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A Review on Land Suitability Analysis for Irrigation

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ABSTRACT

Planning for agricultural expansion and solving the problem of global water shortages both need the use of a critical instrument, the assessment of land suitability for irrigation. A land suitability analysis evaluates a site to determine whether it is suitable or adequate for specific land use in that location. Tools for assessing land suitability have been widely used to find more effective irrigation systems in agricultural areas. The appropriateness of the land was assessed in this research using a GIS-based multi-criteria decision-making (MCDM) approach. Numerous criteria, including bio-physical and socioeconomic indices, were considered in the land suitability analysis. GIS can be a useful tool for locating irrigable land and mapping irrigation-ready area. The fusion of RS-GIS and application of multi-Criteria Evaluation utilizing Analytical Hierarchy Process (AHP)could provide a superior database and route map for decision-makers who are considering switching crop land for irrigation land. A review of the multicriteria analysis used to create the Land Suitability Map was conducted. The best appropriate multicriteria decision making in a GIS system was determined for irrigation land suitability.

Key words: *Land Suitability, GIS, AHP, MCDM, Remote sensing*

Introduction

The evaluation of land suitability for irrigation is a crucial tool for planning the expansion of agriculture as well as for addressing the worldwide issue of water scarcity. According to FAO methodology, "land qualities" including flood risks, water accessibility, and erosion resistance qualities that are in and of themselves immeasurable are closely correlated with land suitability. It is advantageous to use the latter indicators in the land suitability studies and then use the land parameters to determine the suitability of the land for irrigation since these qualities are derived from "land characteristics" such as slope angle and length, rainfall, and soil texture that are measurable or estimable. To combat the consequences of unpredictable and variable rainfall, irrigated agriculture uses water resources to offer supplemental and year-round irrigation. The construction of irrigation systems, which can increase security by lowering harvest variability, as well as intensification of cropping by growing more than one crop per year, may be the answer to the problem of food insecurity.

According to recent statistics and studies, the application efficiency of India's irrigation districts is less than 35%, or little more than 5% below the global average. As a result, compared to pressurized irrigation systems, this leads to low water productivity (kg/m^3). Irrigation has played a significant role in the intensification of agricultural productivity by giving farmers access to water.

AHP, an MCDM technique, isutilized to analyze how a land's suitability might be determined. The

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spatial distribution of land suitable for irrigation under current and projected climatic conditions can be determined using the GIS-based MCDM technique. The MCDM technique, or AHP, identifies prospective appropriate land by considering a number of factors that affect a particular land area's suitability for irrigation. These influencing factors are weighted and mapped to decide individual impacts, and then merged in MCDM to produce a single indexed result. Site selection for convenience stores, urban land use planning (Mosadeghi *et al*., 2015), hospital site selection (Vahidnia *et al*., 2009), site selection for thermal power plants, and solid waste disposal site selection are only a few of the studies that have used MCDM (Zhang *et al*., 2015).

Demarcation of land suitability for irrigation are accessed by MCDM technique

Factors that affect whether a place is suitable for surface irrigation have been established through study and expert opinion. Some of the components that have been studied are biophysical such as soil characteristics, climate, land use type and terrain and socioeconomic aspects e.g., market access such as road proximity and population density (Worqlul *et al*., 2015).

Rainfall decit

Suitability of a location for irrigation is greatly influenced by climate parameters, including rainfall and potential evapotranspiration. Data on rainfall are gathered from weather stations. Data on long-term monthly rainfall were combined to provide a yearly total. The annual precipitation was interpolated using the Inverse Distance Weighting interpolation (IDW) technique using a typical neighborhood to estimate the spatial rainfall across the country. Data on potential and actual evapotranspiration were gathered, and by averaging the daily data, the average yearly potential evapotranspiration over the long term was calculated.

Soil

The appropriateness of a region for irrigation in particular and agriculture in general is significantly influenced by the soil. When establishing whether a region is suitable for agricultural and long-term irrigation, the quality of the soil is crucial. The suitability of the soil for irrigation was assessed using a variety of soil properties, including soil texture, soil depth, drainage, and potential for storing water. Deep soils are necessary to protect plant nutrients and promote plant growth. Each layer includes the drainage class, bulk density, organic carbon content, and soil texture. Additionally, the appropriateness of the soil maps for surface irrigation should be evaluated in accordance with FAO guidelines.

Land use

An irrigation area's productivity can be determined using data on land usage, and irrigation areas can be rated according to their significance for irrigation potential, costs to remove or change for cultivation, and environmental effects within the watershed. A land parcel can be split into suitability classes, according to the widely used (FAO, 1976) classification system for assessing a piece of land's appropriateness for a given set of land-use objectives.

Slope

The suitability of a region for irrigation operation and land preparation depends on the slope of the ground. The slope of a particular area is crucial for irrigation activities generally, but especially for surface irrigation. By using the spatial analyst tool in ArcGIS, slope was generated from a Digital Elevation Model in the current study, and the slope findings were assessed in accordance with FAO guidelines. The slope directly affects plant adaptation, drainage needs, land development, soil tillage, agricultural machine use, irrigation methods, erosion susceptibility, and on-farm irrigation system design.

Population density

In order to implement irrigation, one needs to have access to the market in order to purchase inputs for farming and sell agricultural products. Population density and the distance to the nearest major paved road were used to reflect market access.

Analytical hierarchy process

When making decisions as a committee, the AHP can be utilized as a strategy for achieving consensus (Saaty, 1980). The AHP can be used to help a committee or group reach a choice while making decisions (Saaty, 1980). By identifying and classifying the criteria, the AHP method tries to take into account the context of the spatial planning choice (Vogel, 2008). The three guiding concepts of AHP are decomposition, comparative evaluation, and priority synthesis (Eldrandaly *et al*., 2007). Using many criteria and geographic information, a deci-

sion is made through the process of spatial MCDM.

