FLOOD MONITORING IN GREATER COLOMBO RIVER BASIN USING HEC-RAS FLOODPLAIN ANALYSIS

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ABSTRACT

Study aims to monitor flood by analyzing floodplains for flood discharge of different return periods, using one-dimensional hydraulic model. This will discuss the capability of GIS approach, incorporate with HEC-RAS for analyzing flood extents.
Extracting dynamic flooding information and mapping flooded area accurately, made the main objective of monitoring floods and assess the damages accomplished. Methodology is applied to the canal network in Greater Colombo river basin. A digital terrain model is synthesized from measured bathymetric and Photogrammetric data. Watersheds are delineated using hydrological function in ArcGIS & flood dischargers for different return periods are derived by the rational equation. Then water surface profiles are calculated for considered return periods (2, 5, 10, 25 & 50).
Finally, Results of the hydrological analysis are applied to monitor flood by developing raster and vector floodplains. Inundated areas are monitored using selected factors such as, Flood Depths, Affected Buildings, Inundated Roads, Crop Lands submerged and number of Schools affected. Flood depths of each floodplain are found by subtracting flood levels from area heights average. When consider the affected buildings, floodplain of Kotte Swamp is the most vulnerable. 497 buildings are affected in 2-year probable flood while 948 in 50-year probable flood. The highest Road inundation is in Parliament Lake area. Local roads, length in 2258.52m are flooded in 2-year probable flood while 9215.4m in 50-year flood. Meanwhile, the largest extent of Paddy lands drowned, also in Parliament Lake floodplain (6.59ha in 2-year flood while 34.42ha in 10 year flood) compare only to the Kolonnawa Canal (0.04ha in 2year flood while 0.09ha in 10 year flood) floodplain, as no other floodplains with flooded Paddy. Three affected schools identified only in St. Sebestian Canal, Kirillapone Canal and Mahawatta Canal floodplains, when water level rises in 25 and 50 year probable floods.

1. INTRODUCTION

1.1 Background of the Study

Flood is a very serious natural disaster. Floods are more of common occurrence in Sri Lanka than the other natural disasters, which are a function of the location, intensity, volume, and duration of precipitation (Photogrammetric Engineering and Remote Sensing Vol. 66, May 2000).

As the country governed by monsoon climate, Sri Lanka is subjected to repeated flood disaster. The history of flood control can trace back to about 3000 BC or early (Zhou 1993).

According to the statistics in global level, maximum troubles among natural events, that is related to flood events. Flood always makes very dangerous results, it could not prevent, but it can be controlled effectively. Monitoring flood is one of the important steps in flood management. To achieve that, hydraulic model analysis could be applied and it will be the best solution for monitoring flood.

The urban areas are located in the catchments, in the Greater Colombo River Basin including Colombo city, debris flow and flooding caused damages and losses to shops, commercial centers and house hold units etc. The city transportation system, water supply, sewerage and drainage systems were also subjected to severe destruction or failure in functioning. With less storage capacity for water in urban basins and more rapid runoff, urban streams rise more quickly during South West Monsoon and have higher peak discharge rates than do rural streams. In addition, the total volume of water discharged during a flood tends to be larger for urban canals than for rural streams.

1.2 Statement of the Problem

Flooding is arguably the most pervasive, diverse, and destructive natural hazard not only in Sri Lanka but also in the whole globe. Sri Lanka has experienced several disastrous floods during the past several decades.

Recent example includes **May in 2010** flooding in Colombo District, since Friday, 14th May 2010, heavy monsoon rains have created flash floods, high-winds, landslides, lightning and thunder storms in 13 districts in Sri Lanka including Colombo, Gampaha, Kalutara, Rathnapura, Kegalle, Matara, Galle, Nuwaraeliya, Trincomalee, Puttalam, Mannar, Anuradhapura and Polonnaruwa.

As on Wednesday, 19th May 2010, over **458,783** persons (104,213 families) have been affected by the heavy rains. This includes minor displacement of **9,579** people and **18** deaths. Reports indicate that 172 houses have been destroyed and another 915 damaged. The Government of Sri Lanka in response to the crisis deployed the Navy boat teams to assist in evacuations according to the Disaster Management Centre, Sri Lanka.

Flood in Greater Colombo River Basin in Colombo District on 19th May 2010, had reached the historical record since heavy rains battered Colombo district with the highest fall of **5.3** meters inundating some major streets and roads. Some areas in the sub-urban of Colombo district went under more than 5.5m of water according to the Department of Irrigation. From 1st May till 22nd May 2010, the heavy rain falls at Greater Colombo Basin for an unprecedented period of time enabled a larger area to go under water.

2010 floods are historical in term of magnitude and spread out. Colombo is exposed to floods almost every year but the recent floods breaks all records of the past, if we put bird eye view on an affected area, we see that amount of damage is maximum in term of property and livelihood. Therefore, needs of monitoring the inundated areas and the preparation of rapid statistical report of the damages had become a matter of prime concern to decision makers.

2. STUDY AREA

In view of drainage systems, the Greater Colombo area is composed of a major drainage basin and other small catchments. The major drainage basin covers an area of 85 km^2 bounded by Nugegoda - High Level Road to the south, Talangama -Hokandara watershed to the east, Kelani flood bunds to the north, and elevated urbanized areas of Colombo along the coast to the west as in the following map. The streams collect runoff in the upstream catchment and flow into Parliament Lake. After Parliament Lake, the urbanized areas are drained by the canals and runoff in the basin is discharged through the North Lock Gate to the Kelani Ganga and the Mutwal Tunnel to the sea in the north as well as the Wellawatta and Dehiwala sea outfalls in the south.

