CATCHMENT EXTRACTION FOR IDENTIFICATION OF SUB CATCHMENTS IN DECISION MAKING; CASE STUDY BASED ON PATHAHEWAHETA DS DIVISION, SRI LANKA

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ABSTRACT

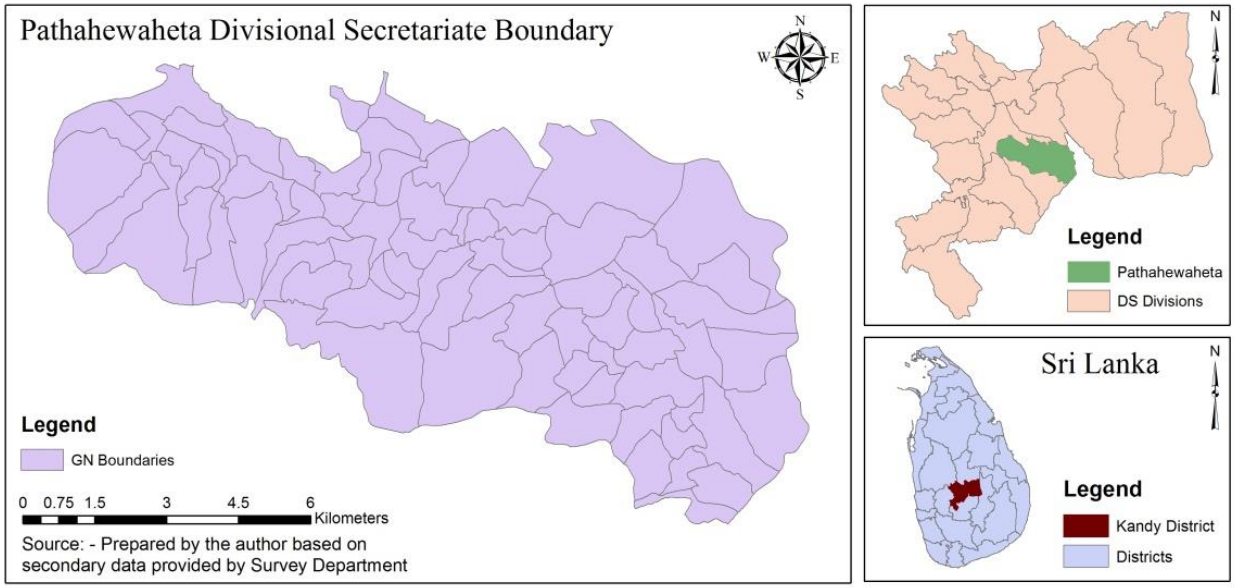
Water is one of the resources which have more scarcity in some regions as well as excess in some parts of the world due to over consumption. Therefore proper utilization of water resources and preservation is highly essential when it comes to water resource management. In water resource management identification and protection of river basins and catchment areas is one of the main focused fields. Normally the focus is given to river basins but this study is focused on identification of sub catchment areas within the main catchment. The impacts or any changes occur in sub catchments likely to affect the functionality and the wellbeing of the main catchment. Therefore it is essential to focus on protecting and preservation of sub catchments in water resource management. The study is focused on Pathahewaheta Divisional Secretariat Division; Sri Lanka belongs to the upper catchment of Mahaweli River. Methodology of the study is based on DEM hydro processing using ARC GIS. Both secondary and primary data and observation of elevation were used to create the Digital Elevation Model (DEM) and steps of the process can be state as sink and fill, calculating flow accumulation, calculating drainage network, ordering the drainage network and calculating the catchment areas. After extracting the catchments, it is used to calculate the overland flow length and flow length to outlet. The sub catchment areas were then overlay with land use and land cove of the study area to identify the concentrated areas of human activities. Changes of the land use will also indicate the changes which can be identified in sub catchment area. Increasing population has created many land use and land cover changes during past years. Agricultural activities are also contributing towards the natural overland flow of the catchment areas. Sometimes it contribute towards the increase of infiltration which some time leads to landslides as well. Secondary data as well as primary data on land use and land cover were used to identify the land use changes in the area. Mainly due to human activities this sub catchment properties are changing rapidly. Therefore in this study, a case study has also conducted based on Haragama Grama Niladhari Division (GND) which has severe issues regarding water scarcity. Results indicate that bed rock of Harahama area has some concentration of lime stones and due to the construction of new road the ground water levels has declined rapidly. Main reason is villages are pointing out is the construction of road. They believe that the blasting of bed rock may be the reason. Therefore it clearly indicates that the changes in sub catchments can have direct impact on natural flow of water and it is important to study them for local government planning schemes, regional plans and other authorities to making decisions.

