Potential Aquaculture Practices In Saline Waterlogged Land Using Geospatial Approach Rohtak District (Haryana)

Dinesh Kumar[1], Chander Shekhar[2]*, Sandeep Kumar[3], Banti[4]

[1]Project Fellow, Gurugram Metropolitan Development Authority (Gurugram).
[2]*Head of Geospatial Centre, Hisar (Terra2map).
[3,4]Senior Project Assistant, Municipal Corporation Gurugram.
Email: shekharonly26@gmail.com

Abstract:
For farmers whose agricultural land had been waterlogged and therefore unusable for years, there is some good news. Currently, the state administration is working to turn the flooded fields into ponds that can be used for fish aquaculture. In order to replace the "Green Revolution" with the "Blue Revolution," The study focuses on the waterlogging issues and aquaculture potential in Rohtak district, Haryana, India, utilizing spatial and non-spatial data. Rohtak district spans 1,745 square kilometers, representing 3.9% of Haryana's total area. With average annual rainfall of 592 mm, the region experiences significant waterlogging, especially during the southwest monsoon season. Landsat-8 satellite imagery from 2022 was analyzed using unsupervised classification and the Normalized Difference Water Index (NDWI) to identify waterlogged areas. The depth of the water table and salinity levels (EC values) were also assessed using groundwater data. Results indicate that 42,229.4 hectares are severely waterlogged, while 82,693.8 hectares have salinity levels slightly unfavorable for aquaculture. Based on water depth, 12,061.7 hectares have excellent aquaculture potential, whereas 54.1% of the district is only slightly suitable for aquaculture. This study provides insights into water management challenges and opportunities for aquaculture development in the district.

Keywords: Aquaculture potential, Waterlogging, Salinity, Spatial data analysis, Remote sensing, GIS.

Introduction:
Food security continues to be a top priority for all nations, and ensuring the production of food, forage, and fibre is dependent on the sustainable management of soil health and water resources. 'According to a survey by the district administration, approximately 2,500 acres of agricultural land owned by district farmers have been sitting idle due to waterlogging for years, which is a national loss. Now, waterlogging areas will be transformed into ponds and utilized for Aquaculture'. Farming is frequently difficult due to wage labour and "smallholder agriculture". Hence, one of the main objectives of ICAR Indian Institute of Water Management is to increase water productivity in ecosystems that are challenged, such as waterlogged areas (Ambast, S.K.2015).

In Haryana, a state that is rapidly developing, 0.45 million hectares of land are affected by waterlogging and salinity, which has become one of the greatest obstacles to growing crops in the state's eight districts, including Rohtak, Jhajhar, Charkhi Dadri, Bhiwani, Hisar, Jind, Sirsa, and Faridabad. In the irrigation command regions of these districts, waterlogging is negatively affecting the cropping pattern and agricultural productivity, causing significant socioeconomic losses.

Study Area:
One of the smaller states in India, Haryana is located in the northwest and spans latitudes of 27°39' to 30°35' N and longitudes of 74°28' to 77°36' E. The Rohtak district covers a total area of 1670 square kilometres, or roughly 3.77 percent of the state of Haryana's total area of 44,212 square kilometres. It is located between latitudes 28°40' and 29°05' north and 76°13' and 76°51' east. The Rohtak district covers a total area of 1745 square kilometres, or roughly 3.9% of the state's total area (Figure 1).

The district was made up of five blocks—Kalanaur, Lakhan-Majra, Meham, Rohtak, and Sampla—with 146 villages. In Rohtak district's eastern region, certain areas are level while others are uneven, suffer from water ponding, and are vulnerable to water logging in the monsoon season.