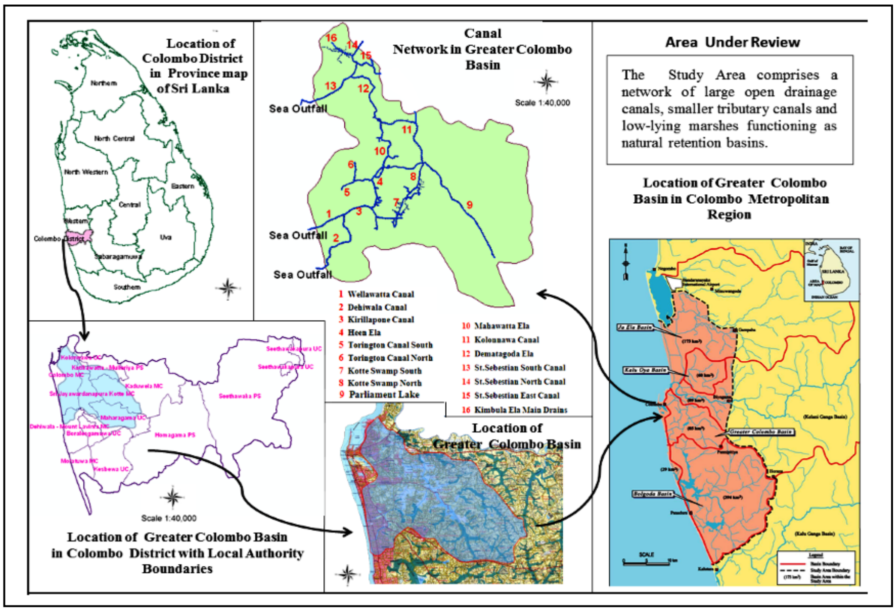


Figure 1: Location of Study Area

3. OBJECTIVES

The research study focused to achieve the following objectives.

Main Objective

- ❖ To monitor the floods and assess the damage

To make the main objective accomplish above, following sub objectives has to be fulfilled

Other Objectives

- ❖ To extract the dynamic flooding information
- ❖ To map the flooded area more accurately

4. METHODS OF DATA USED

The success of the study is purely depending on the entire process of data collection and analysis. A great care has to be emphasized prior selecting the type of data to be collected. Then the next most important thing is deciding the method of collecting the required data. After deciding the types of data required for the study and, then determine how best that the precise data and information is gather. Accordingly, the type of data required and the method of collection was planned in such a manner to achieve the objectives.

4.1 Data Used

The study depends on the primarily collected data and processed secondary data.

1. Primary Data
2. Secondary Data
3. Raster Images

Bathymetric data & vector layers are used as Primary Data while RAS Layers, Building Footprints, Road Layer of the Area & Land Cover Data are using as vector layers. Meanwhile, 2010 Google Satellite Images & Ikonos 2005 are used as necessary Raster data.

