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INVESTIGATE THE POST WAR IMPROVEMENTS OF HYDRAULIC INFRASTRUCTURE IN IRRIGATION SYSTEMS OF KANAGARAYAN ARU RIVER BASIN USING HYDROLOGICAL MODEL

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KeyWords: Kanagarayan Aru river basin, Iranamadu, Kanagarayan Kulam and Chemamadu Irrigation Scheme, HEC-HMS Hydrological Modeling

ABSTRACT

Jaffna, Kilinochchi, Mullaitivu, Vavuniya and Mannar districts are under the Northern Province. Most of the northern region got affected due to the civil war around 30 years. Due to this war water resources development were damaged severely. The major, medium and minor irrigation systems were dilapidated conditions. After the resettlement stack holders are engaged with agriculture activities and several investments were done for the irrigation infrastructure. However still stack holders suffering with cultivation issues. Most of the area of the Northern Province has been used for paddy cultivation. During the dry seasons most of the irrigation schemes in this area became dry. Hence the command area of those irrigation schemes cannot be irrigated successfully for two seasons. As a consequence cultivated crops fail and farmers are affected heavily. Hydrological Modeling is a commonly used tool by water resources planners to simulate the hydrological response in a basin due to the precipitation for the purpose of management of basin water. With the increasing demand for limited water resources in every basin, careful management of water resources becomes more important. The Kanagarayan Aru River Basin in Srilanka supplies water to number of new and ancient irrigation systems and the management of water resources in the Kanagarayan Aru River Basin. total catchment area of this River Basin is 906Sq.Km. Important for optimum utilization of water for these irrigation systems in the project continuous rainfall-runoff modeling in part of the Iranamadu Tank, Chemamadu Tank and Kanagarayan Kulam Tank. Storage Irrigation systems using the hydrological Engineering centre – Hydrologic Modeling System (HEC-HMS) VERSION 3.0.1 to estimate the runoff in the Kanagarayan Aru River

1.0 INTRODUCTION

The Northern Province comprises the whole of five districts namely Jaffna, Kilinochchi, Mullaitivu, Vavuniya and Mannar. Agriculture including fisheries has been the principal economic activity in the province. All most all the population of North part of Sri Lanka got affected due to the civil war in continued about 30 years. Most the irrigation schemes, roads and houses were damaged severe. Most of the population in this district was engaged in agriculture activities due to the displacement and after the resettlement people are back in their villages and started the cultivation activities. The major, medium and minor irrigation systems are in dilapidated conditions. The displaced farmers are fully depending on the farming activities of this area and they are facing severe problems for their irrigation issues to the cultivated crops. Since no water resources development were taken place for the past twenty years in this area. People are finding difficulties for consuming their water requirements for domestic and economic purposed.

1.1 Kanagarayan Aru River Basin

Kanagarayan Aru river Basin starts from Vavuniya district and ends with Kilinochchi Chundikulam Lagoon through Mullaitivu. Length of this River is 86Km. figure shown in Fig 1.1. The total catchment area of this river basin is 906 Sq.Kms. The major scheme in this river basin is Iranamadu tank. There are two medium schemes namely Kanagarayan Kulam, Chemamadu Kulam. The capacity of Iranamadu Scheme is 106,500 Ac.ft. The Capacity of Chemamadu is 2560.0Ac.ft and the capacity of Kanagarayan Kulam is 1100 Ac.ft. There are 64 Minor Tanks in this river basin. Alluvial soils are found in a strip along the Kanagarayan Aru spreading towards Paranthan area. Kanagarayan Aru River Basin was selected as the study area to investigate the performance of hydrological modifications.

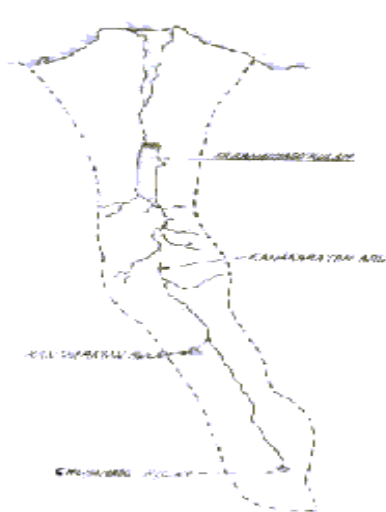


Fig 1.1 Kanagarayan Aru River Basin

1.2 Iranamadu Irrigation Scheme



Fig 1.2 Iranamadu Irrigation Scheme

The Iranamadu scheme was established in several stages since 1902 and presently it has the water holding capacity of 131 MCM to provide irrigation facilities to 9000 ha of paddy lands. Due to the conflict situation prevailed during the last 3 decades and inadequate funds made available for maintenance, satisfactory maintenance couldn't be carried out. In addition to this, severe damages caused by the heavy floods and conflict had worsened the situation. All the canals, control structures and agriculture roads were in a dilapidated condition. Due to such uncontrolled system, the water losses were very high, depriving cultivation to a significant extent during Yala session. Apart from this around 2500ha of paddy lands along the fringes are also cultivated using the drainage water from the Iranamadu filed. After resettlement in 2010, there was strong demand from main stakeholders including farmers to improve the system in order to utilize the scheme efficiency and effectively.