INTRODUCTION

Throughout the evolution humans have changed the mother Earth in many ways where the adverse impacts are now immerging in many forms. They have changed the natural environment to fulfill their needs and natural resources are becoming more valuable today more than ever. Extracted fossil fuels have emitted so many carbon partials where the global warming has triggered resulting climate change. Extreme cases of climate events are one of the adverse impacts that humans are witnessing today. Proper decision making is one of the focused areas in every discipline in the world under the discussions on sustainable development and protecting future of the Earth. In order to make proper decisions interdisciplinary approaches, new concepts along with advance tools have been introduced. Geographical Information System (GIS) is one set of tools which is applicable in almost all the fields. Water resource management is one of the highly discussed topics in the current scenario where some parts of the world the scarcity of water is high. Even though more than 70% of the Earth surface is covered with water some parts of the world does not have enough water to fulfill their drinking needs. Some parts of the world suffer from excess water in the forms of floods. Therefore water resource management is given prominence in many development projects.

Surface water can be seen as in many forms like solid, liquid or even gas and they accumulate in many forms as rivers, lakes, ponds, oceans and many other forms. Mainly the rivers are more connected with human activities since even from the beginning the flood plains are used for agricultural activities. Based on the accumulation of water each river has its own catchment area demarcated by the water shed. Drainage basin, also called Catchment Area, means where which all precipitation flows to a single stream or set of streams. (https://global.britannica.com) Any river of the world has its own catchment area where the river tapped its water from. Some catchments have large extent and some are very small. Some catchments are perennial and some flows throughout the year. Most of the time the focus is given to the whole catchment as one and the development planes are based on the decisions made by that perspective. Catchments are determined by the terrain characteristics based on the elevation. Therefore depending on the terrain features each catchment can be segmented in to sub catchment areas where the precipitation accumulates to a single point.

Figure 01: - Pathahewaheta DS Division



Source: - Prepared by the author based on secondary data by Survey Department.

Main objective of the study is to identify the sub catchments in Pathahewaheta Divisional Secretariat Division in order for proper decision making under water resource management. Area of study is Pathahewaheta DS Division which belongs to Kandy district, Sri Lanka. Kandy is part of the hill side of the country with more access to water resources. Pathahewaheta DS Division is bounded by the Victoria reservoir under the Mahaweli development project. Figure 01 indicates a map of the study area and its hydrological features to be identified.

Pathahewaheta DS Division also belongs to the upper catchment of the Mahaweli River which is the longest river and the largest catchment of Sri Lanka. Its magnitude is 71.4 Sq. Km. Pathahewaheta divisional secretariat division which is situated in the middle part of the central province is surrounded by the Kundasale and Gangawatakorale Divisional secretariat divisions which are bounded by the Mahaweli River from the north and from the east Hanguranketha Divisional Secretariat Division which is situated in the Nuwaraeliya District and from the south Deltota Divisional Secretary Division and from the west Doluwa as well as Gangawata Divisional Secretary Divisions. (http://www.pahathahewaheta.ds.gov.lk) It also belongs to the wet zone of the country based on the three climatic zones of Sri Lanka as Wet, Dry and Intermediate. Even though it belongs to the wet zone some parts of the study area has more dry conditions and some parts indicate wet climatic conditions. Haragama Grama Niladhari Division is one of the devastated areas with high water scarcity.

METHODOLOGY

Methodology of this study can be segmented in to three as data collection, analysis and visualization based on both qualitative and quantitative approaches. Both primary and secondary data were used in the analysis to identify the sub catchments along with the related characteristics of socio economic origin. Catchment extraction was executed based on a Digital Elevation Model (DEM) created by both secondary and primary data. Secondary data were obtained from the

Survey Department of Sri Lanka, from metric maps of the 1:10,000 scale. Primary data were collected during the field survey conducted in the study area. The study is conducted as catchment extraction to identify the sub catchments of the area and also as a semi structured questionnaire regarding the issues on water.