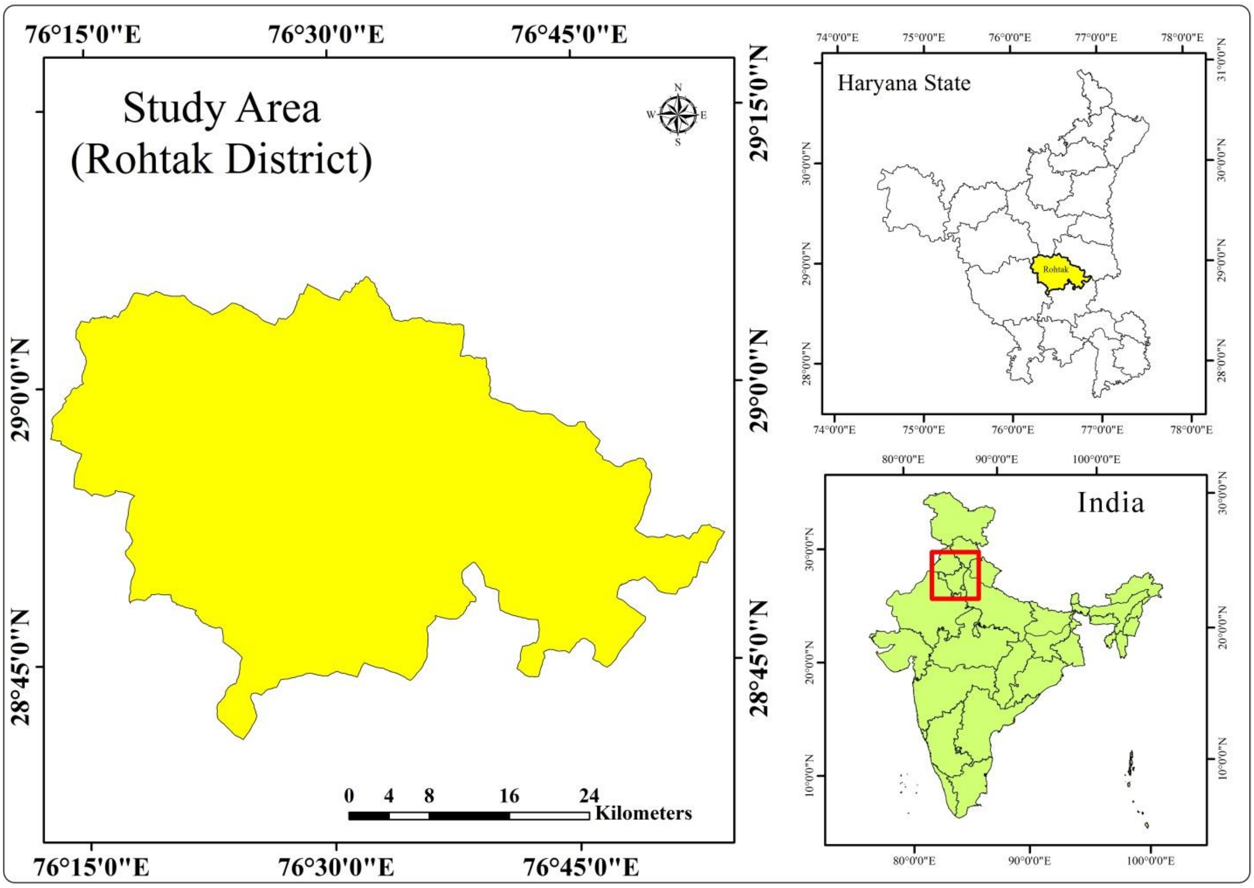

Figure-1: Location map of study area (Rohtak District)

In the Rohtak district, there is an average of 592 mm of rain every year, spread out across 23 days. The south west monsoon, which is responsible for around 84% of the annual rainfall, arrives in the final week of June and departs at the end of September. These are the wettest months: July and August. In the wake of thunderstorms and western disturbances, 16% of the annual rainfall falls during the non-monsoon months.

Methodology:
The study relies on spatial and non-spatial data from a variety of sources. Data from the ground water analysis and the Landsat-8 satellite (Depth of Water level and EC value for salinity of water) Figure: 2.

Satellite Image: The Rohtak command area's waterlogged region concerns have been identified using Landsat-8 data (August) of the year 2022. The Three spectral bands in the satellite data two visible and one Near Infrared—could be used to identify the waterlogged area. With an 8-bit radiometric resolution, has a 30 m spatial resolution.

Unsupervised Classification: Iterative Self Organized Data Analysis Method A, K Means, and Unsupervised Clustering Algorithm (ISODATA). The number of statistically distinct features (clusters) in a stack of pictures is calculated using statistical clustering methods to do an unsupervised classification. The number of classes that the data is divided into for clustering within each land cover can be specified by the user using the ISODATA approach. The statistical cutoffs that were utilized to distinguish between the classes in the ISODATA analysis and the waterlogged region that was blocked out. The tonality, texture, and association of FCC pictures made up of NIR, Red, and Green bands were visually examined for potential locations of waterlogging for both seasons. On the satellite data, the wet patches typically stand out sharply from the surrounding areas. The visible and infrared spectrum of optical sensors can easily detect these spectral characteristics of wet environments. Depending on the depth of the water, the standing water sections seem from dark blue to black, while the wet portions appear from dark grey to light grey in hue or tone.