Restoration of the tank was commenced in 1902 and completed in 1920. The F.S.D was 22' at that time. Subsequently the tank was augmented to F.S.D 28' in 1952 and again in 1956 augmentation was done and F.S.D was brought up to 30'. Lastly the tank was augmented in 1977 to F.S.D 34'. There are 6nos of electrically operated pumps used to lift irrigate 1103 Acres. These have not functioned from 1990, due to stoppage of grid power supply.(Jaffna and Kilinochchi Water Supply and Sanitation Project (RRP SRI 37378))

1.3 Chemamadu Irrigation Scheme

Chemamadu Tank is situated in the Kanagarayan Aru River Basin. This tank impounds flow of the top most reaches of Kanagarayan Aru. The tank may have obtained its name from the "Shema" flowering plants often found in the jungle. Then present tank was restored in 1958. The left bank and

Right bank channel system conveys supply for the development of 600 Acres of paddy cultivation. 200 farm families benefited in this tank. The length of bund is 5000 ft long. People left the area in 1997 due to security operation and now after 5 years they were returned to their original places and started their cultivation activities. It was found that bund and irrigation systems were damaged. The tank bund has been rehabilitated in 2012 under ADB funded CARE project. RB Sluice also reconstructed under the same project. Part of the canal system also rehabilitated in 2012 under CARE project where canal lining turn out structures cause-way and FTO's have been constructed in LB & RB canal and a trough has been constructed in LB canal.

1.4 Kanagarayan Kulam Irrigation Scheme

Kanagarayan Kulam Tank is situated in the Kanagarayan Au River Basin. The present tank was in 1888-1896 original name said to be suggestive of one time colonist settles of the vanni. The "Rayans" located along with Pallavarayan and Akkarayan kulam. The left bank channel system conveys supply for the development of 314 acres of paddy cultivation. The present Kanagarayan Kulam was restored in 1896 and then breached in 1996 and again restored in 2000. It impounds flow of the top most reaches of a tributary of Kanagarayan Aru. The length of bund is 3500 long. 120 farm families were benefited in this tank. This tank bund and part of the canal system have been rehabilitated under ENREP project during 2012-2013. During 2018 the bund has been proposed to rehabilitate by GA's fund.

2.0 LITERATURE REVIEW

2.1 Recent developments in hydrological modeling

Commonly model is a good representation of a system of the natural or man-made world that allows for estimate the properties of the system and predicts the future outcomes. There are three areas of recent developments in hydrological modeling: prediction in ungauged basins (PUBs), predicting responses at interior catchment points using distributed models, and estimate the impact of climate and land use change on hydrological prediction (Pechlivanidis et al., 2011). Majority of practical applications are from ungauged or poorly gauged catchments which have been identified as a scientific task for the current decade (2003-2012) (Sivapalan, 2003).

2.2 Rainfall Runoff Models

Catchment is a single unit, averages over catchment area represent variable (Beven, 2001). Empirical algebraic equations account of spatial variability of processes, inputs, boundary conditions, catchment geometric characteristics

(Singh, 1995). Spatial variability boundary conditions, and catchment characteristics are used in distributed models however, often parameters are averaged mainly due to data availability (Beven, 2001). Distributed models make predictions that are distributed in space, with state variables that represent local averages, by discretizing the catchment into a number of elements and solving the equations (Singh and Frevert, 2006).

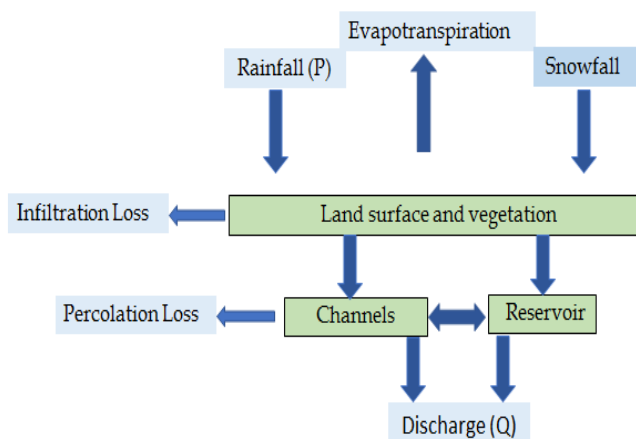


Fig2.1 Schematic representation of HEC-HMS model

2.3 Hydrological Models

Hydrological Modeling is a commonly used tool to estimate the basin's hydrological response due to precipitation. Various type of hydrological models from black box models which require less basin data to physically based models which require large amount of basin data have been developed (Chong, 2002).