4.2 Methodology

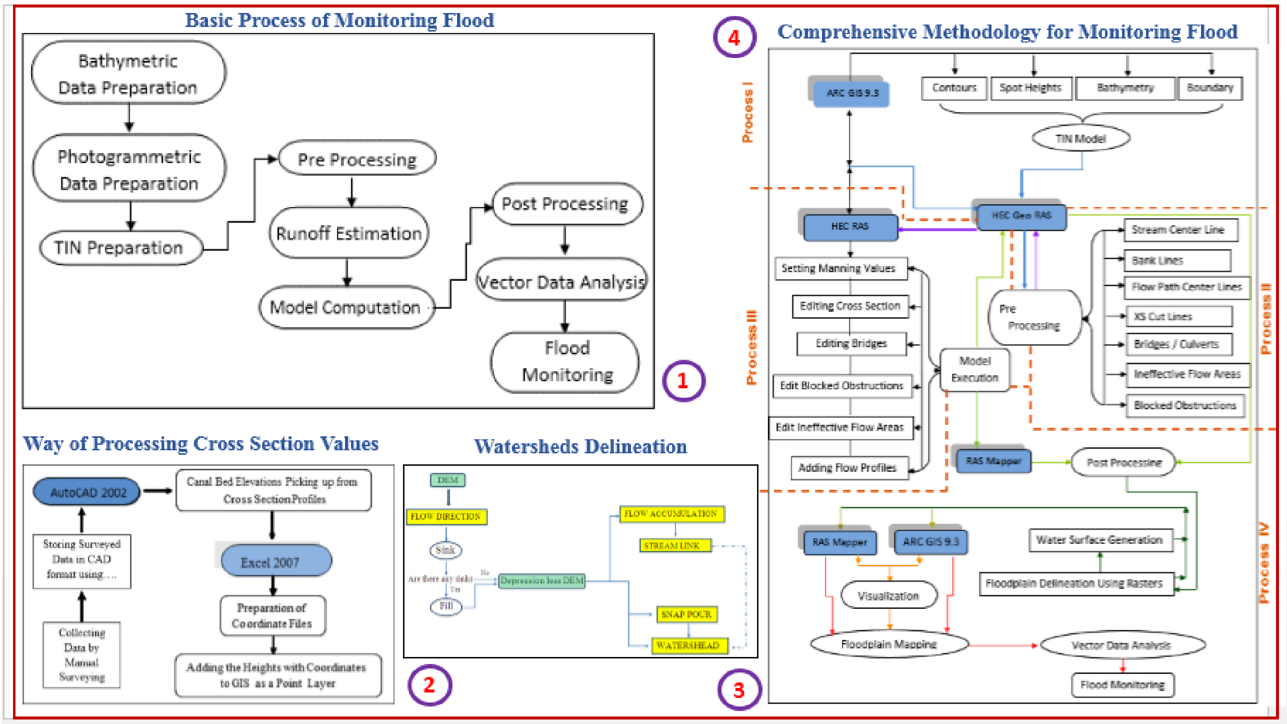


Figure 2: Process of Monitoring Flood

- ❖ Since bathymetric data were not in processed level as to be able to utilize in GIS, the values on depth measurement were picked from profiles which were stored in AutoCAD format and prepared the coordinate file on Excel. Then the output of that preparation used on ArcMap to prepare the TIN Model
- ❖ Discharge information is required in order to calculate the water surface profiles. For that, watersheds were delineated by using the hydrological function in ArcGIS.
- ❖ Using GIS for hydrologic/hydraulic modeling usually involves three steps: 1) pre-processing of data, 2) model execution, and 3) post-processing/visualization of results. It is common to use a single map document to handle a single project, but this ends up with too many feature classes/layers in a single map. It is then cumbersome to find out which feature classes were used during pre-processing, and which feature classes contain results for

visualization. To avoid this confusion, HEC-GeoRAS uses separate data frames to organize pre- and post-processing data.

- ❖ In pre-processing stage, HEC-GeoRAS involves creating the attributes in GIS, and then exporting them to the HEC-RAS geometry file. In HEC-GeoRAS, each attribute is stored in a separate feature class called RAS Layer. The geometry file for HEC-RAS contains information on cross-sections, hydraulic structures like bridges, river banks and other physical attributes of river channels.
- ❖ After creating RAS layers, those are added to the map document with a pre-assigned symbology. As these layers are empty, next task is to populate some or all of these layers
- ❖ Depending on the project needs, and then create a HEC-RAS geometry file.
- ❖ Then, according to the study needs, the capability is there to edit the imported geometry data in GIS format on HEC-RAS. Water surface profiles will be given by the successful simulation only after editing the data correctly and by being confident that there are no any erroneous facts.
- ❖ After that, the simulated water surface profiles were exported and floodplain delineation can be done on both ArcGIS and RAS Mapper to be surer of results. Finally, the visualization and monitoring can be done by preparing maps and creating relevant statistics.

4.3 Basic Process

1. Bathymetric Data Preparation
2. Photogrammetric Data Preparation
3. Formation of an Integrated Terrain Model
4. Pre Processing
5. Model Calibration
6. Peak Runoff Estimation
7. Model Computation
8 Exporting Model Output & Visualization (Results) 9. Damage Assessment 10. Findings

4.3.1 Bathymetric Data Preparation

Table 1: Way of Calculating Coordinates of Cross Sections

P1 Cs 0+000													
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭
		Distance		Bearing			Distance		Coordinates				
Distance	Elevation	from Center	Degree	Minutes	Seconds	Distance	from Center	Latitudes	Departurs	North	East	Elevation	Code
0.000	2.197	-19.070	351	18	3	351.3008333333	19.070	18.851	-2.884	493750.859	401064.996	2.20	cs0
9.950	2.2	-9.120	351	18	3	351.3008333333	9.120	9.015	-1.379	493741.023	401066.501	2.20	cs0
11.358	1.878	-7.712	351	18	3	351.3008333333	7.712	7.623	-1.166	493739.631	401066.714	1.88	cs0
11.876	1.878	-7.194	351	18	3	351.3008333333	7.194	7.111	-1.088	493739.119	401066.792	1.88	cs0
11.883	-0.504	-7.187	351	18	3	351.3008333333	7.187	7.104	-1.087	493739.112	401066.793	-0.50	cs0
15.206	-0.51	-3.864	351	18	3	351.3008333333	3.864	3.819	-0.584	493735.827	401067.296	-0.51	cs0
19.071	-0.62	0.001	171	18	3	171.3008333333	0.001	-0.001	0.000	493732.008	401067.883	-0.62	cs0
22.799	-0.6	3.729	171	18	3	171.3008333333	3.729	-3.686	0.564	493728.322	401068.444	-0.60	cs0
25.862	-0.5	6.792	171	18	3	171.3008333333	6.792	-6.713	1.027	493725.295	401068.907	-0.50	cs0
25.862	2.101	6.792	171	18	3	171.3008333333	6.792	-6.714	1.027	493725.294	401068.907	2.10	cs0
26.412	2.101	7.342	171	18	3	171.3008333333	7.342	-7.258	1.110	493724.750	401068.990	2.10	cs0
26.412	1.73	7.342	171	18	3	171.3008333333	7.342	-7.258	1.111	493724.750	401068.991	1.73	cs0
31.937	1.7	12.867	171	18	3	171.3008333333	12.867	-12.719	1.946	493719.289	401069.826	1.70	cs0
P2 Cs 0+049													
0.000	2.079	-20.951	12	45	20	12.75555556	20.951	20.434	4.626	493777.192	401109.722	2.08	cs1
11.778	2.079	-9.173	12	45	20	12.75555556	9.173	8.946	2.025	493765.704	401107.121	2.08	cs1
11.978	4.464	-8.973	12	45	20	12.75555556	8.973	8.751	1.981	493765.509	401107.077	4.46	cs1
11.985	4.464	-8.966	12	45	20	12.75555556	8.966	8.744	1.980	493765.502	401107.076	4.46	cs1
12.339	1.9	-8.612	12	45	20	12.75555556	8.612	8.399	1.901	493765.157	401106.997	1.90	cs1
12.807	1.9	-8.144	12	45	20	12.75555556	8.144	7.943	1.798	493764.701	401106.894	1.90	cs1