NDWI: In this work, the delineation of the water bodies and simultaneous removal of the soil and vegetation features were accomplished using the Normalized Difference Water Index (NDWI) method. The index is calculated as follows (McFeeters, 1996):

$$NDWI = (GREEN-NIR) / (GREEN+NIR)$$

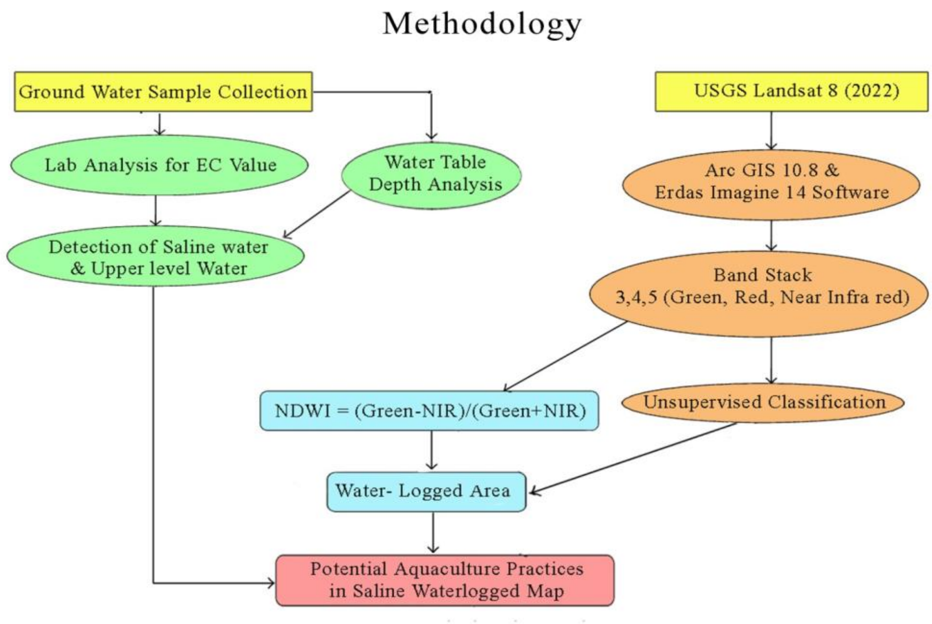

Figure-2: Flow chart of methodology.

Depth of water Level: The groundwater data for the year 2022 is gathered from a number of sources, and any anomalies or inconsistencies are then examined. All of Rohtak's well and Tube well locations have been plotted, their positional correctness has been verified, topology has been formed, projected into the intended system as previously described, and lastly attributes, such as the depth of the water at the time of water sample collection, have been added. Using the point locations in ArcGIS, the depths of water level data have been spatially extrapolated to create the depth of water level spatial distribution.

Result and Discussion:
Identification of Saline and Waterlogged Areas:
Rohtak district, affected by varying levels of waterlogging, soil salinity (measured as Electrical Conductivity or E.C.), and water table depth, presents a mixed potential for aquaculture development. The integration of these factors using geospatial analysis helps classify areas into different suitability categories for fish farming. Using satellite imagery, the waterlogged areas of Rohtak district were identified through a series of remote sensing techniques. The data showed that approximately 15% of the district's agricultural land was affected by Electric Conductivity and waterlogging. The spectral signatures in the satellite imagery, primarily derived from Landsat 8 and Sentinel-2 data, were processed to identify soil salinity and surface waterlogging.

