HYDROLOGICAL APPROACH FOR CONSERVATION AND MANAGEMENT OF WATER FOR SUSTAINABLE RICE PRODUCTION IN KOLE LANDS OF THRISSUR

By

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CHAPTER V

SUMMARY AND CONCLUSION

The present study entitled "Hydrological approach for conservation and management of water for sustainable rice production in *kole lands* of Thrissur" was conducted in the North *kole* lands, covering an area of 8,071.4 ha in Thrissur district, Kerala.

The runoff accumulation estimation was carried out to quantify water accumulation in Thrissur North *kole* lands to improve flood management and irrigation planning. The study employed geospatial and hydrological tools, including a Digital Elevation Model (DEM) from Google Earth Pro, processed through interpolation in ArcGIS, and water depth measurements collected via installed scales in selected *padavus*. To monitor water depth, 36 water depth measuring scales were installed across various padavus. Data were collected twice a week from July 1st to September 30th in the year 2022. From field surveys and stakeholder consultations, the preparation of spatial maps of padavus were done which were further used for geoprocessing. DEM data was clipped to *padavu* boundaries and accumulated runoff volume in each *padavu* was calculated using the surface volume tool in ArcGIS, based on bottom surface elevation (BSE) and top surface elevation (TSE) values derived from field water depth data and DEM. Model builder was used for tasks like DEM clipping and runoff volume calculations for 132 padavus, significantly enhancing efficiency.

The estimation of canal storage in Thrissur North *Kole* lands is vital for managing water and supporting irrigation and flood control. Canal storage estimation involved measuring water depths in canals when the Enamakkal and Idiyanchira regulators were fully closed. Variations in water depth along canals were calculated using bed slope data and measurements taken at multiple points (start, middle, and end). The trapezoidal rule was applied to estimate the storage capacity of each canal, with calculations performed on a 10-days basis.

The simulation of regulators for floodwater control focuses on managing floodwaters and ensuring irrigation in Thrissur North *Kole* lands. These regulators control water discharged from rivers, including Keecheri, Peramanagalamthodu and Puzhakkal, and water dewatered from *kole* fields, directing it toward the Arabian Sea while preventing saltwater intrusion. A 10-days water balance simulation model was employed, incorporating key components such as river inflows (estimated using the SWAT model), inflow resulting from dewatering schedules, outflow from regulator (estimated using water balance equation) and canal storage (estimated using trapezoidal rule).

A new zonal cultivation system is proposed for the Thrissur North *Kole* lands to replace the traditional approach, which was continued still 2015. This system is based on a scientific classification using a Digital Elevation Model (DEM) created with Google Earth Pro, which categorizes the *kole* lands into three zones according to elevation levels. Zone-I includes padavus at elevations ranging from -6.33 m to -2.50 m below sea level, Zone-II covers padavus at elevations from -2.49 m below sea level to sea level, and Zone-III comprises padavus at elevations from sea level to 20.49 m above sea level.

Based on zone wise classification of *kole* lands, dewatering schedule is prepared. A survey was conducted to identify the locations, horsepower (HP), and number of axial flow pumps installed in each padavu of the Thrissur North *kole* lands. The survey utilized the 'GPS Essential' app for precise mapping of pump locations. Discharge rates for 50 HP vertical submersible pumps and vertical propeller pumps are 2,141 m^3/h and 2,090 m^3/h, respectively were selected for calculation of number of days required to drain out water from *kole* lands.

A zone -wise crop calendar has been developed for the North *Kole* lands of Thrissur to provide a structured schedule for agricultural activities and optimize rice production. The calendar includes timelines for essential tasks such as dewatering, land preparation, lime application, broadcasting or transplanting, intercultural operations, harvesting, and post-harvest processes like drying and baling straw. Each zone within the *kole* lands has a crop calendar and cropping pattern to address its specific conditions. In this study, two crop calendars were designed to the

preferences and needs of farmers. The first calendar is based on the medium-duration rice variety Uma, which is widely favoured for its yield and adaptability. The second calendar is designed for a short-duration rice variety to provide flexibility in cropping schedules. Based on the crop calendar suggested in this study, irrigation requirement is calculated on 10-days basis.