Calculation of Co-ordinates for Cross Sections (Manually Collected Bathymetric Data) in Dematagoda Canal

Identification of each column in the Table 1 is as follows,

1. **Distance** of Existing Drawing of Cross Section
2. **Elevation** (from Mean Sea Level)
3. **Distance from the Centre Point** of Cross Section
4.
5. } **Bearing** of Cross Section
6.
7. **Bearing in Radians** (for easy calculation)
8. **Cumulative Distance from Center** to each point along the Cross Section

9. **Latitude** = Distance in to Cosine Value of Bearing (Polar Coordinates to Cartesian X, Y) in here it gives us Y value (North)

10. **Departure**= Distance in to Sine Value of Bearing (Polar Coordinates to Cartesian X, Y) in here it gives us X value (EAST)

11. **North Value** of the Measured Point (Nothing)
12. **East Value** of the Measured Point (Easting)
13. **Elevation** of relevant point
14. **Code** to identify each Cross Section in TIN (identical code for each Cross Section)

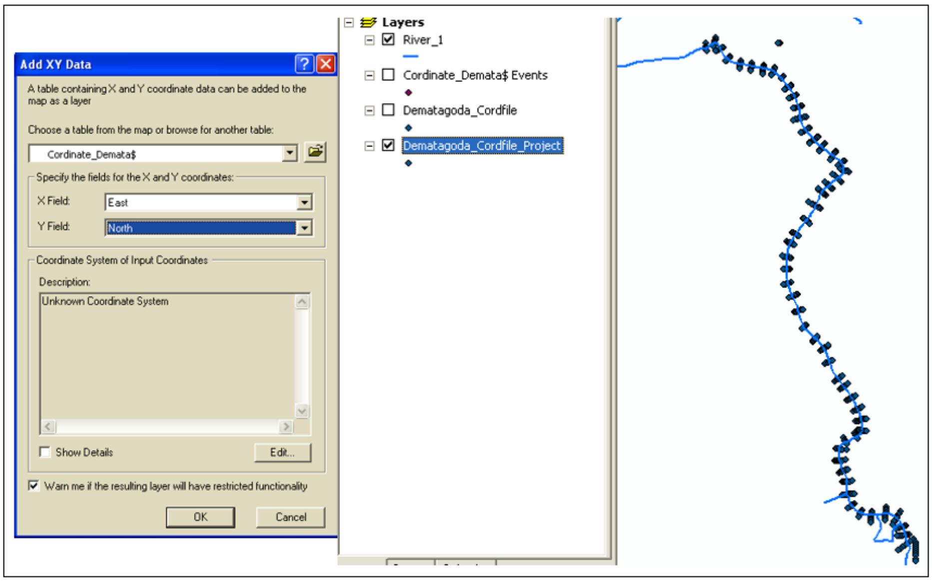


Figure 3: Overlaying of Canal Line of Dematagoda Ela over the Center Point Coordinates of Prepared Cross Sections

4. 3.2 Photogrammetric Data Preparation

Since Contours from the Department of Survey is not adequate to prepare an accurate TIN Model, illustrated as follows, tried to correct the dangle errors by applying the rule of "Must Not Have Dangles". The rule says "a line from one layer must touch lines from the same layer at both end points". But as the result expected couldn't reach and in order to be the result more accurate and reliable, spot heights of the area also used as follows.

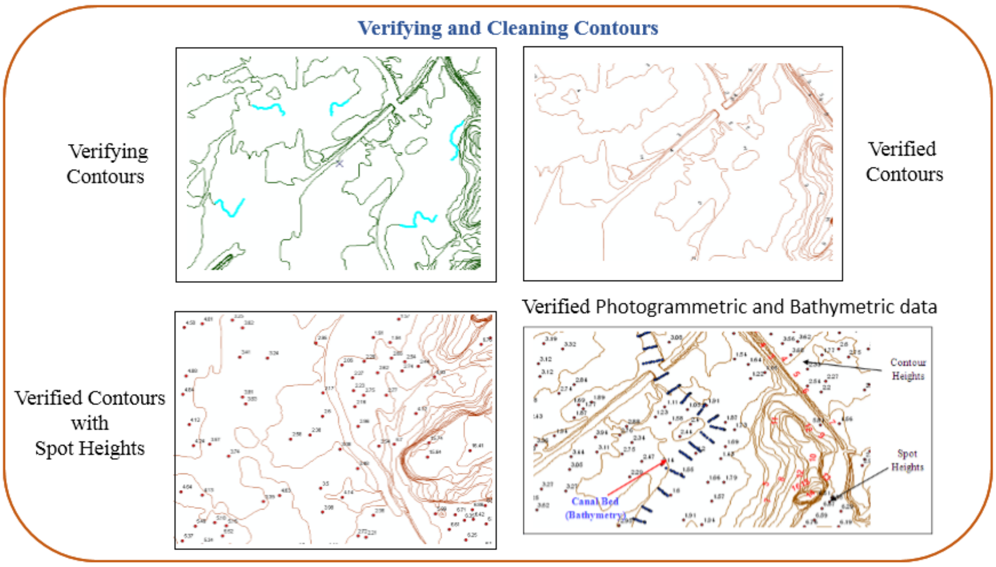
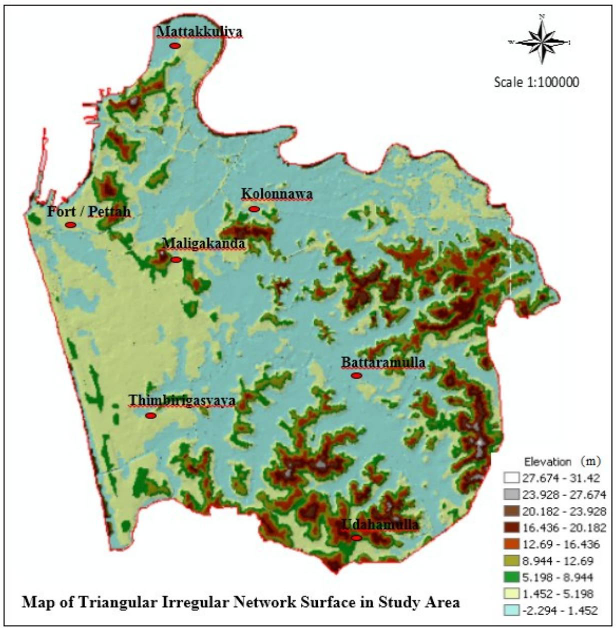