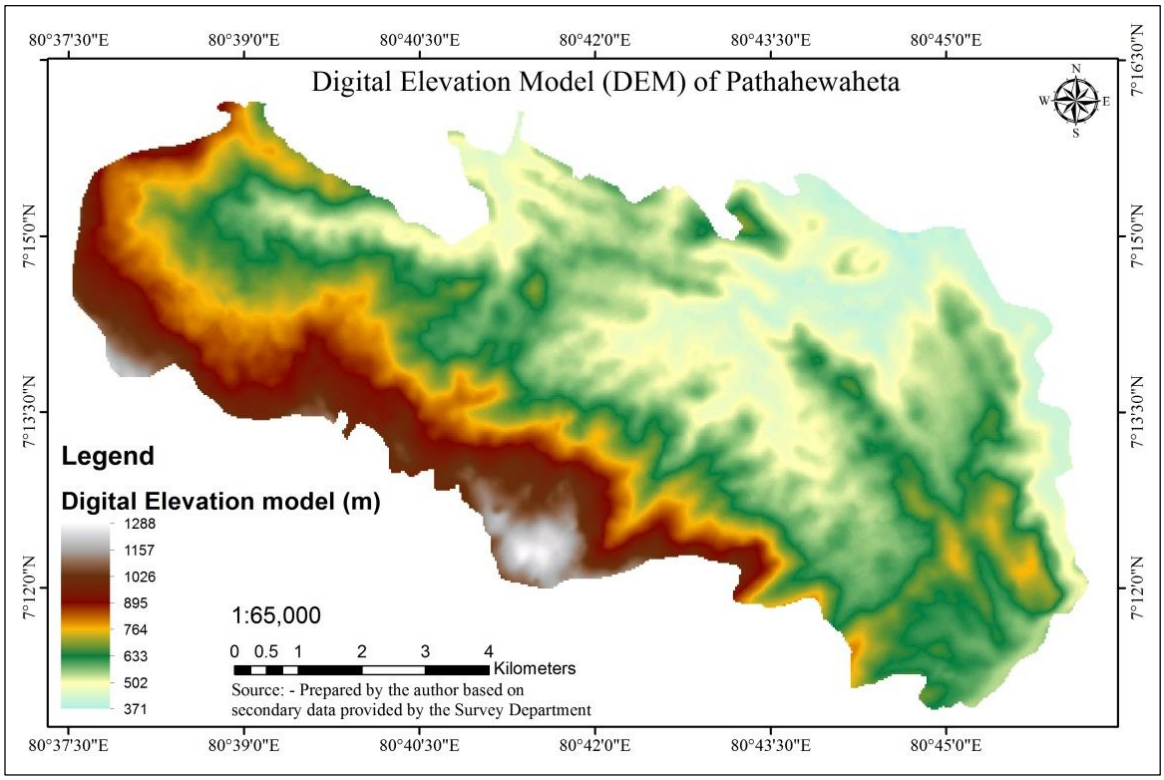
For catchment extraction Arc GIS 10.1 is used as the software component and hydrology tool was used for the process. GIS provides increased efficiency for typical hydrographical analysis was performed using traditional methods. In a hydrographical analysis, efficiency means primarily minimizing the expense in acquiring data and time required for completing the analysis. A complete analysis of efficiency should consider a task once, but also the likelihood that some or all tasks may need to be performed more than once. The steps in the catchment extraction can be illustrated as follow. First step is to create DEM using both secondary and primary data. Triangular Irregular Network (TIN) is used for creating the DEM in the first place. The DEM may have sink areas depending on the data available for the analysis. Therefore fill sink option is available in GIS to mitigate the problem. Fills sinks in a surface raster to remove small imperfections in the data. After that the flow accumulation tool is used to create a raster of accumulated flow into each cell. The accumulated flow is based on the number of cells flowing into each cell in the output raster. Flow direction is calculated thereafter which gives a clear picture of the natural drainage in the area. Calculating stream order will provide overall picture on river order. It is important to identify the river order to understand the potentials of the river when comes to water resource management. Finally the watershed tool is used for the classification of sub catchments of the area. The data obtained from the questionnaire was analyzed based on statistical methods, mostly by the descriptive statistical methods.

