Title Simulating Irrigation Networks

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Background and Objectives

The use of computer simulation models in water resources systems is an important tool in the development, assessment and prediction of water needs. This study focuses on the modelling of irrigation systems serviced by surface water storage systems: i.e. reservoirs. With the aid of these simulation models large number of design configurations can be investigated, by selecting different cropping patterns combined with suitable reservoir operating policies.

We study the irrigation networks in the lowland area of the Walawe basin, which is in the southern part of Sri Lanka. We have built a model for this using *Simulink* toolbox of *Matlab* and evaluated it against historical irrigation pattern. The output of the model gives satisfactory results when compared with historical data.

The final objective of the study is to construct a highly reliable computer model which can be used in the decision making process for future development activities. This will be achieved by incorporating water demands other than irrigation: generation of hydropower, industrial water supply, flood control etc. At this level, only the irrigation and domestic water demands are considered.

Research Design / Materials and Methods

The following data were acquired from the Water Management Secretariat (WMS) of the Mahaweli Authority of Sri Lanka (MASL) and from Mahaweli Economic Agency (MEA) office at Embilipitiya,

curves of volume of stored water vs. surface area of reservoir
river flow data at the reservoir sites
pan evaporation rates
rainfall over the irrigated area
monthly variation of temperature, relative humidity, wind speed and daily sun shine hours
cropping patterns

Figures 1 and 2 show the location map and the schematic diagram of our area of study.

First, the reference evapotranspiration is calculated for the crops cultivated in that area. Then, considering the rainfall contribution to the crops the monthly water demand for the system is calculated.

After obtaining the demand series, a water balance equation is developed considering the following;

- inflow into the Udawalawe reservoir
- demand: irrigation demand calculated in the previous section
- losses:
  i. evaporation from the water surface (this is equal to pan evaporation multiplied by the water spread area of the reservoir)
  ii. seepage losses (in this study seepage loss is assumed to be 0.5% of the volume of water stored in the reservoir[1])
- spillage

The water balance equation is obtained as below;

$$S_{n+1} = S_n + I_n - D_n - L_n - Sp_n$$

Where,
S_{n+1} - storage at the end of the month
S_n - storage at the beginning of the month
I_n - inflow during the month
D_n - demand during the month

L_n - losses during the month
Sp_n - spillage during the month

The procedure that is followed by the model at each time step (here the time step being one month) is as follows;

1) determine values of pan evaporation and river inflow for next month
2) determine volume of evaporation and leakage from reservoir
3) determine the water demand for current month
4) by considering the results obtained from the above steps, the carry over storage from the previous month and reservoir operation policy curve , determine if it is possible to satisfy demand, and compute magnitude of any spills or shortages
5) store these values and prepare for next time step

The toolbox *Simulink* of *Matlab* is used to model the system. The main advantage of this toolbox is that it provides a graphical user interface for constructing block diagram models using drag-and-drop operations, thus, side-stepping much of the nuisance associated with conventional programming.

A complete version of the *Simulink* model developed for the Walawe Irrigation System is annexed (figure 3).

Results and Findings

Initially the model was tested with the past data available from the MEA records. Then, different crop diversification patterns were tried out with different operating policies imposed on the main reservoir: the Udawalawe.

The Udawalawe reservoir is considered as the main source of water to the system. Some of the smaller tanks are also included in the model as buffers to store the excess water when Udawalawe is spilling. This model can be further improved if the inflows to the smaller tanks, especially Chandrilawewe, are also considered and included. In this study, the operation of the Samanalawewe reservoir, which is upstream of Udawalawe, was not considered. The operation of Samanalawewe has not affected the system so far, as the water levels are kept at a constant level since after the burst in the right bank.

Conclusions

The results obtained from the model are comparable with the past records. As earlier stated developing a model using this technique is not as difficult as it is with conventional programming. The expansion of the model or adding and/or removing new elements to the model can also be easily done. Thus, this can be easily expanded to include all the major water bodies in a basin to study its responses for a given configuration.