Figure 4: Verification & Combination of Bathymetric and Verified Photogrammetric data in Preparation of TIN

4.3.3 Formation of an Integrated Terrain Model

By following the way mentioned above, TIN surface for the entire study area was prepared and output will be shown by the Map1 below.



Map 1: Output TIN Model for Entire Study Area

4.3.4 Pre Processing

As the most essential requirement for the study is fulfilled and this section describes the basic data requirements for One-Dimensional Flow calculations. Since the outcome of pre-processing in HEC-GeoRAS is the creation of HEC-RAS geometry file, coordinate system must be same for all the data. That's the pre requirement for the model execution. In this study, the geometry file for HEC-RAS contains information on Stream Center Line, Cross-Sections, Canal Banks, Flow Paths, hydraulic structures like Bridges and Culverts, Blocked Obstructions and other physical attributes of canals like ineffective flow areas. But before creating river attributes in GIS, it creates empty GIS layers using the RAS Geometry menu on the HEC-GeoRAS toolbar. The pre-processing using HEC-GeoRAS involves creating the attributes too in GIS, and then exporting them to the HEC-RAS geometry file.

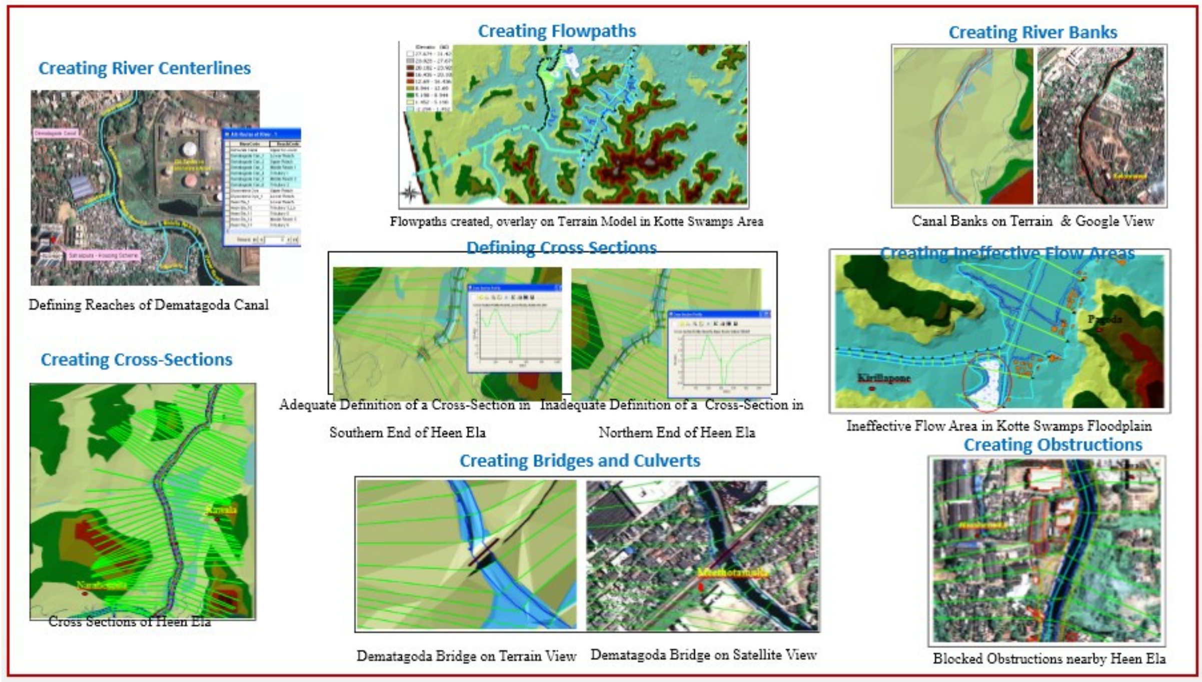


Figure 5: Pre Processed Layers in HEC-GEORAS

4.3.5 Model Calibration

The basic geometric data consist of establishing the connectivity of the canal system (Canal / River System Schematic) such as Cross Section data, Reach Lengths, Canal Junctions, Energy Loss Coefficients (Contraction & Expansion Losses) and Hydraulic Structure data (bridges / culverts, weirs, etc.) are also considered as geometric data. The canal system schematic is required for any geometric data set within the HEC-RAS system. The schematic defines how the various river reaches are connected, as well as establishing a naming convention for referencing all other data. The canal system schematic is developed by drawing and connecting the various reaches of the system within the geometric data editor. It's required to develop the canal system schematic before any other data can be entered. Accordingly, importing geometric data into HEC-RAS, assigning Manning's n Values to cross-sections, editing Cross sections editing Related Structures, editing Ineffective Flow Areas, Editing Blocked Obstructions will be satisfied in this section.

