

Research Article

Flood Modelling and Analyzing of Attanagalu Oya River Basin Using Geographic Information System

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Publication Date: 29 June 2018

DOI: <https://doi.org/10.23953/cloud.ijarsg.366>

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Abstract GIS (Geographic Information Systems) are used to store and process terrain data. Using GIS for could be very effective in flood modelling as it becomes very accurate with the use of the Digital Elevation Models. These DEMs could be analyzed with various tools in GIS software and by processing these terrain models, data necessary for the development of flow and flood models can be extracted with a minimum effort in the field. In this research Attanagalu Oya river basin was selected due to its constant exposure to floods and the model for Attanagalu Oya would be processed and the data extracted would be exported in to Hec-Hms and Hec-Ras software to model the flow and create a flood simulation to determine the extent of the flood. By using future rainfall forecasts in the flood simulation developed in this research future floods can be forecasted with great accuracy. As this model could be used to forecast the future floods and their extent it makes this model a warning system for future floods and could be used to mitigate the property loss and the damage incurred.

Keywords GIS; Geographic Information Systems; Arc map; Hec-Hms; Hec-Ras; DEM; Digital Elevation Model; Attangalu Oya basin; flood modelling

1. Introduction

Constant exposure to large scale floods has become a major problem in Gampaha district. Many lives households and cultivations and many other more aspects are affected by this problem. With the increase in population and the limited amount of resources, man has done a lot more damage to the nature in search of these resources. Weather man made or not many reasons have led to the increased the frequency of large scale floods in a Gampaha district. The Land Reclamation Commission of Sri Lanka is trying to solve the flood problem in Gampaha district and they have selected the Attanagalu oya basin to do a GIS modelling and analyze the data to find possible solutions for the problem

Total catchment area of the Attanagalu Oya basin is about 736km² and it extends till it reaches the sea at Negambo (Wijesekara, 2016). Attanagalu Oya basin was specially selected depending on the availability of data. A Digital Elevation Model (DEM) of the area was used for the studies of the research. This study focuses mainly on the ability use GIS to forecast the future flood events in the Attanagalu Oya basin. The forecast would further include the extent of the flood event corresponding

to a series of rainfall data. Furthermore, this kind of a model could be used as a pre-disaster warning system and in the hand of the relevant authorities it would be very useful in reducing the casualties.

Objectives

- Developing a model to check the past flood events and their extent.
- Forecasting the flood extent of the Attanagalu Oya river basin.

2. Methodology

Development of the model was carried out through a series of steps which included several software (Figure 1). Mainly the following were used:

- Arc map 10.3
- Hec-Hms 4.2.1
- Hec-Ras 5.0.3

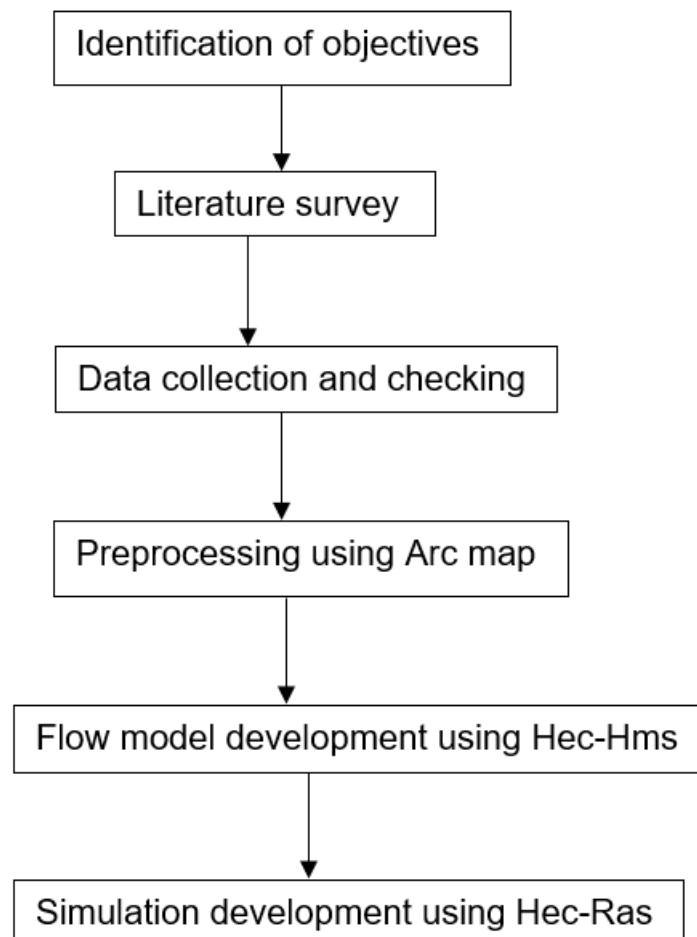


Figure 1: Methodology of flow chart

First Arc map was used to extract the necessary geometry data gathered from the survey department of Sri Lanka (Survey department of Sri Lanaka, n.d.) and then these data were exported to Hec-Hms software to create a flow for the Attanagalu Oya. Then this data along with the geometry data from Arc map was imported to Hec-Ras to create the flood simulation for the area. The simulation has the ability to represent the flood depth along the river for any given date with in the simulation time. If correct future rainfall forecasts are available this model would be able to simulate the flood levels in the future.