The following recommendations are made for future studies;

include Samanalawewe and other smaller tanks to the system
explore the possibility of incorporating water quality also into the system

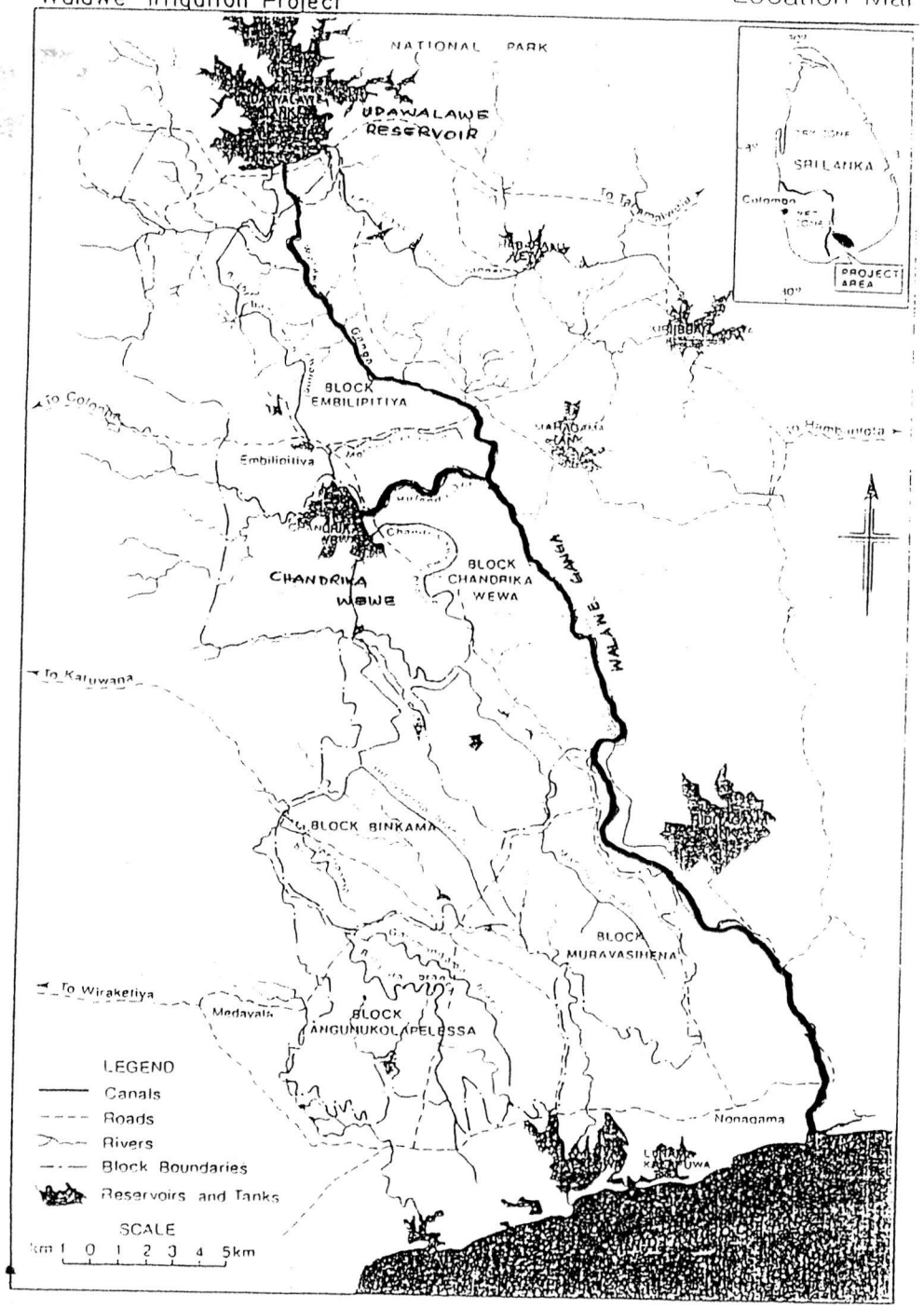
Acknowledgments

We thank the Director General of the Mahaweli Authority of Sri Lanka and the Resident Project Manager of the Mahaweli Economic Agency, Embilipitiya for providing us with the necessary data and all those associated with its aquisistion.