4.3.6 Peak Runoff Estimation

Discharge information is required in order to calculate the water surface profiles. The probable peak runoff discharge under existing conditions has been estimated at the most downstream base points of the respective basin using the Rational Equation as follows

$$Q = c.i.A/360$$

- Q (m3/s): peak discharge flow.
- c (a dimensional): runoff coefficient. It varies with the storm's return period, ground cover, and the uses of the land.
- i(mm/h): rainfall intensity.
- A (há.): drainage area.
- 360 is the coefficient that permits work with the different units in the SI System. To work in other unit system you have to do the conversions.

Figure 6: Applied Rational Equation for finding Probable Peak Runoff Discharge

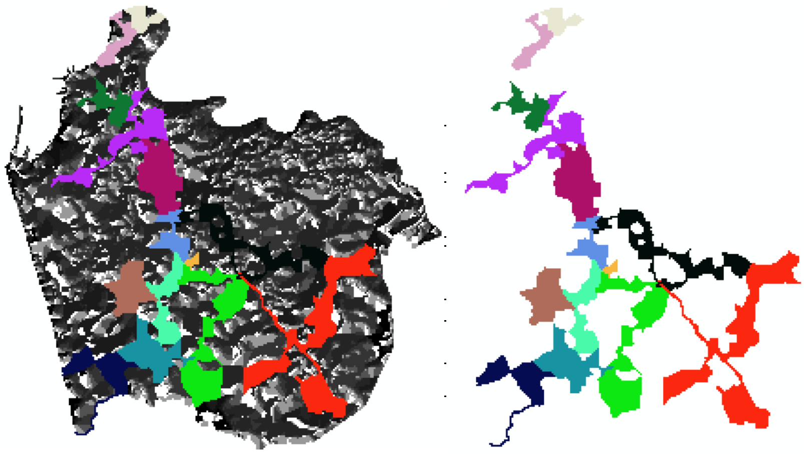
Based on the daily rainfall data of 6 rainfall gauging stations in and around the study area, which are operated by the Department of Meteorology, the probable annual maximum daily rainfalls (rainfall intensities) and return periods have been estimated and calculated as follows by the **Sri Lanka Land Reclamation & Development Corporation.** In that estimation, the rainfall records at Colombo indicate that the annual maximum daily rainfall as 130mm in a normal year. It is observed that events of daily rainfall exceeding 250mm occurred only thrice in the last 30 years with 493mm/day in July 1992, 284mm/day in April 1999 and 426.5mm/day in November 2010.

Table 2: Probable Daily Maximum Rainfall in Study Area

Daily Maximum Rainfall Suggested from Statistical Analysis		
T(YEARS)	P-DAILY (mm)	REMARKS
2	134.7	
5	195.0	
10	254.1	
25	360.9	
50	472.7	
100	621.6	
38	426.5	November 2010 Rainfall

Source: Hydrological Division of Sri Lanka Land Reclamation and Development Cooperation

Delineating of Sub watersheds & calculating extents of the area (each catchment) were done as follows by using the hydrological function in ArcGIS (as on diagram no. "3" in Figure 2) to find the "Drainage Area" to solve the equation above,



No	Descriptio	Area in Hectares
1	Wellawatta Canal	10.05
2	Torrington West	5.70
3	Torrington canal	19.81
4	Torrington BOI	1.46
5	St Sebestian East	22.27
6	St Sebestian Canal South / North	57.44
7	Parliament Lake	357.38
8	MahawattaEla	56.45
9	Kotte Swamp	112.32
10	Kolonnawa Canal	319.79
11	Kirillapone Canal	121.65
12	Kimbula Ela Maindrain	9.17
13	HeenEla	94.51
14	Dematagoda Canal	27.56
15	Dehiwala Canal	11.14

Source: Prepared by Author, 2011

Figure 7: Delineated Sub watersheds and the Extents of the Area

Based on Widely used Typical Runoff Coefficients in the Rational Method, calculated the "c" value of the equation as follows.

Table 3: The way of Estimating Runoff Coefficient

Heen Ela			
Calculating "c" for 2 Year Return Period		**Calculating "c" for 5 Year Return Period**	
0.0415	Urban Area	0.04424	Urban Area
0.0132	Semi-urbanized area	0.014008	Semi-urbanized area
0.1693	Marshy	0.185426	Marshy
0.22396	Total = c	**0.24367**	Total = c
Calculating "c" for 10 Year Return Period		**Calculating "c" for 25 Year Return Period**	
0.045899	Urban Area	0.048664	Urban Area
0.015244	Semi-urbanized area	0.01648	Semi-urbanized area
0.20155	Marshy	0.233798	Marshy
0.26269	Total = c	**0.29894**	Total = c
Calculating "c" for 50 Year Return Period			
0.050876	Urban Area		
0.018128	Semi-urbanized area		
0.257984	Marshy		
0.326988	Total = c		

Table 4: Probable Peak Runoff Estimation - Dematagoda Canal

Return Period	c	i	A(ha)	Constant	Q
2 Year	0.23	134.7	32.6	360	2.8055
5 Year	0.25	195	32.6	360	4.4146
10 Year	0.27	254.1	32.6	360	6.2127
25 Year	0.30	360.9	32.6	360	9.8045
50 Year	0.32	472.7	32.6	360	13.698

Table 5: Estimated Discharge Values for Dematagoda Canal, Heen Ela and Torrington Canal

Return Period (Years)	2 year	5 year	10 year	25 year	50 year	Canals
Peak Runoff (m^3/sec)	**2.81**	**4.41**	**6.21**	**9.80**	**13.70**	Dematagoda
Peak Runoff (m^3/sec)	**7.78**	**12.29**	**17.34**	**28.42**	**40.95**	HeenEla
Peak Runoff (m^3/sec)	**2.74**	**4.19**	**5.87**	**8.94**	**12.75**	Torrington

4.3.7 Model Computation

In this study, hydrological and hydraulic model for the canal system in Greater Colombo Basin will be run as a Subcritical Flow Regime. When run the model, if incomplete data are existed, various kinds of errors could be appeared. If such errors come across, geometry or flow data needs to be modified based on error message to run the simulation successfully as below.