Preparation of Data

Geometry data of Attanagalu Oya area was needed for the model development. For this aerial photograph of the basin were obtained from drones and these photographs were used to create a DEM (Digital Elevation Model) file of cell size 1mx1m (Figure 2) (Mitchell, 2012). The entire pre-processing part of the Arc map software was based on this model.

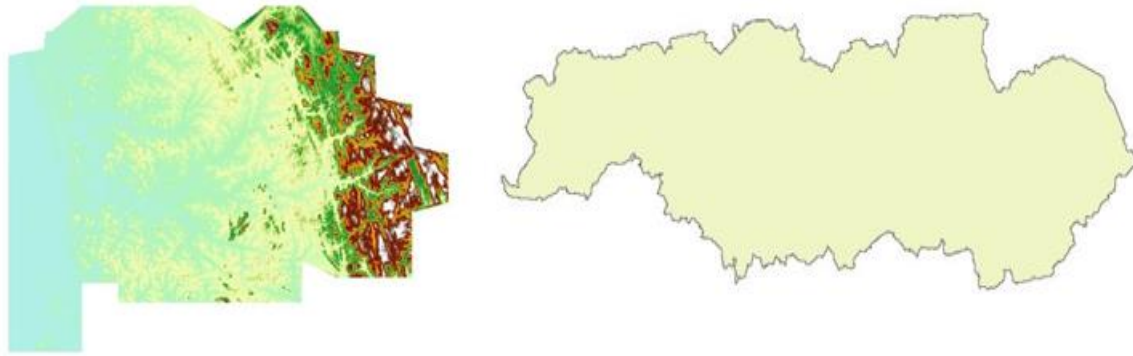


Figure 2: *DEM of the catchment*

Pre-processing using Arc Map

The DEM file of the area was processed in arc map to find the following parameters needed for the next steps of model development in Hec-Hms and Hec-Ras

1. Area of the Catchment (Figure 3).
2. Longest flow path (Figure 4)
3. Slope of the catchment
4. River cross section data (Figure 5)

Arc hydro and spatial reference tools were used to process the terrain data. Data obtained from terrain processing was used in creating the flow model in Hec-Hms.



Figure 3: *Processed catchment*

Table					
LongestFlowPathCat					
Shape *	OID *	Shape_Length	HydroID	DrainID	LengthDown
Polyline	1	41776.732081	<Null>	<Null>	<Null>
Polyline	2	17338.161892	<Null>	<Null>	<Null>
Polyline	3	26013.481728	<Null>	<Null>	<Null>
Polyline	4	53240.473632	<Null>	<Null>	<Null>

Figure 4: Attribute table of longest flow path raster

River cross section data were obtained using the HEC GEO RAS tools (Chndramali, 2012). XS cut lines were drawn on a base map and then the data along the lines were extracted from the DEM. Data along the cut lines were taken as the cross-section data. These cross-section data were used in Hec-Ras flood simulation to model the river.

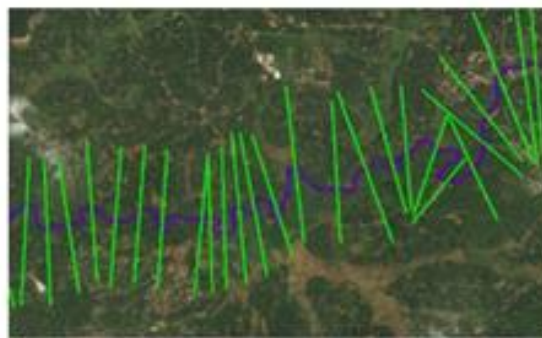


Figure 5: XS cut lines on a base map

Flow Model Development using Hec-Hms

SCS unit hydrograph method was recognized as the ideal transformation method of the Hec-Hms model (Halwathura, 2013).

Following data from Arc map pre-processing was imported to the Hec-Hms flow model.

1. Catchment size - 191.82 km²
2. Slope - 12%

Along with these data soil types of the Attangalu Oya basin were used to determine the SCS curve number of the basin. "Red Yellow" podzolic was determined as the major soil type appearing in the Attanagalu Oya basin (Wijesekara, 2016). Based on the characteristics of the basin and the soil type 45 was selected as the curve number for the Attanagalu Oya basin.