Figure 02

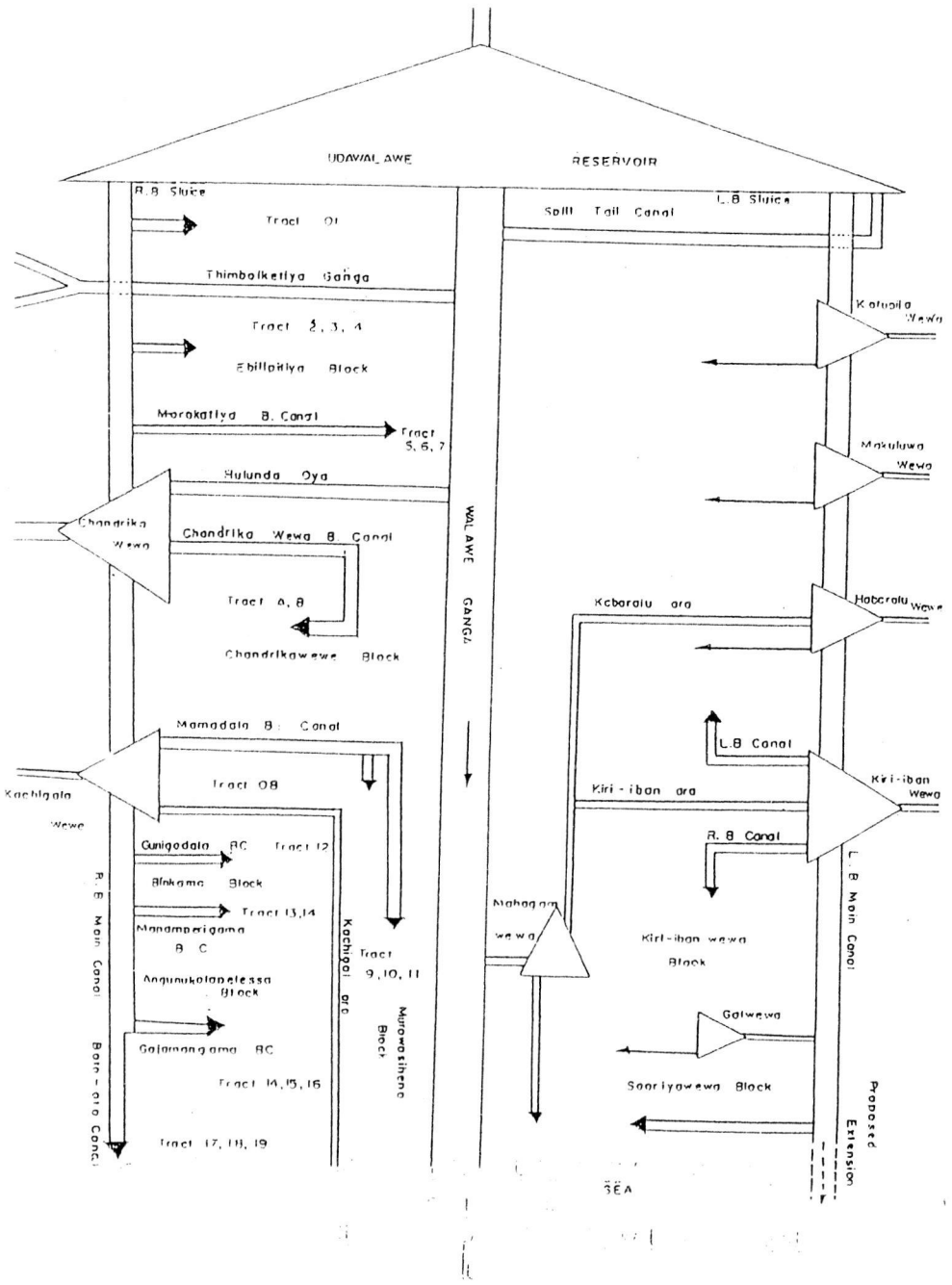
Location Map

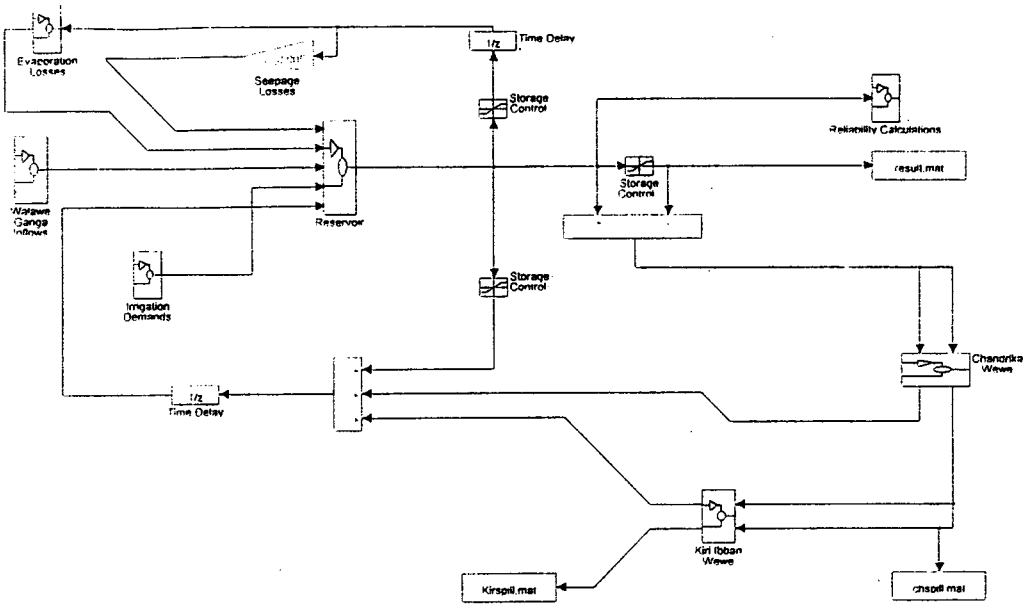
Walawe Irrigation Project



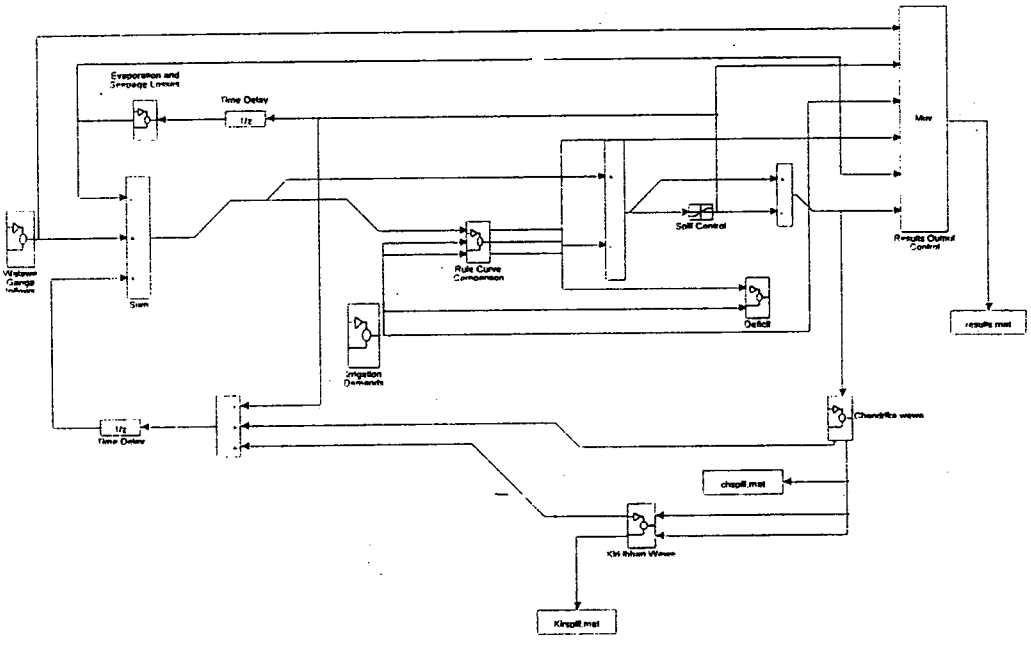
SCHEMATIC IRRIGATION LAYOUT OF WALAWE PROJECT

FIGURE 01

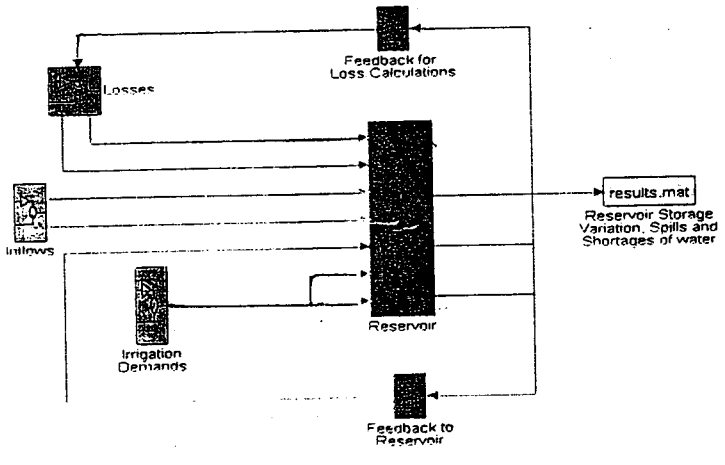




Complete Version of the Simulink Model without Rule-Curve Included



Complete Version of the Simulink Model with Rule-Curve Included



General Layout of the Model