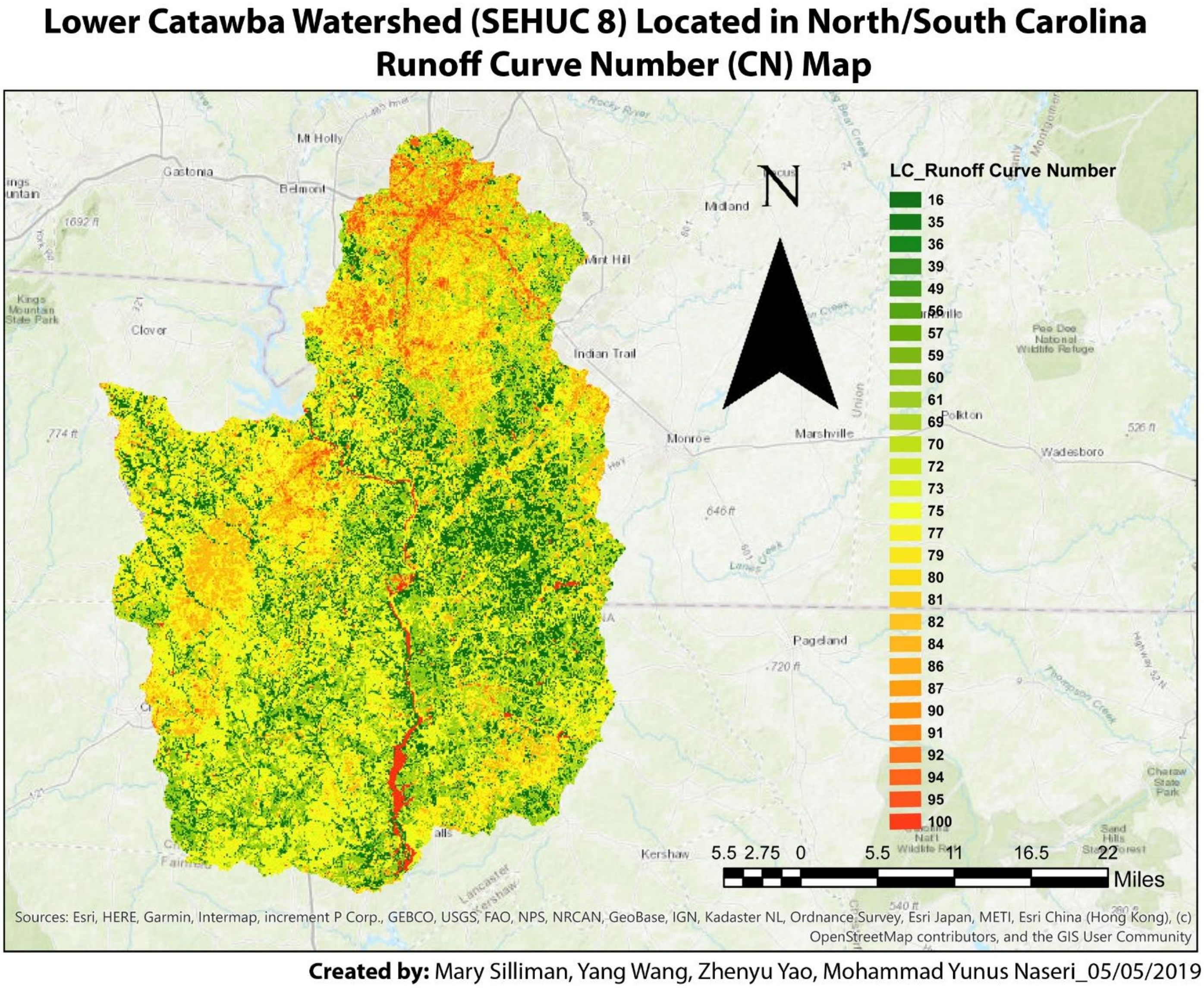

Fig. 8. A Map of Curve Number in Lower Catawba Watershed, North/South Carolina.

REFERENCES

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