Gurara (2020) evaluated the appropriate land resource potential for irrigation development for the Katar River watershed in the Rift Valley Basin of Ethiopia using GIS-based Multi-Criteria Evaluation (MCE) methods. The process involves defining the watershed, describing it using suitable criteria including slope, soil texture, soil depth, drainage classes, proximity to a river and an urban area, and land use and land cover, as well as reclassifying and mapping the watershed. The characteristics produced a classification of 34.08% as highly suitable, 58.08% as fairly acceptable, 3.21% were deemed unsuitable, while 3.8% were only somewhat appropriate for the development of surface irrigation.

In Loma Woreda, Southwest Ethiopia, Girma *et al*. (2019) examined the possible physical land suitability for surface irrigation. With the help of weighted overlay analysis, they determined that 770.58ha (0.65%) of the entire area is extremely suitable for surface irrigation, followed by 46,554.12ha (39.36%) and 67,253.13ha of the total area (56.86%). 3.12% of the entire area, or 3,690.09ha, were still unsuitable. According to the results, 114,577.83ha (96.8%) of Loma Woreda's total 118,267.92ha are possibly appropriate for surface irrigation, falling within the ranges of very and marginally suitable.

In the Ethiopian Abbay basin, Kassie *et al*. (2022) used the analytical hierarchy approach to assess land suitability for irrigation while taking both surface and groundwater sources into account. According to their findings, 5.3% of the basin (10364 km^2) and nearly 10% of the basin (19192 km^2) are eligible for surface irrigation using groundwater and rivers, respectively. They discovered that South Gojam was the best sub-basin for surface irrigation, and Muger was the best sub-basin for surface irrigation from rivers and groundwater, respectively. This is a promising finding for the growth of surface irrigation.

The AHP and geographic Multi-Criteria Decision Analysis (MCDA) have been combined by Paul *et al*. (2020) to assess the viability of using recycled water for agricultural irrigation in California. This study comprised five evaluation criteria: crop type on agricultural land, climate, water policy, irrigation status, and proximity to wastewater treatment facilities. Utilizing the hybrid approach and taking into account all three scenarios simultaneously, a composite suitability map was created. The study's findings improved regional understanding of sustainable recovered water use for crop irrigation. They have proven how crucial it is to include data-driven and knowledge-based criteria and sub-criteria in the decision framework.

Yigeltu and Alemu (2022) used GIS and the AHP approach to evaluate the land's potential for surface irrigation in Ethiopia's Bedessa watershed. Using the AHP tool in Arc GIS, they weighed five factors, including soil, slope, land use/land cover, river proximity, and road proximity. As a result of their analysis, irrigation suitability maps were created, and the potential irrigation land for irrigation was calculated as 1.81%, 5.64%, 86.83%, and 5.72% for S1, S2, S3, and N, respectively. Utilizing the Crop Wat version 8.0 model, the amount of irrigation water needed is determined and is higher during the driest months of the year. According to their findings, the potential irrigable land is determined by comparing the gross irrigation demand of the identified irrigable land with the available monthly river flow.

In order to assess the land resource potential of the Kangsabati river catchments in the Purulia district for irrigation development, Mandal *et al*. (2018) conducted research and used GIS to create a georeferenced map of these resources. A number of irrigation suitability parameters, including soil type, slope, land cover and usage, and separation from a water source, were considered in order to identify prospective irrigable land. According to the examination of these elements' irrigation suitability, 4.15, 31.16, and 64.69% of the soil are, respectively, extremely, moderately, and marginally suitable for surface irrigation. Additionally, the research area's slope (51.82%) is ideally suited for surface irrigation. In terms of land use and cover, 31.38% is off-limits to irrigation development, whereas 68.62% of the area is extremely appropriate. The 34020.1 ha of land was identified by the weighted overlay analysis of these parameters as being particularly suited for possible surface irrigation of the river watershed.

Sengupta *et al*. (2022) took into account topography features, soil qualities, Euclidean distance, and land components in addition to climatic parameters. The FAHP model is used to combine every thematic layer into one layer and produce an agricultural land suitability map in a GIS context. According to the analysis, 11.17% of the entire study area (509700 ha) is extremely suitable for agricultural use, while the remaining 20.73%, 13.81%, and 54.29% of region are only marginally and moderately acceptable for

agricultural use, respectively.

Iqbal (2022) studied land type and each piece is suitable for certain types of uses depending on its abilities and potential and suitability for different uses. The method and type of usage decision should be checked for suitability for different purposes. Today, land resources are developed without exploiting the potential of the land, with optimal use of surrounding areas for cultivation, non-productive land, etc., and good fertile agricultural land for settlements, industry, and road construction. etc. has been eaten up which turns into a degraded wasteland. They determined land suitability analysis using RS and GIS techniques by evaluating parameters such as slope, topography, and land use/land cover.

Conclusion

Information on land suitability for agriculture is crucial for the development of agriculture and long-term planning. A land suitability assessment for agricultural uses has been conducted in light of this in order to aid decision-makers and agricultural development planners and determine how proper or appropriate it is for a particular use of the land in a particular location that are more suitable for certain agriculture use. However, it is necessary to further classify the land suitability by evaluating the availability of water for irrigation and the commercial viability of water delivery in order to evaluate the feasibility and actual design of individual projects. Based on numerous reviews of the more recent literature in this topic, this study has offered information on the significance of Land Suitability for Irrigation, several methodologies, and an overview of the AHP method. In practice, mapping land suitability information is a relatively common operation, but using remote sensing and GIS together offers a useful way to evaluate a variety of data and identify the places that are more conducive to development.

Conflict of interest : No conflict of interest.

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