RESULTS

The Digital Elevation Model (DEM) which illustrated by the figure 02 indicates clearly about the elevation changes of the area. Eastern part has the Victoria Lake where the surface runoff of the DS division accumulated. And the elevation is high in the West side and decline towards the west. Figure 03 illustrates the flow accumulation of the Pathahewaheta Divisional Secretariat Division where the drainage floor. It also indicates the flow of water throughout the surface and the accumulation patterns. By looking at the floor accumulation pattern; it is visible that there are two main streams of surface flow and it could be segmented in to two basins. One is in North West side of the study area and the other one towards South Eastern. Figure 04 shows the segmented sub catchments belong to the Pathahewaheta Divisional Secretariat Division. Using hydrology tool in arc GIS the sub catchment extraction is executed and according to that there are six sub catchments which can be identified with in the Pathahewaheta DS Division. There are three big catchments and small sub catchments towards the south eastern side of the DS Division. These three small catchments can be considered as one as figure 03 even illustrates that it is the boundary of a main drainage flow. Therefore it can be merged as one catchment when finalizing the map. Then there will only be four sub catchments with in the Pathahewaheta DS boundary. Figure 05 is an illustration of land use along with the sub catchments of the Pathahewaheta DS Division. According to the map the upper part of the DS Division consists with tea cultivation. Large portion of the area consist with residential areas and the lower part of the DS is bound to Victoria Lake.

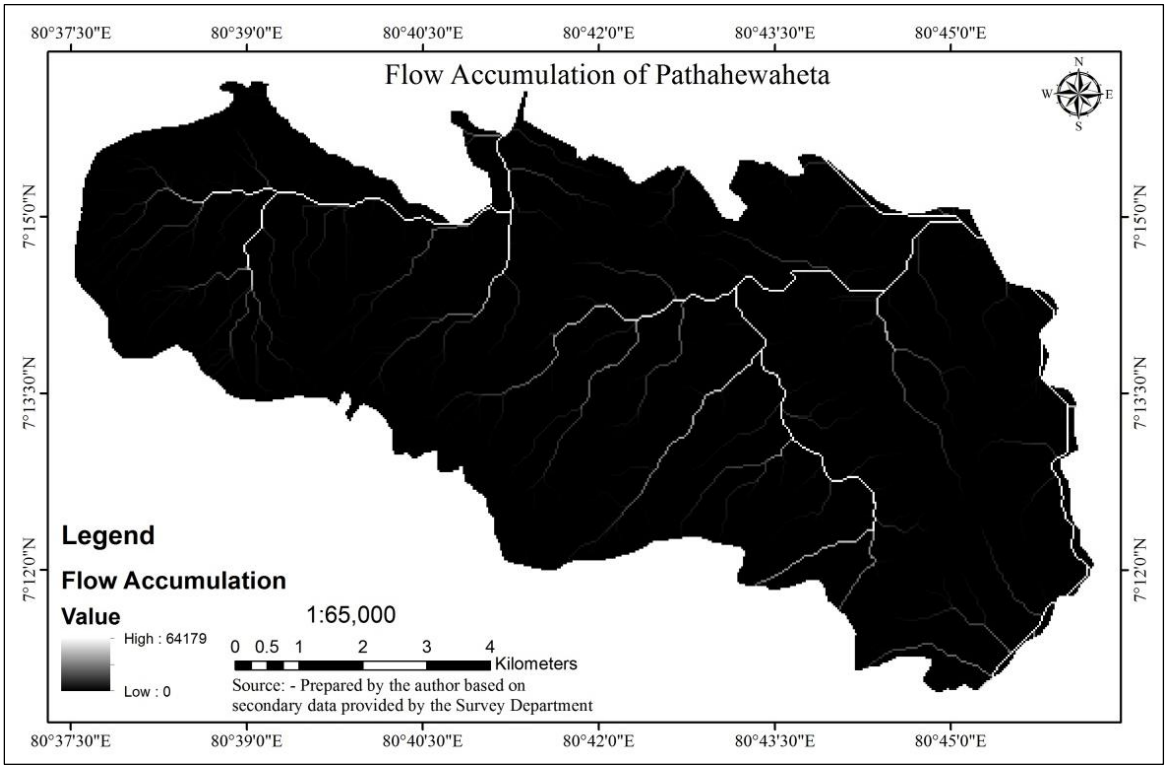
Identification of these sub catchments is highly important in different ways. Changes made by the humans to sub catchments will result in many adverse impacts. According to the figure 06 considerable areas can be recognized as homesteads. Upper part of the DS Division is used for tea cultivation. Tea cultivation can change the soil type of the upper area; sometimes increasing the infiltration of the upper relief of a given region which may impact as an adverse effect creating landslides. Most landslide risk areas can be identified early with proper monitoring and even casual observations. There are many types of landslides and in Sri Lanka but most frequent ones are associated with mudslide and sinks associated with water. That is the reason for most of the landslides occur in Sri Lanka can be seen during the rainy season. In such case the path of the landslides can be determine based on the sub catchments. Sometimes due to the cultivation the removal of top soil is also high. Therefore each sub catchment will help by calculating the exact values and the directions under the given parameters.