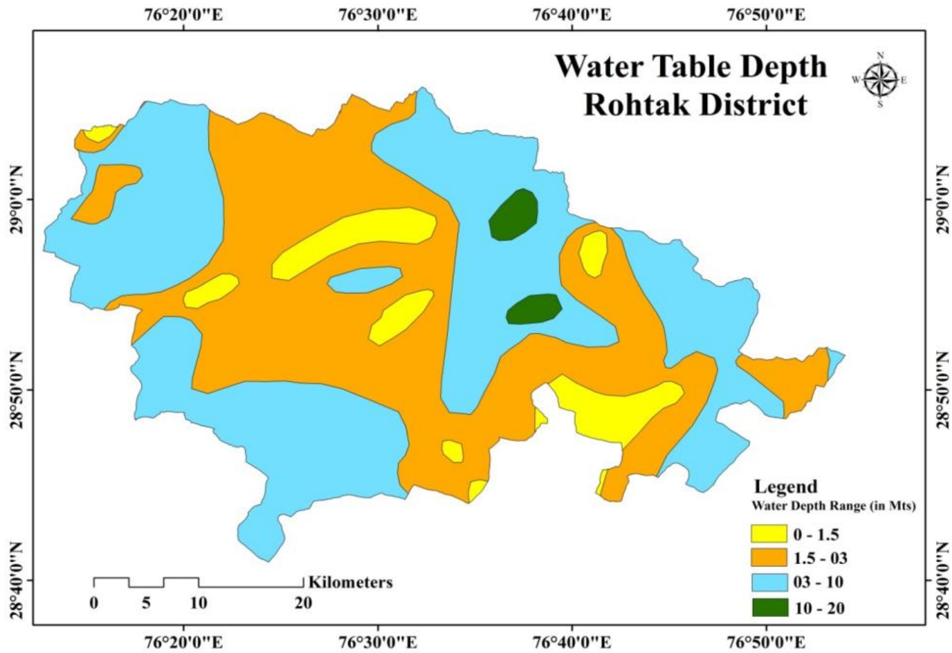

Figure-3: Map of water table depth.

The table-1 shows the relationship between water table depth and aquaculture potential in Rohtak district, with different areas categorized by their suitability for fish farming.

Table-1: Relationship between water table depth and aquaculture potential (Area) in Rohtak.

Water Table Depth Range (in Mtr.)	Potential for Aquaculture	Area (in Hectare)
0-1.5	Excellent	12061.7
1.5-3	Good	73440.9
3-10	Slightly Poor	79382.5
10-20	Poor	2407.3
Total		**167292.4**

Areas with a water table depth of 0-1.5 meters, covering 12,061.7 hectares, have **excellent potential** for aquaculture due to the ease of water access. Zones with a depth of 1.5-3 meters, spanning 73,440.9 hectares, offer **good potential**, requiring moderate water management. In areas with a depth of 3-10 meters (79,382.5 hectares), the potential is **slightly poor** due to increased difficulty in maintaining water levels, while regions with a depth of 10-20 meters (2,407.3 hectares) are considered **poor** for aquaculture because of the high cost of water extraction.

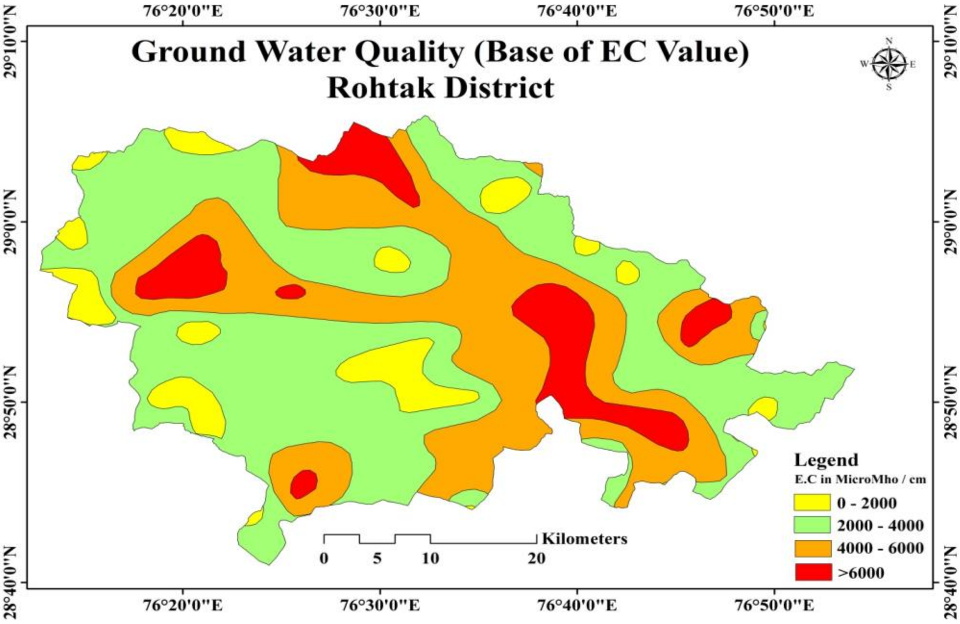

Figure-4: Map of Ground Water Quality base of EC Value (Rohtak District).

The table-2 presents the classification of areas based on Electrical Conductivity (E.C.) levels in microMho/cm, which is an indicator of water salinity, and their corresponding potential for aquaculture along with the area covered (in hectares).