Rainfall data for the Attanagalu Oya basin was taken from the department of Irrigation, Sri Lanka (Department of Irrigation Sri Lanka, n.d.). For the model simulation rainfall data during a flood event May 2016 was used (Department of meteorology Sri Lanaka, n.d.).

Hec-Hms produced the outflow for the sub basin relevant to the precipitation data provided (Figure 6). Kirpich formula was used to calculate the time of concentration of the sub basin and from the result the lag time for the sub Basin was derived. Kirpich formula for the time of concentration can be mathematically expressed as:

$$t_c = 0.0078 \left[\frac{L^{0.77}}{S^{0.385}} \right] \quad (\text{Rajapakae, 2013})$$

Where t_c is the time of concentration, L is the travel length and S is the slope of the catchment.

Kirpich formula for lag time can be expressed mathematically as:

$$t_L = 0.6 t_c \quad (\text{Rajapakae, 2013})$$

Where t_L is the lag time and t_c is the time of concentration for the sub basin.

Results obtained from the Hec-Hms was used in the Hec-Ras flood simulation (Figure 7).

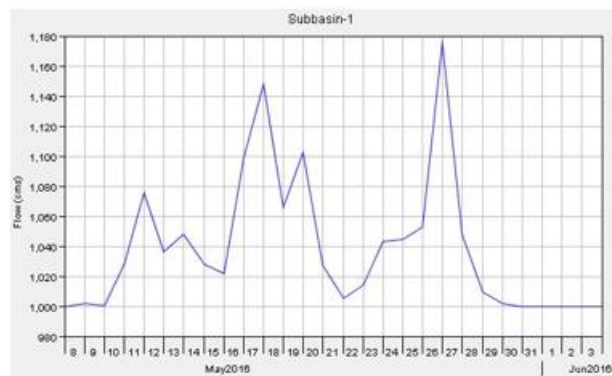


Figure 6: Out flow of the Hec-Hms model

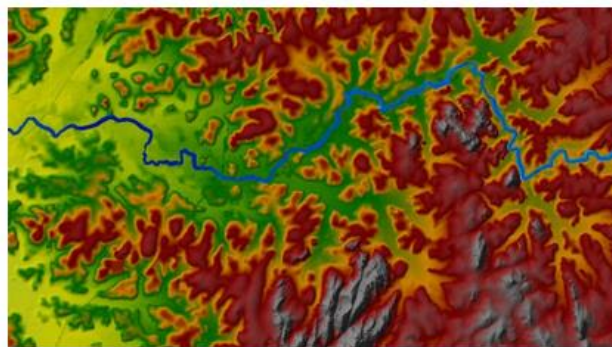


Figure 7: Hec-ras simulation

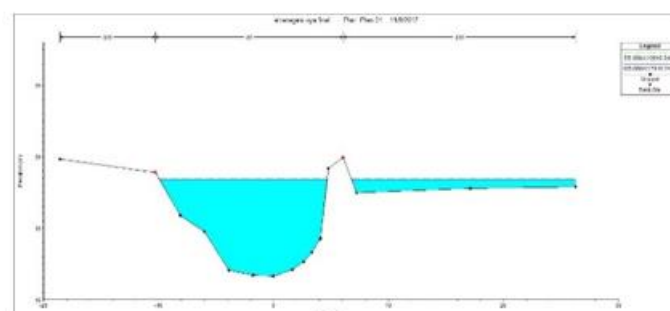


Figure 8: Cross section in Hec-Ras

Simulation Development using Hec-Ras

Cross section data from Arc map preprocessing and flow from Hec-Hms flow model was exported to the Hec-Ras model.

From Hec-Ras a simulation based on the rainfall data from May 2016 was created. From this simulation variation of the flood level at any given time could be visualized given that time fall in the range of the simulation run (Figure 8).

3. Results and Conclusion

Models developed in this research were able to simulate the May 2016 flood event accurately. The extent of the flood prone area could be calculated from the Arc GIS software.

A warning system could be modelled based on the results of these models. The model can be used to create a future flood event with a high accuracy and the people living in the area could be warned and evacuated beforehand the flood and the damage could be mitigated.

Accuracy of the model was the main concern of this research. Accuracy depends on mainly on two factors.

- Accuracy of the DEM
- Accuracy of the rainfall data

DEM has to be accurate, without any discrepancies of high level. They could occur due to the photographs used in to create the DEM capturing the tree tops not the land. If any high-level discrepancies were found a field survey has to be done to determine the validity of the relevant points. If the validity of the points is found to be compromised they should be removed manually and this would require field surveying.

With accurate rainfall data, the simulations could be more and more accurate. For the forecasting of future floods rainfall forecasts of high accuracy should be used as the output extent of the flood depends on it.

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