Figure 02: - Digital Elevation Model of Pathahewaheta



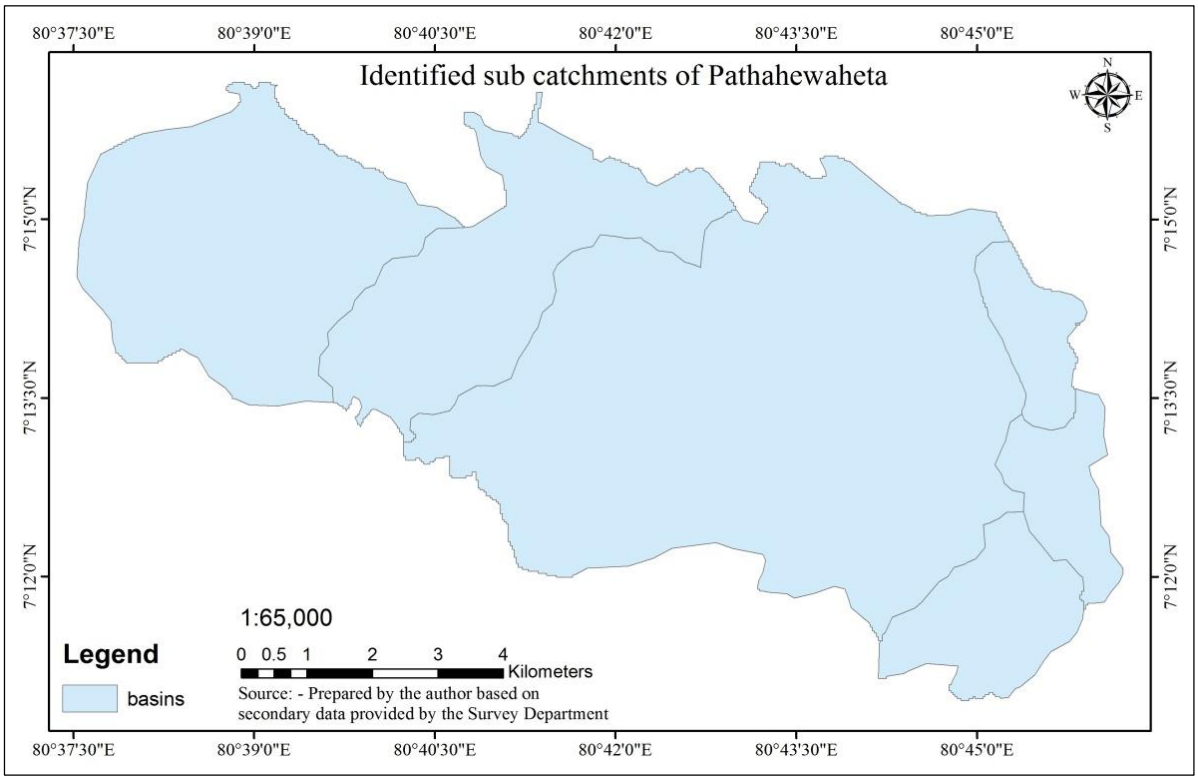
Source: - Prepared by the author based on secondary data by Survey Department.

