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5. **Topic of research:** **"GIS and Remote Sensing based approach for Sustainable Water Resources Management"**

ABSTRACT

Key words: GIS, Remote Sensing, MATLAB, Sustainability, Optimization

In the present study sustainable water resources management policies are evolved by means of decision support tools (GIS & remote sensing; optimization tools of MATLAB), integrating water demands (domestic, agricultural, industrial & future needs) and integrating available water sources (canal water, groundwater, ranney well water and surface run-off) with emphasis laid on food and nutritional security, sustainable agricultural economy, optimal utilization of land resources, alleviation of poverty and unemployment through sustained labour employment & environmental concerns. The proposed approach is applied to a real life case study (Nuh region of Mewat district of Haryana state, India). The study area has problems of salinity, scarcity of potable drinking water. Its irrigation canal system depends on Gurgaon canal. Unfortunately due to lack of sufficient irrigation system and improper planning and management of water resources the region of study area has not been able to develop so far.

GIS and remote sensing based analysis of the study area has been carried out by using digitized data (processed geospatial data procured as tiff images from SOI). Data related to study area has been collected through repetitive visits to concerned government and non-governmental organizations, research organizations, referred reports etc. Based on data analysis of the study area input parameters & constraints are identified. The proposed optimization model comprises of maximization of benefits as objective function with area of crops as decision variables (in the present case 12 crops i.e. 12 variables; for 119 villages $12 \times 119 = 1428$ variables). This is subjected to water, land & human resources related constraints and emission constraints as well.

The proposed linear programming model is analysed by using ‘linprog’ module of MATLAB for various case scenarios. Input parameters required for the model are Water available for irrigation (IW), Cultivable area of Kharif season (CAK), Cultivable area of Rabi season (CAR), Net return from each crop (NB), Human labour requirement (HLR), Human labour availability (HLA), Fertilizer (nutrient) use (FC), Total Emission as N_2O of existing condition (TEEN), Total Emission as CO_2 of existing condition (TEEC), Lower bound of crop area based on food (lb), Upper bound of crop are as storage (ub) and Crop water requirements (NIR).

The model is applied to five different scenarios based on water availability (S1: Actual, S2: 100%, S3:75%, S4:50% and S5:25% availability) and a total of 80 cases have been studied. The analysis further continued for actual water availability criteria. Output parameters obtained from the approach are optimal cropping patterns, optimal operational policies, optimal water use plans, net benefits, human labour employment & requirements, emissions as N_2O & CO_2 and emissions as CO_2 equivalents (CO_{2e}) were analysed to evolve sustainable policy. The approach proposed in the present study has the ability to suggest suitable cropping patterns and to assess various cropping patterns for different water resources scenarios. Optimal operational policies for optimal cropping patterns for all the divisions are suggested. Proposed approach dwells further and proposes optimal cropping patterns and corresponding water use policies to each village. Emissions at village level in the form of N_2O due to the use of nutrients in agriculture and emissions of CO_2 due to groundwater pumping are also given due consideration in order to minimize them. Moreover, the impact of varied pump efficiencies on CO_2 emissions is also assessed.

Evolved policy was further subjected to post optimal and sensitivity analysis by considering additional aspects and constraints such as saline resistant crops, soil health, minimization of water use, maximization of human employment etc. Future scenario with respect to land, human and water resources was carried out. To implement the proposed policy at ground level Decision Support Tables (DSTs) have been generated, which are helpful to water resources planners for execution at ground level.