The optimization of regulator operations in Thrissur North *Kole* lands aims to enhance water management by balancing inflow to regulators, canal storage, evaporation loss from canals, seepage from canals, inflow resulting from dewatering from *kole* lands and irrigation demand. In this study two crop calendars are prepared, hence two optimization model was developed corresponding to that. The objective function of the Enamakkal Regulator system focuses on minimizing water deficit by optimizing the use of existing canal storage and river inflows. Based on field experiences, the regulator should be operated at a minimum water level of 0.7 m and a maximum of 1.2 m. Based on this, canal storage and constraint and deficiency constraints were developed. The schedule of opening and closing of regulators were proposed based on outflow obtained from optimization models by considering the design discharge of regulators.

A total of 132 padavus (collection of paddy fields) in North *kole* lands were digitized using ArcGIS, resulting in digital maps at the gramapanchayath and blockpanchayath levels. The digitized north *kole land* gave an area of 8084.60 hectares, resulting in a variation of 0.37 %. The water level recorded in *kole lands* ranged from 0.4 to 2.4 m during monsoon season, highlighting significant variations across the area. Purathur and Inchumudi padavu have maximum water depth of 2.4 m. The average water depth across all padavu was 1.62 m with highest fluctuation seen in Jayanthi padavu of 1.8 m. A DEM was prepared using Google Earth Pro by considering 3,154 elevation points, revealing that the elevation across *kole* lands varied from -6.9 to 20.82 m.

Using input parameters such as water levels in the *kole* lands, the spatial map, and the Digital Elevation Model (DEM), the accumulated runoff volume was estimated spatially. The analysis revealed a maximum runoff volume of 122.67 Mm^3 and 87.04 Mm^3 before dewatering. Among the padavus, Jubilee Thevar Padavu

recorded the highest values for both maximum accumulated runoff volume (15.84 Mm^3) and accumulated runoff volume before dewatering (14.44 Mm^3).

All canals in the *kole* lands were digitized within an ArcGIS environment, revealing a total canal length of 77.02 km. A 10-days estimation of canal storage capacity indicated that the storage volume in the canals ranged from 29.0 to 53.86 Mm^3, with an average storage capacity of 42.40 Mm^3. The relationship between water level at Enamakkal regulator and canal storage was also developed.

The results of the SWAT model showed that the highest inflow volume to the Enamakkal regulator was 73.32 Mm^3 during the second 10-days of August. The SWAT-CUP calibration results indicate that the model performed well, with an NSE value of 0.6 and an R^2 value of 0.8, both being classified as "very good." This confirms the suitability of the SWAT model for predicting future inflows from the Keecheri River basin. From the simulation model, the highest outflow was calculated as 43.55 Mm^3 in the third 10-days of August. The developed simulation model effectively predicts the inflow-outflow relationship for the regulator.

Entire North *kole* lands was classified into three zones based on elevation. Zone- I include padavus with elevations ranging from -6.33 m to -2.50 ms below sea level, comprising 31 padavus and covering an area of 2,869.49 ha, which accounts for 35.65% of the total area. Zone-II consists of padavus with elevations between -2.49 m below sea level and sea level, including 29 padavus and spanning an area of 2,907.63 ha or 36.13% of the north *kole*. Zone III encompasses padavus with elevations from sea level to 20.49 m, consisting of 62 padavus and covering 2,270.87 ha, making up 28.25% of the total area.

A GPS survey conducted in the *kole* lands to identify the locations of various axial flow pumps and spatial maps of location of pumps were made using ArcGIS revealed the presence of 197 Petti and Para, 50 submersible pumps, and 16 vertical axial flow pumps during 2022. Based on the available pump capacities and accumulated runoff volume, a zone-wise dewatering schedule was developed for the *kole lands*, with the required dewatering time ranging from 0 to 20 days. In Zone I, Manalur *Padavu* required the longest dewatering period of 17 days. In Zone II, Mathookara Vadak *Kole* Karshaka Sangham has the longest dewatering time of 20

days, while in Zone III, Elavathur Kizhake *Kole* Karshaka Sangham required 15 days for dewatering. Zone wise cultivation suggested in this study increased gross cultivated area to 13,825.11 ha which could give yield 1434.74 ton of pulses and 32,296.6 tons of paddy.