Figure 03: - Flow Accumulation of Pathahewaheta



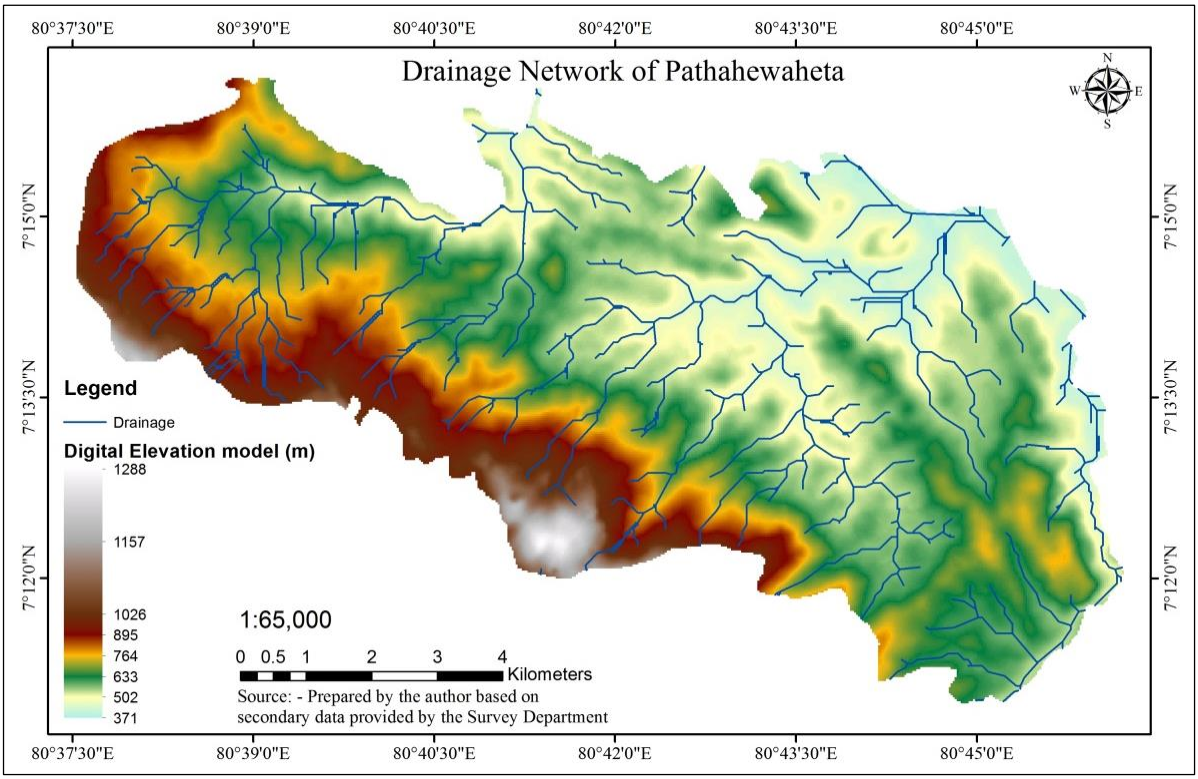
Source: - Prepared by the author based on secondary data by Survey Department.