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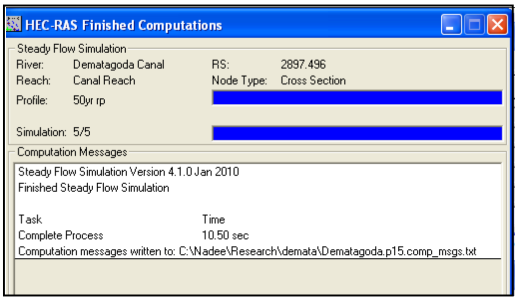
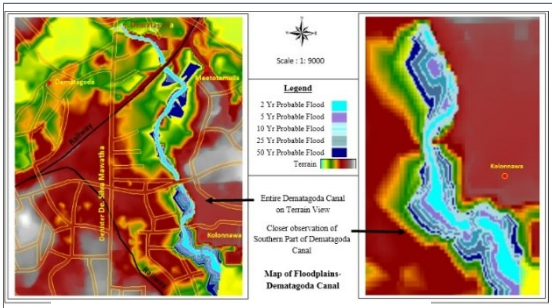


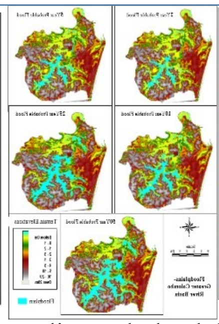
Figure 8: Model Computation

4.3.8 Exporting Model Output & Visualization (Results)

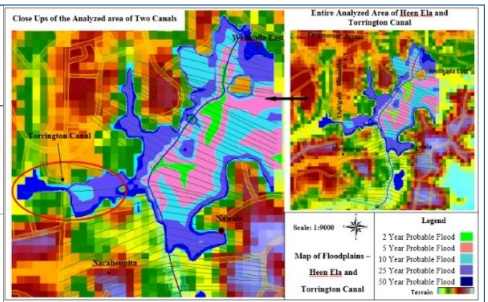
Outputs can be visualized on ArcMap as well as on RAS Mapper as mentioned in methodology. Though the facilities are there to extract floodplains on both, in this study, RAS Mapper will be utilized. The simulation of flood runoff and inundation under existing land use condition was carried out for five different probable storm rainfalls in the return periods of 2, 5, 10, 25 and 50 years for each objective drainage basin. Initially, for clear visualization, delineated floodplains of "Dematagoda Canal" will be demonstrated by the Map 2 & the flooding given by the model computation for "Heen Ela" and "Torrington Canal" are given in Map 4 below. Flood plains of Torrington Canal are enclosed by a red circle. Inundations can be viewed apparently for each return period on Map 4, since they extend far and wider than on Dematagoda Canal. Map 3 shows the entire floodplains in the study area.



Map 2: Delineated Floodplains - Dematagoda Canal



Map 3: Delineated Floodplains – Entire Study Area



Map 4: Delineated Floodplains Heen Ela and Torrington Canal

4.3.9 Damage Assessment

The research described in this report offers procedures for the automation of floodplain mapping based on hydraulic model output. Obtained results from the hydrological analysis were applied to monitor flood by assessing damage using few factors. Accordingly, the considered factors are, Flood Depths, Affected Buildings, Inundated Roads, Crop Lands submerged and number of Schools affected.

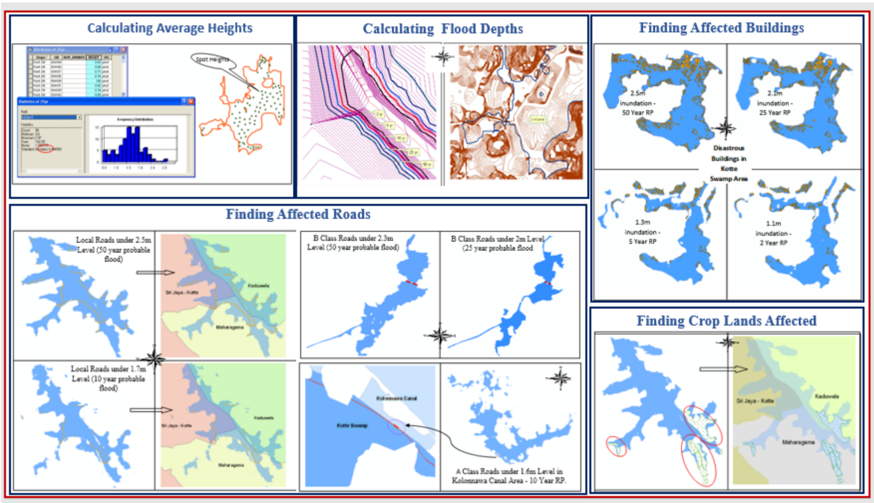


Figure 9: Damage Assessment

4.3.10 Findings

After assessing the damage using above mentioned factors, findings received as follows The reasons to inquire only the said factors are, the urban areas are located in the catchments, especially in Colombo city as well as in Greater Colombo region, debris flow and flooding caused damages and losses to shops, commercial centers and house hold items such as furniture, electronic items etc. The city transportation system, water supply, sewerage and drainage systems were also subjected to severe destruction or failure in functioning. However, water supply, sewerage and drainage system is an extensive topic and should be discussed deeply under separate study, that part won't be taken into account in this study