A new cropping pattern has been proposed for the preparation of a crop calendar in the North *Kole* region. The first crop will be paddy in all three zones, while the second crop will be paddy in Zone II and pulses in Zone I. Two crop calendars have been suggested: Crop Calendar 1 (CC-I), will commence cultivation on August 15th and conclude on April 13th; and Crop Calendar 2 (CC-II), starting on September 15th and ending on April 30th. Irrigation requirements were calculated using CROPWAT based on the suggested calendars, with water demands of 135.67 Mm^3 for CC-I and 175.28 Mm^3 for CC-II.

Seepage analysis conducted using SEEP/W revealed that the highest seepage occurred at 182,325.14 m^3 during the second 10-days of May, contributing to a total annual seepage loss of 56,09,519 m^3. Additionally, evaporation loss from the canal was estimated by considering the dynamic nature of the water level, which influences the top width of canal water surface. The analysis showed that the highest evaporation loss recorded was 15,199.60 m^3 in the first 10-days of February, while the lowest loss was 3,748.64 m^3 in the third 10-days of August.

Two optimization models were developed for the Enamakkal and Idiyanchira regulators, considering inflow to the regulator, canal storage, outflow from the regulator, and water demand for crop cultivation in the *kole lands,* with the objective of minimizing water deficit. The model estimated an increase in canal storage of 564.5 Mm^3 for Crop Calendar-I and 593.5 Mm^3 for Crop Calendar -II, thereby enhancing irrigation support for cultivation in the *kole* lands. The results from the optimization models showed a reduction in water deficit of 9.84 Mm^3 for Crop Calendar -1 and 33.27 Mm^3 for Crop Calendar -II, demonstrating effective utilization of water in the canals and inflows from the rivers.

Based on these models, the operational schedules for the shutters of the Idiyanchira and Enamakkal regulators were suggested. From June 1st to mid-September, the Idiyanchira regulator remains fully open and is kept closed for the

remaining part of the year. Similarly, the Enamakkal regulator is fully open during the monsoon season (June 1st to mid-September) and is operated based on outflow recommendations from the optimization model for the rest of the year.

The following conclusions could be drawn out of study,

- The estimation of runoff accumulation in *kole* lands can help the authorities to plan cropping patterns and irrigation strategies accordingly.
- The accumulated volume just before dewatering, 87.01 Mm^3 is enough to meet the water needs of 3,521,959 people for six months or irrigate 72,508 ha of paddy for 100 days.
- Managing runoff accumulation in *kole* lands requires a holistic and integrated approach that considers the unique ecological and hydrological characteristics of the region. Local stakeholders, government agencies, and environmental experts should work together to develop and implement effective strategies for runoff management in *kole* lands.
- The study helps to prepare dewatering schedule, crop calendar and optimum use of accumulated water for double cropping within the *kole* lands
- The relationship developed between Enamakkal water level vs canal storage provides valuable insights into the dynamics of water storage and water depth which can be used for managing existing regulator and to estimate the canal storage for a given water level at Enamakkal regulator.
- By integrating the forecasted inflow data and the current canal storage levels, the simulation model developed in this study can predict how much will need to be released as outflow.
- Results from the dewatering schedule helps stakeholders and decision-makers assess the scale of challenges and to determine the need of additional pumps for efficient water management.
- The optimization model developed for the *kole* lands can improve decision-making process but also increase efficiency by maximizing the utility of available water resources.

Scope for future studies

- Continuous recording of water levels in *kole* lands potentially improves water management and agricultural productivity.
- Measurement of water entering to *kole* lands from the rivers improves the accuracy of estimation of inflow using of SWAT model.
- Forecasting future water inflows and climatic conditions is essential for creating an effective crop calendar, enabling more accurate and timely water management.
- Studies should be carried out to verify the hydraulic design of the Enamakkal regulator.
- Optimizing the operation of the Illikkal regulator is necessary to effectively manage water releases from the Chimmoni dam.
- Preparation of crop calendar, dewatering schedule is required for Ponnani and Thrissur South *kole*.