Table-2: Classification of areas based on Electrical Conductivity (E.C.).

E.C in MicroMho / cm	Potential for Aquaculture	Area (in Hectare)
0-2000	Poor	13465.4
2000-4000	Slightly Poor	82693.8
4000-6000	Good	54784.3
>6000	Excellent	16348.9
Total		**167292.4**

Areas with low E.C. (0-2000 microMho/cm) covering 13,465.4 hectares have **poor potential** for aquaculture due to insufficient salinity. Zones with E.C. between 2000-4000 microMho/cm (82,693.8 hectares) are **slightly poor**, while areas with E.C. between 4000-6000 microMho/cm (54,784.3 hectares) offer **good potential**, suitable for salt-tolerant fish species. Areas with E.C. above 6000 microMho/cm (16,348.9 hectares) provide **excellent potential** for aquaculture, ideal for saline-adapted fish farming.

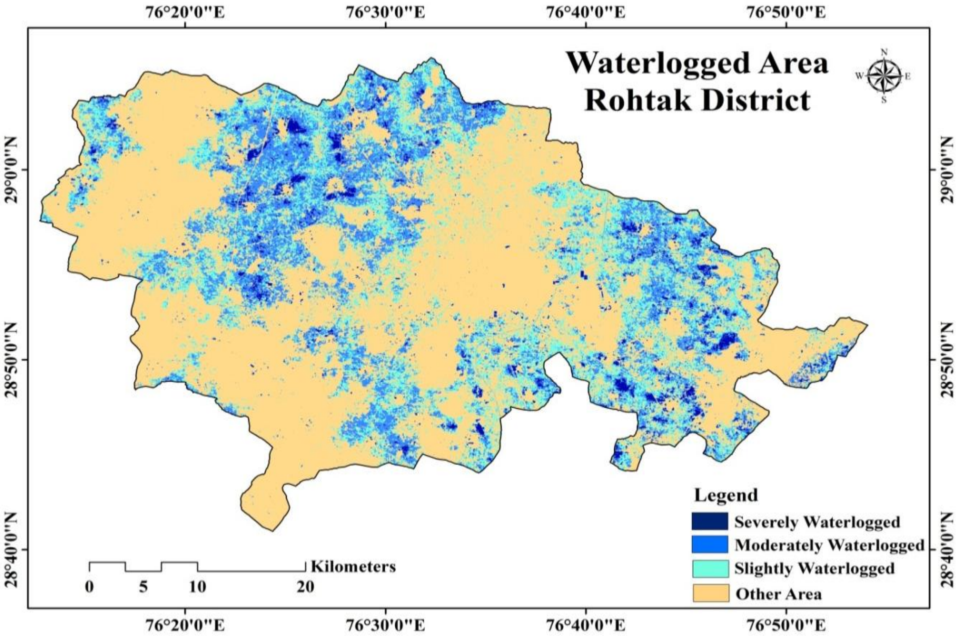

Figure-5: Map of Water logged area of Rohtak District.

The table-3 categorizes land in Rohtak district based on waterlogging severity and area affected. **Severely waterlogged** areas (4,229.4 hectares) are heavily impacted by stagnant water, making them unsuitable for farming but potentially ideal for aquaculture.

Table-3: Categorizes land in Rohtak district based on waterlogging severity and area affected.

Class	Area (in Hectare)
Severely Waterlogged	4229.4
Moderately Waterlogged	27636.4
Slightly Waterlogged	28781.8
Other Area	106644.8
Total	**167292.4**

Moderately waterlogged areas (27,636.4 hectares) face moderate water retention and can be adapted for aquaculture with some water management. **Slightly waterlogged** regions (28,781.8 hectares) experience minimal waterlogging and can support both seasonal crops and fish farming. The **other areas** (106,644.8 hectares) are unaffected by waterlogging, remaining suitable for agriculture and other land uses.