The HEC-HMS, developed by Hydrologic Engineering center of U.S Army corps of Engineers (Najim,I, 2013) is a Hydrological model that supports both lumped parameter based modeling as well distributed parameter based modeling (Scharffenberg, and Fleming, 2006). HEC-HMS is a set of mathematical models to simulate the precipitation runoff-routing process of dendritic watershed system. HEC-HMS model can be applied to analyze the basin flow, urban flooding, flood frequency, flood warning system planning, reservoir spillway capacity, stream restoration, etc (U.S. Army Corps Engineers, 2008).

3.0 METHODOLOGY

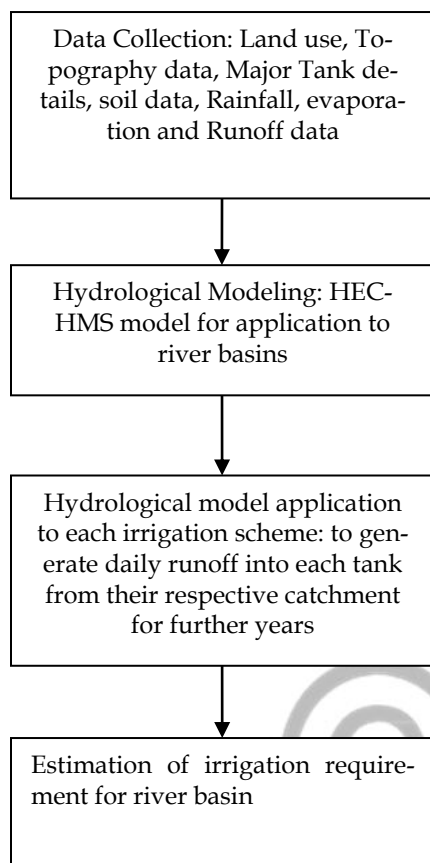


Fig 3.1 Flow chart of the Methodology

3.1 Flood Discharge

Flood Discharge was estimated for three river basins. Flood discharge capacity of the irrigation scheme network by the rational formula due to small nature of the catchment.

The Rational formula can be expressed as,

$$Q = C I A$$

Where

C = Runoff coefficient

I = Rainfall intensity for one hour expressed in inches per hour

A = Drainage area in Acs

The sizing of the canals can be done by the application of Manning equation assuming the steady flow conditions. However in this project the combined flow from the tributary canals eventually leads to the main canals and flow in the main canals become unsteady when the canals are entering the River. This is due to the tidal action of the river and the flow in the canal is influenced not only by the up-

stream flow conditions, but from the tidal action by the river. Therefore it is decided to design the main canals under gradually varying flow conditions assuming the unsteady flow conditions.

3.2 Manning Formula

The Manning formula can be expressed as,

$$V = \frac{1.49}{n} R^{2/3} S^{0.5}$$

R = Hydraulic Radius

S = Energy slope

V = Canal velocity

N = Drainage area in Acs

For designing the rivers under unsteady conditions, a hydraulic model based on the unsteady flow equations will be used during this study.

3.3 Observed Data

The daily rainfall data were collected for precipitation gauge stations of Iranamadu and near to Chemamadu and Kanagarayan kulam basin from meteorological department. The gauge stations are Iranamadu, vavunikulam and vavuniya. The Iranamadu basin 1: 50,000 sheets and digital data include land use patterns, area, location names, hydrological details and contour details. Basin terrain was determined according to contour details. Land use and ground cover, vegetation details were cross checked by field visit, digital data got from survey department and from the project report of Democratic Socialist Republic of Sri Lanka: Jaffna and Kilinochchi Water Supply and Sanitation Project and Sri Lanka: Water Resources Development Investment Program (Asian Development bank).

3.4 Data Collection

The study area sub basins are controlled by Kilinochchi Irrigation Department and Vavuniya Irrigation department. Hydro data and investments data could be collected from there. Following Table 4.1 shows the capacity of each sub basins.

