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Optimization of Water Resources in the Northern Province River Basins for Irrigation Schemes Used for Food Production in Sri Lanka

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Abstract— Sri Lankan consumes rice as the main source of food. Hence most of the area of the country has been used for paddy cultivation. Therefore improving the paddy cultivation will lead to a positive impact on the society in every aspect. Northern Province of Sri Lanka is divided into two distinct geographic areas: Jaffna peninsula and the Vanni. Jaffna peninsula is irrigated by underground aquifers fed by wells whereas the Vanni has irrigation tanks fed by nonperennial rivers. Major rivers include: Akkarayan Aru, Aruvi Aru, Kanakarayan Aru, Kodalikkallu Aru, Mandekal Aru, Nay Aru, Netheli Aru, Pali Aru, Pallavarayankaddu Aru, Parangi Aru, Per Aru, Piramenthal Aru, Theravil Aru. During dry seasons most of the irrigation schemes in this area become 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. This study includes collection of field data, estimation of water availability in the river for diversion, inflow to tanks from catchments by hydrologic modelling, estimation of water demand for cultivation using crop water management model and estimation of the potential improvement of the cultivation areas and cropping intensity. Based on the preliminary study we suggest to improve the irrigation system in the study area, and proposes to construct diversion canal/feeder canals and anicuts across the rivers, by considering these river basins, the final aim can be achieved at investigating the improvement in irrigated areas and cropping intensity by the diversion canal proposed.

Index Terms— Croping intensity, Irrigation schemes, Paddy cultivation, Food production, River basins

1 Introduction

PADDY cultivation in Sri Lanka has a long history. Our ideal climatic conditions yielded a flourishing crop which encouraged many Sri Lankans to make paddy cultivation their way of life. Thus, the rice is the single most important crop occupying 34% of the total cultivated area in Sri Lanka. About 1.8 million farm families are engaged in paddy cultivation in Sri Lanka. (Department of Agriculture, 2006)

As we all aware water is the main resource for the paddy cultivation. People have established several organizations to protect the water resources. In Sri Lanka "Irrigation Department" is the sole authority for the water resources management and irrigation activities.

The Northern Province has a land area of 885000 hectares of which over 50% of the land area is occupied by perennial, annual and seasonal crops. The land of the region is relatively flat and of low elevation towards the coast and falls under low country dry – zone. The mean annual temperature is 28°c and Annual rainfall is 1200 mm to 1500 mm; 75% of the precipitation is received from North- east monsoon in the months of October- December.

There are 65 major and medium irrigation schemes and 698 functional minor irrigation schemes out of 2038 minor tanks. Iranamadu and Giant Tank are the largest and the oldest irrigation schemes in the region. The Irrigation schemes mainly depend on rainfall run off and river basins for capacity filling.

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2 Litrature Review

2.1 Introduction

Reputed journal papers and books reviewed are discussed in this chapter and the softwares which are used for the hydrological and water allocation modelling are considered.

2.2 Previous Studies

1. Some Detailed Water Balance Studies of Research Catchments (Clarke, et al, 1978)

The paper suggested that the comparison of water yields from the Wye and Severn catchments, which were under hill pasture and coniferous forest respectively, gave results which have considerable bearing on the future management of water resources from upland areas when the aim of management was to maintain supplies of water even during periods of drought as extreme as the years 1975-76. The effect on reservoir operation of neglecting to allow for change in land use was illustrated by a hypothetical example using an artificial 30-year stream flow sequence containing a drought year with very long return period.

In this paper, drought severity was assessed in a form intermediate between those described above. The effects of the 1975-76 drought are described in four areas of England and Wales, two upland and two lowland, these areas containing experimental catchments within which the Institute of Hydrology measures components of water balance. The maximum length of stream flow record is twelve years; the calculation of return periods would therefore be difficult to justify, while the limited geo-graphical distribution of the experimental sites precludes a full description of spatial variability of the drought.