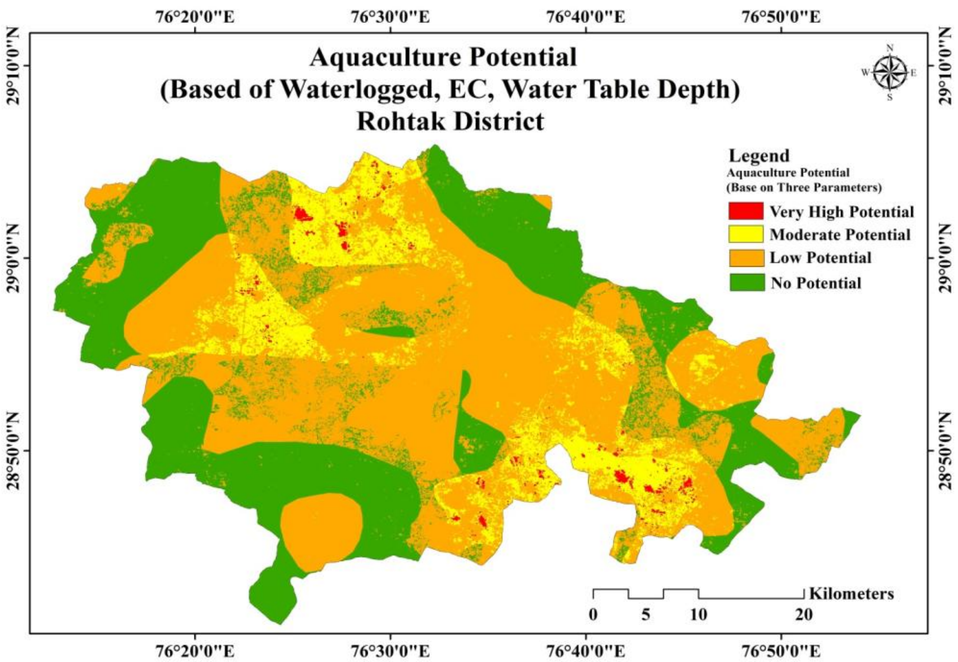

Figure-6: Map of Aquaculture Potential (Base of waterlogged, EC and Water table depth).

The table-4 classifies land in Rohtak district based on its potential for aquaculture, considering factors such as water depth, salinity, and waterlogging, and presents the corresponding area in hectares and percentage.

Table-4: Area and Percentage of Suitability of Aquaculture in Rohtak district.

Aquaculture Potential	Area (in hectare)	Area (in %)
High Suitable	1620.4	1.0
Moderate Suitable	20592.3	12.3
Slightly Suitable	90531.6	54.1
Not Suitable	54548.0	32.6
Total	**167292.4**	**100.0**

- **High Suitable (1,620.4 hectares, 1.0%)**: These areas are the most favorable for aquaculture, with optimal conditions such as ideal water depth, appropriate salinity levels, and consistent water availability due to waterlogging. Though the total area is small (1% of the district), it represents prime locations for aquaculture development with minimal intervention.
- **Moderate Suitable (20,592.3 hectares, 12.3%)**: These regions are moderately suitable for aquaculture, where conditions are generally favorable but may require some water management, such as regulating salinity or controlling water depth. This category covers a larger portion (12.3%) of the district, making it a significant target for aquaculture expansion.
- **Slightly Suitable (90,531.6 hectares, 54.1%)**: The majority of the district falls into this category. These areas are suitable for aquaculture but may present challenges such as fluctuating water depth, inconsistent salinity, or varying waterlogging levels. With some interventions, these areas can still be used for fish farming, but profitability and sustainability may vary.
- **Not Suitable (54,548.0 hectares, 32.6%)**: A substantial portion of the land is classified as unsuitable for aquaculture due to adverse conditions like insufficient water depth, excessive salinity, or lack of water retention. These areas are better suited for other forms of land use, such as traditional agriculture or non-aquatic activities.

Conclusion:

The geospatial analysis of saline waterlogged areas in Rohtak district reveals significant potential for aquaculture as an alternative land use, particularly in regions where traditional agriculture has been severely impacted. Approximately **13.3%** of the district, comprising **highly** and **moderately suitable** zones, offers favorable conditions for fish farming, with optimal water depth, salinity levels, and water retention. However, the majority of the land (**54.1%**) falls under the **slightly suitable** category, where aquaculture is feasible but may require targeted interventions such as water management or salinity control. A notable **32.6%** of the area is deemed **not suitable** due to poor water conditions, highlighting the need for other land-use strategies in these regions.

Overall, this study emphasizes the importance of harnessing the **highly** and **moderately suitable** zones to promote sustainable aquaculture in Rohtak district. By converting saline waterlogged areas into productive fish farming zones, local farmers can diversify their livelihoods, improve water management, and mitigate the negative impacts of salinity and waterlogging. However, the success of these initiatives will depend on ongoing government support, infrastructure development, and farmer training to maximize the benefits of aquaculture in the district.

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