Table 6: Results Obtained from the Floodplain Analysis for 2 Year Probable Flood

DS Division	Inundated Area	Flood Depth		Buildings	Road Length in Meters			Crop in Hectare		
		Bello 0.5m	Above 0.5m	No of Buildings	A Class	B Class	Local	Paddy	Home Garden	No of Schools
Colombo	Kimbula Ela-Maindrain - 1m *			10			1.78			
	St.Sebestian Canal - 1.1m	0.07		7						
Kolonnawa	St. Sebestian Canal - 1.1m	0.07								
	St. Srbestian Canal East - 1.1m	0.37		119						
	Dematagoda Canal - 0.2m	0.05								
	Kolonnawa Canal - 1.1m	0.26		17			72.42			
Thimbirigasyaya	Dematagoda Canal - 0.2m	0.05		3						
	Heen Ela - 1m	0.21					56.16			
	Torrington West - 1.8m	0.08		6			42.93			
	Torrington canal - 1m *						14.91			
	Kirillapone Canal - 1m	0.23								
Sri J'pura Kotte	Mahawatta Ela - 1.1m *			11						
	Kolonnawa Canal - 1.1m	0.26		32	14.42		97.97			
	Heen Ela - 1m	0.21		3			29.79			
	Parliament Lake - 1.1m	0.33		37	387.18		802.62			
	Kotte Swamp - 1.1m	0.27		334	169.88		576.94			
	Kirillapone Canal - 1m	0.23		41						
Kaduwela	Parliament Lake - 1.1m	0.33		7	479.25		537.98	4.92		
	Kolonnawa Canal - 1.1m	0.26		12			237.11	0.04		
Maharagama	Parliament Lake - 1.1m	0.33		8			917.92	1.67		

* As no spot heights for this area, couldn't classify the depth.
- Flood Levels are given in meters , next to the name of the floodplain
- If the Inundation is below 0.5m, there will be only a Loss and if it is above 0.5m, a damage will be there.
- No Schools or no Home Gardens to affect there.

Table 7: Results obtained from the Floodplain Analysis for 50 Year Probable Flood

DS Division	Inundated Area	Flood Depth		Buildings	Road Length in Meters			Crop in Hectare		No of Schools
		Bello 0.5m	Above 0.5m	No of Buildings	A Class	B Class	Local	Paddy	Home Garden	
Colombo	Kimbula Ela Maindrain - 2.4m		0.53	134			303.57			
	St.Srbestian Canal - 2.3m		0.58	856	72.14	156.48	2708.07		No Crops	1
	St. Srbestian Canal North - 2.1m *			10						
	Dematagoda Ela - 1.9m	0.48					12.72			
Kolonnawa	St. Srbestian Canal - 2.3m		0.58	47	105.65		15.25			
	St. Srbestian Canal East -2.3m		0.61	493						
	Dematagoda_Ela_1.9m		0.59	338			139.71		0.05	
	MahawattaEla_2.4m	0.49		13			38.28			
	Kolonnawa_Ela_2.6m		1.19	540			1357.88		0.46	
	StSrbestian_Canal_North_2.1m *			2						
Thimbirigasyaya	Dematagoda_Ela_1.9m		0.59	217			98.53			
	MahawattaEla_2.4m	0.49		297			637.64			
	HeenEla_2.2m		0.82	257			955.89			
	Sea Outfall - Dehiwala Canal - 2m	No Flood		42			51.63			
	Dehiwala Canal - 2m		0.7	273	30.44		549.62			
	Wellawatta Canal - 2m	0.5		0						
	Sea Outfall - Wellawatta Canal - 2m		No Flood	0	22.49		43.45			
	Kirillapone Canal - 2.2m		0.95	324			770.33			1
	Torrington BOI Canal - 2.4m	0.35		70			187.53			
	Torrington Canal - 2.3m		0.53	427			1767.09			
	Torrington West - 3m *			97			543.52			
Sri J'pura Kotte	Mahawatta Ela - 2.3m	0.49		844			954.91			1
	Kolonnawa Ela - 2.4m		1.19	278	23.97		639.49			
	Heen Ela - 2.2m		0.82	358	13.07		590.36			
	Parliament Lake - 2.5m		1.19	306	1345.28		2166.2			
	Kotte Swamp - 2.5m		1.16	948	528.97		1847.49			
	Kirillapone Canal - 2.2m		0.95	695			294.25			
Kaduwela	Parliament Lake - 2.5m		1.19	442	1848.27		3581.4	27.78		
	Kolonnawa Ela_2.4m		1.19	481			3036.914	10.18		
Maharagama	Parliament Lake - 2.5m		1.19	373			3467.8	30.28		

- Flood Levels are given in meters , next to the name of the floodplain * As no spot heights for this area, couldn't classify the depth.
- If the Inundation is below 0.5m, there will be only a Loss and if it is above 0.5m, a damage will be there.

5. CONCLUSION

- GIS relate technologies are very useful in flood monitoring and damage evaluation.
- In this study GIS and HEC-RAS combination provided a better evaluation that useful for understanding overall situation.
- HEC-GeoRAS and HEC-RAS in emergency rapid response to global disasters like flood was firmly established and flood monitoring has become an easy task with the advent of the said technology.
- By using a comprehensive method, an effective flood map can be established very quickly.
- The result can also provide quick & useful information in order to prevent and reduce the effect of the flood damages, and for decision making.
- According to the model results, there is a considerable flooding in the area even at 2 year probable flood.

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