Table 4.1 Capacity of Sub basins

N o	Name of the Tank	D.S Division	Capacity (Ac.Ft)	Irrigable Area (Ha)	Catchment Area(sq.k m)
1	Iranamadu Tank	Karachchi	106,500	8,897.21	587.93
2	Chemamadu Tank	Vavuniya	2560	242-82	37.56
3	Kanagarayan Kulam Tank	Vavuniya North	1100	127.07	9.07

(Source: Water Resources and Agriculture Development Strategy North East Province)

4.0 DATA ANALYSIS

4.1 HEC-HMS Model and Model Setup

The hydrological modeling system (HEC-HMS) is designed to simulate the precipitation-runoff process of dendritic drainage basins. The correct elements were applied to basin model. The basin model of the study area is shown in figure 4.1.

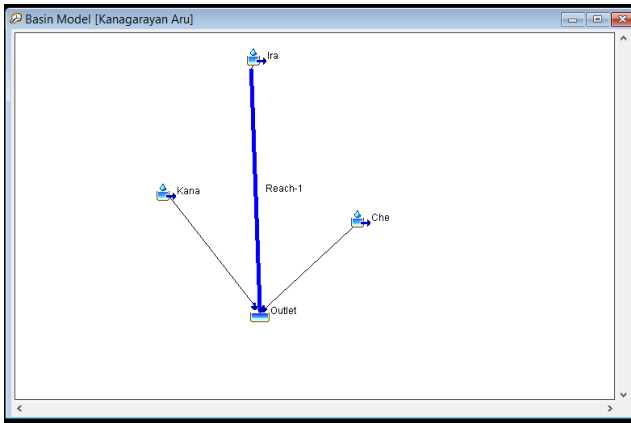


Figure 4.1 Basin Model of the Study Area

4.2 Basin and Sub Basin Areas

The catchment (basin) areas were collected from district irrigation departments. The sub basin areas are shown in figure 5.2

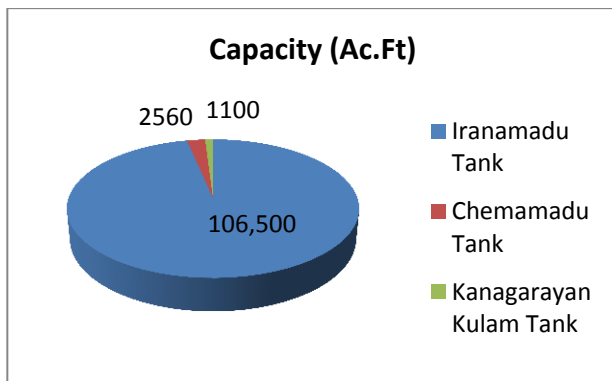


Figure 4.2 Area distribution of Kanagarayan aru river basin

4.3 SCS Curve Number

The SCS curve number was estimated according to land use, ground cover and hydrological soil group details. SCS curve numbers for each sub basin are given in the table 4.1.

Table 4.1- SCS Curve number for Sub basins

Sub basin name	SCS CN
Sub basin 1	82
Sub basin 2	86
Sub basin 3	86 ¹

4.4 HEC - HMS Outputs

HEC - HMS model outputs the runoff series for the sub basins of the Iranamadu basin for the simulation period 2016 June – 2018 June. Figure 4.3 shows basin model of Kanagarayan aru river basin.

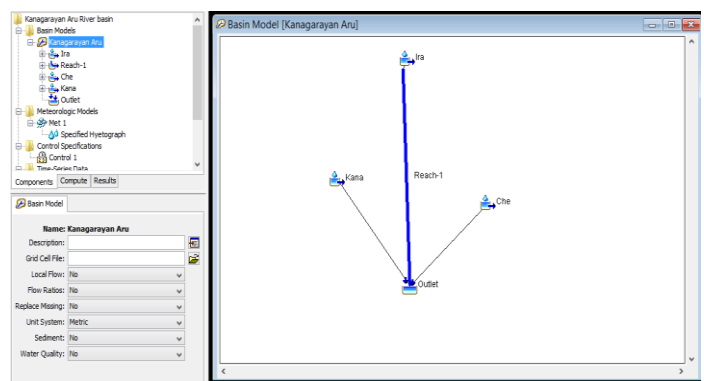


Figure 4.3 HEC-HMS basin model of Kanagarayan aru river basin.