Figure 04: - Sub Catchments of Pathahewaheta



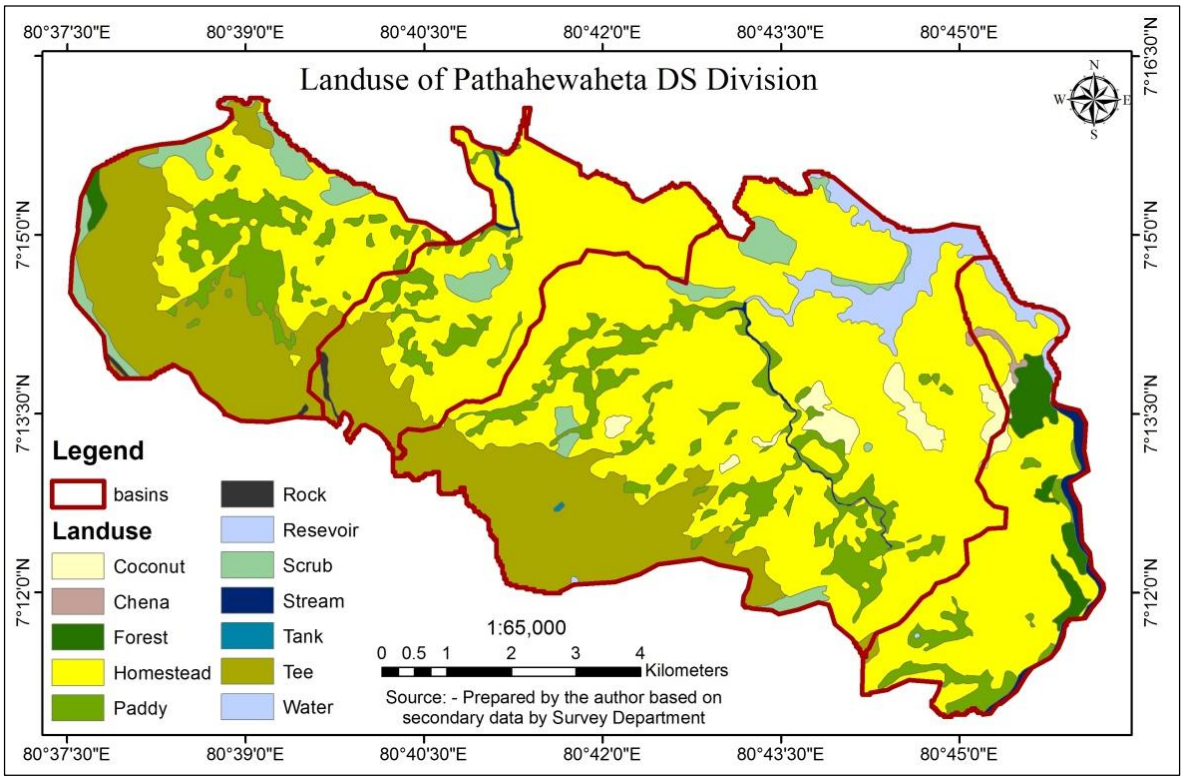
Source: - Prepared by the author based on secondary data by Survey Department.

Figure 05: - Drainage Network of Pathahewaheta



Source: - Prepared by the author based on secondary data by Survey Department.

Figure 06: - Land use of Pathahewaheta drainage basins



Source: - Prepared by the author based on secondary data by Survey Department.

CONCLUSION

These sub catchments are also integrated part of the main catchment. Main catchment is a system where all these sub catchments are interlinked with each other. Therefore changes caused in the sub catchments will have an impact of the main catchment directly. Due to anthropogenic causes like urbanization and agricultural activities tend to change the relief and the surface of the terrain in most of the parts which resulted in changing the natural flow of water. Blocking of drainage, increasing of infiltration or changing the natural parts of the drainage are some of the resulted impacts that can been seen in present scenario. Therefore preservation of sub catchments are highly important. For an example due to the construction of upper Kothmale dame, natural water flow has disturbed resulting the beautiful sent Claire's fall to be drained. The study conducted in the Haragama GN Division reveals that due to the construction of roads the groundwater levels of the area has decline creating no access to ground water in the area. Haragama GN Division consists with the underling limestone layer. Therefore villagers pointed out that due to explosion of the bed rock during the road construction the bed rock may have cracks which may be resulted in draining of the soil water and aquifers to be disappear. The smallest change in a catchment can create adverse impact on both physical and human environment. From the ancient times Sri Lanka is highly associated with water and it can also be seen in modern social context also. Therefore the regional development approach should consider the sub catchments in development projects. Especially when it comes to water resource management this approach should consider the most. Identifying sub catchments is not an impossible task since new technology and tools have given the platform to new approaches. Using Geographical Information System (GIS) along with Remote Sensing technology have enable the decision makers to analyze and come up with solutions in a productive and accurate manner.

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