2. Water Balance to Identify Lunugamvehera Reservoir Management Requirements (Wijesekere, 2001)

Water balance of a reservoir can easily identify the fluctuations of reservoir storage through the fluctuations of inflows to the reservoir, seepage from reservoir, evaporation and water extractions for purposes such as cultivation and domestic. Recent studies showed estimation was much less than the actual situation at design stage (evaporation and seepage losses). The water balance model outputs fitted to the observed data provided the opportunity to analyze the sensitivity of evaporation and seepage volumes from the reservoir.

A comparison of seepage coefficient changes from 0.5% to 2% indicated that the order of magnitude of seepage when compared with the effective water in the reservoir was very low. This fact could be effectively used for reservoir planning and management in data deficient periods. Therefore, a seepage coefficient study using soil moisture parameter measurements might provide better management of water in the reservoir. Similarly identifying pan evaporation values from the reservoir would also provide a better controlled water management. A long-term rainfall study for the watershed and evaporation, seepage parameter measurements at site would lead to finer management of water in the reservoir and might effective where farmers had been agitating for more water.

3. Long-term Water Balance of an Inland River Basin in an Arid Area, North-Western China (Moghadas, 2009)

Long term water balance for years between 1963 and 2001 was studied at Shiyang River basin, an inland catchment in Gansu province in western part of China. Calibration for the model could not be applied because of immense data limitation, though the model computes a fairly good estimation of water volume of the region which was applied in water balance equation. The hydrologic components e.g. water supply and demand of the region was determined and the trend of changes of the components were also presented for the study period. The study showed a good cooperation between GIS and HEC-HMS to apply for water balance study and gives a good estimation of component values despite limited data.

The results were the simulated runoff from the defined points at out let of sub basins. The simulated values compared with the observed values at the points and gave an estimation of water usage in different parts of the catchment. The results showed different trends in two periods, an increasing trend of precipitation during 1962 to1985 while the precipitation trends between years 1985 to2001 was decreasing. According to the results the precipitation trends for different sub basins were different which makes sense for such a big catchment with different conditions in different places.

4. Modelling of Event and Continuous Flow Hydrographs with HEC–HMS: Case Study in the Kelani River Basin, Sri Lanka (Silva, et.al. 2014)

This case study described of event and continuous hydrologic modelling in the Kelani River basin in Sri Lanka using the Hydrologic Engineering Centre Hydrologic Modelling System (HEC–HMS). An extremely high rainfall event in November 2005 was used to calibrate model parameters, and extremely high rainfall events in April–May 2008, May–June 2008, and May 2010 were used to validate the event model. The calibrated, direct runoff and base flow parameters were then used in the continuous hydrologic model. The Green and Ampt infiltration loss method was used to account for infiltration loss in event-based modelling and five-layer soil moisture accounting loss method was employed in continuous modelling. The Clark unit hydrograph method and the recession base flow method were used to simulate direct runoff and base flow, respectively. The results depict the capability of HEC–HMS to reproduce stream flows in the basin to a high accuracy with averaged computed Nash–Sutcliffe efficiency.

It is concluded as that the study demonstrates the usefulness of HEC–HMS applications in disaster mitigation, flood control, and water management in medium-size river basins in the tropics and the model is a useful tool to issue early warnings in the lower Kelani River basin during extreme rainfall conditions in the upper basin. The ability of HEC–HMS to simulate long-term daily flows shows its applicability as a tool for planning water resources development in the lower Kelani River basin.

2.3 Modelling Software

Hydrological Models

Hydrologic models are simplified, conceptual representations of a part of the hydrologic cycle. They are primarily used for hydrologic prediction and for understanding hydrologic processes.

There are many modelling softwares available for hydrological models, but HEC-HMS and HYSIM are considered here. All of this in a GIS-based data processing framework will make the task of watershed modeling and mapping easier than ever before. So, the ArcGIS is also studied.

Crop water and Irrigation Models

Simulation of the soil water balance and related crop growth (crop water productivity modeling) can be a valuable decision support tool. By conjunctively simulating the effects of different influencing factors (climate, soil, management, crop characteristics) on crop production, models allow to better understand the mechanism behind improved water use efficiency, to schedule the necessary irrigation applications during the drought sensitive crop growth stages, considering the possible variability in climate, to test strategies of specific crops in new regions, and to investigate the effects of future climate scenarios or scenarios of altered management practices on crop production.