4.4.1 Metrologic Models

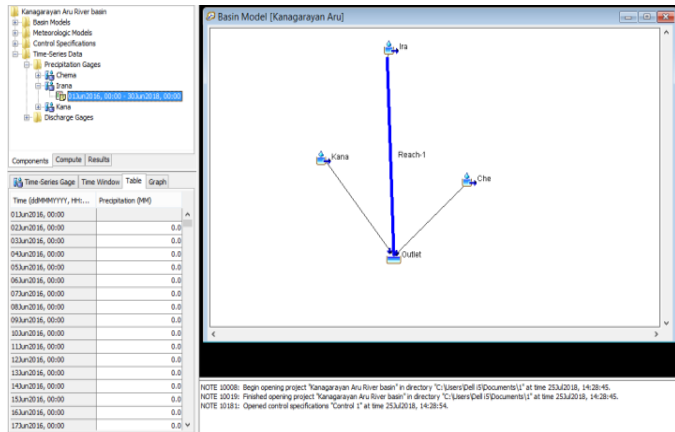


Figure 4.4 HEC-HMS Metrologic model

4.4.2 Precipitation Gauges

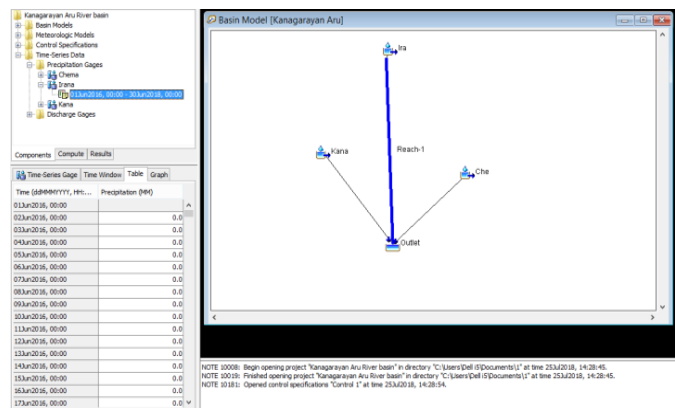


Figure 4.5 HEC-HMS Precipitation gauges

4.4.3 Global Summary

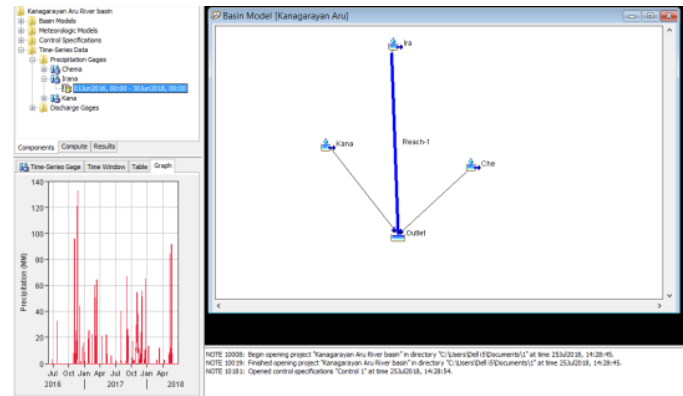


Figure 4.6 HEC-HMS Global Summary

4.4.4 Flow and Depth Graph for Iranamadu

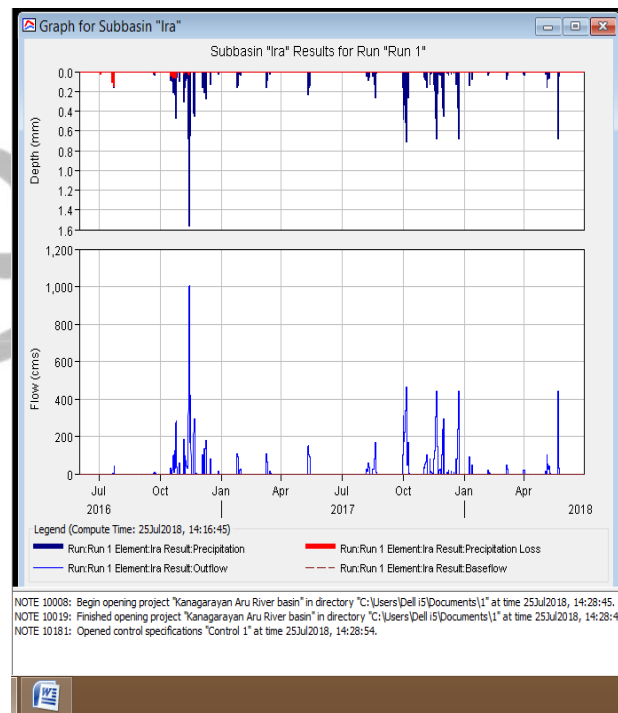


Figure 4.7 Flow and depth graph for Iranamadu

5. CONCLUSION

Model is useful to estimate the release from small tanks and required releases from canal into the tank. The study used the computed skill metrics of simulated stream flow against observation and found the consistency

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