Here CROPWAT, WEAP and AquaCrop are considered for the modeling purposes

3 OBJECTIVE

The main objectibes are

1) To study the water requirements of available tanks and their command areas.
2) To find out the capacity of the canal to irrigate the existing area under tanks.
3) To find the maximum command area that can be cultivated from tank, using remaining canal water.

This research is concerned about facilitating more area for cultivation using the water from the canal. Hence command area of each tank will be estimated for this. Finally, remaining part of the water after supplying all the demands along the canal will be sent to the final tank in the cascade.

4 METHODOLOGY

The methodology used in this research is given as a flow chart in figure 1.

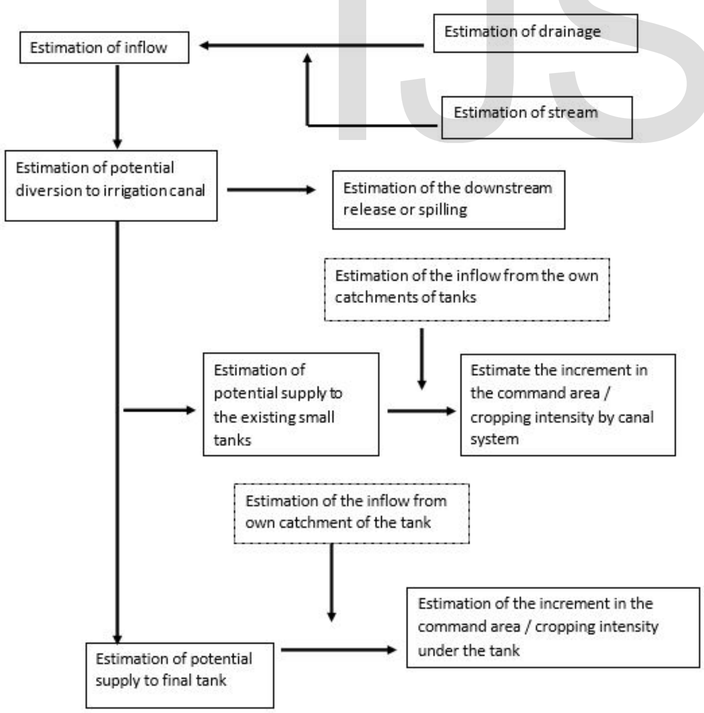

Figure. 1: Flow Chart of Methodology

4.1 Data Collection

This research is about hydrologic modelling. Therefore, reliable data is very important to achieve useful results. Following list of data has to be collected for analyses.

1) Tanks that are going to be connected to the canal and their volumes
2) Command area of each tank – If data available, can be used otherwise software will be used to find the command areas from survey maps.
3) Catchment areas – Software will be used to find from survey maps.
4) Weather data – If data available in respective areas, can be used otherwise data can be extracted from relevant books. (such as Rainfall, Temperature, wind speed)
5) Stream flow data

4.2 Data Analysis

In this modelling process various types of software are involved. Many of the details about those softwares are elaborated. Here some of those softwares are going to be used.

For the analyzing purpose WEAP are used throughout the modelling. It plays a major role in water balancing work. Using the available data current status of the system will be studied. By forming different scenarios further analyses and predictions can be made. It is hope to predict the behavior of the system for 10 years in future.

ArcGIS are used to find the catchment areas, command areas of those tanks in order to calculate the required parameters. This will be very helpful when there is no data in this regard. Survey maps will be used in different scale according to the requirement.

HEC-HMS is used here to find the inflow from the catchment using the available rainfall data.

5 BENEFIT OF THIS RESEARCH

This research will help to find the Optimum amount of water to feed requirement and the optimum amount for diversion. The findings will be useful for planning and improving adaptation in the northern river basins for the proposal of constructing anicut across the rivers.

4 CONCLUSION

The conceptual study of this research suggest to improve the irrigation system in the study area, and proposes to construct diversion canal/feeder canals and anicuts across the rivers, by considering these river basins, the final aim can be achieved at investigating the improvement in irrigated areas and cropping intensity by the diversion canal proposed.

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