Determining the Suitable zone for Aquaculture, Using Geographical Information system and Remote Sensing methods: Nuh District (Haryana)

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Abstract
The geospatial method of GIS and Remote Sensing techniques were used in this work to map the suitability of several sites for Aquaculture in the Nuh District of the state of Haryana. Aquaculture management is the procedure for gathering information, analyzing it, planning, consulting on it, making decisions, coming up with regulations, and putting them into effect. Breeding, growing, and harvesting fish, shellfish, and aquatic plants are all part of aquaculture. Essentially, it is aquaculture. Aquaculture in the United States contributes to healthier environments, rebuilds stocks of threatened or endangered species, and provides environmentally friendly sources of food and commercial goods. The study's GIS boundary, a 2021 Sentinel-2 satellite picture, digital elevation data, water samples from wells, tube wells, and hand pumps, geospatial data of ground control points satellite imagery, and software from ArcGIS 10.8 and Erdas Imagine were all employed as the study's data sources. The weighted Overlay tool and Union tool were used to weigh four criteria (land cover/land use, EC, pH, and water level). These sites were found to be capable of supporting irrigation ponds as well as aquaculture ponds. The Most Suitable Class covered 20373.60 hectares, or 13.57% of the total area of the land, mainly in and around the built-up region. Aquaculture cannot be located in a built-up region because that is where most academic activities are carried out, thus it is not appropriate. This study consequently established the validity of the integration of GIS and satellite remote sensing for the selection of fish farm sites based on the topography of an area, and it strongly suggests that the entire community be included in its extensive and thorough use.
Keyword: Aquaculture, Suitability, Geographical Information System, Remote Sensing.

Introduction: An initial stage in determining if land, or any other region, is likely to be feasible and beneficial for the sustainable growth of an anticipated endeavor is to conduct a suitability study. Fish farming has frequently been done in places that are unsuitable in terms of the climate, the water and soil quality, and other infrastructure (Richard and Chima, 2016). Fish farming has historically been conducted in places without adopting any scientific and systematic inputs, according to Sahnoor et al(2016) .'s observation. According to Hossain et al. (2007) and William (2014), there is a tremendous need to distribute fish ponds to acceptable places in order to settle competing land use demands, eliminate adverse environmental effects, and assure the operation's profitability.

Fish are raised in ponds (lentic water) in the majority of the world's nations, but sadly, these aquaculturists are not as conscious of the significance of water quality management in fisheries. If they are given the right instructions and made aware of the best methods for managing water quality, they can.

By using low input costs and obtaining a high output of fish yield, they are able to produce the highest fish yield in their ponds. For maintaining a healthy aquatic environment and for the production of enough fish food organisms in ponds to increase fish production, it is important to consider a number of factors, including temperature, transparency, turbidity, water colour, carbon dioxide, pH, alkalinity, hardness, ammonia, nitrite, and nitrate.

In order to effectively collect, store, modify, retrieve, analyse, display, and report all types of geographically related information targeted towards a certain set of goals, GIS is an integrated assembly of computer hardware, software, geographic data, and employees. Physical, social, and economic data can all be handled by a GIS. This information is spatially referenced to the earth and has a similar locational or geographic basis (Karen 2008). Fish farming development planning requires the use of GIS and remote sensing. Moreover, GIS can be used to analyse data, make predictions, and evaluate the effects of different development options before implementing them in the landscape. Additional applications of GIS include effective management, analysis, and storage of both spatial and non-spatial data (Hossain et al. 2007)

Study Area:

One of the 21 districts that make up the northern Indian state of Haryana is Nuh (Mewat). On 4 April 2005, the district was created from the former Gurgaon and Hathin Block of Faridabad districts to become the 20th district of Haryana. Though In 2008, the Hathin Sub Division was moved to Palwal's New District. It is bordered on the north by the Gurgaon district, on the west by the Rewari district, and on the east by the Faridabad and Palwal districts. The administrative centre for this district is Nuh town. The district covers 1859.61 km2 in size. The district has 10,89,263 residents (2011 census). The Meos, who practise agriculture, live in Mewat.

Mewat district is located between 76° 51' and 77° 20' East longitude and 27° 39' and 28° 20' North latitude. Alluvial plains dominate the region, which is divided by long ridges of Delhi quartzites. The district's groundwater is salty, and the salinity rises with depth. The neighbourhood has a low socioeconomic level. Irrigation is not provided for agriculture, the main source of income for the population. There is no river, and the area is drained by the Nuh, Ujina, and Kotla drains, which are man-made. They transfer rainfall into the Yamuna River. Water from the Gurgaon canal is distributed across the locality via the Nuh, Firozpur Jhirka, Uttawar, Mandkola, Hathin, and Chhyansa distributaries.

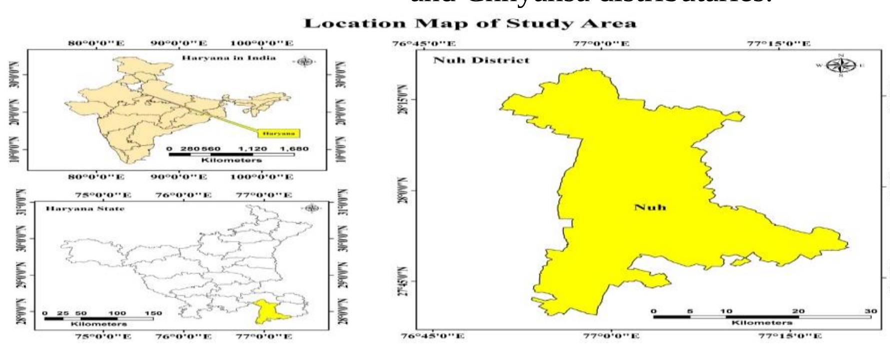

Figure-1: Location map of Study area.

Methodology: The work's technique was carried out in ten (10) stages, including data acquisition, layout stacking, subsetting, categorising, sample collection, lab analysis, union of all suitable and unsuitable parameters for aquaculture, creation of detail maps, and generation of suitability maps (Figure-2).

Sample Collection: The Mewat district's administrative blocks Nuh, Taoru, Nagina, Punhana, and Ferozepur Jhirka all had groundwater samples taken from them (Fig. 2). The groundwater well data from the Public Health Department, Nuh, and the software Google Earth were used to identify the sampling sources. The majority of the groundwater wells in the area are shallow handpumps, tube wells, and excavated wells, with an average depth of 45 metres.

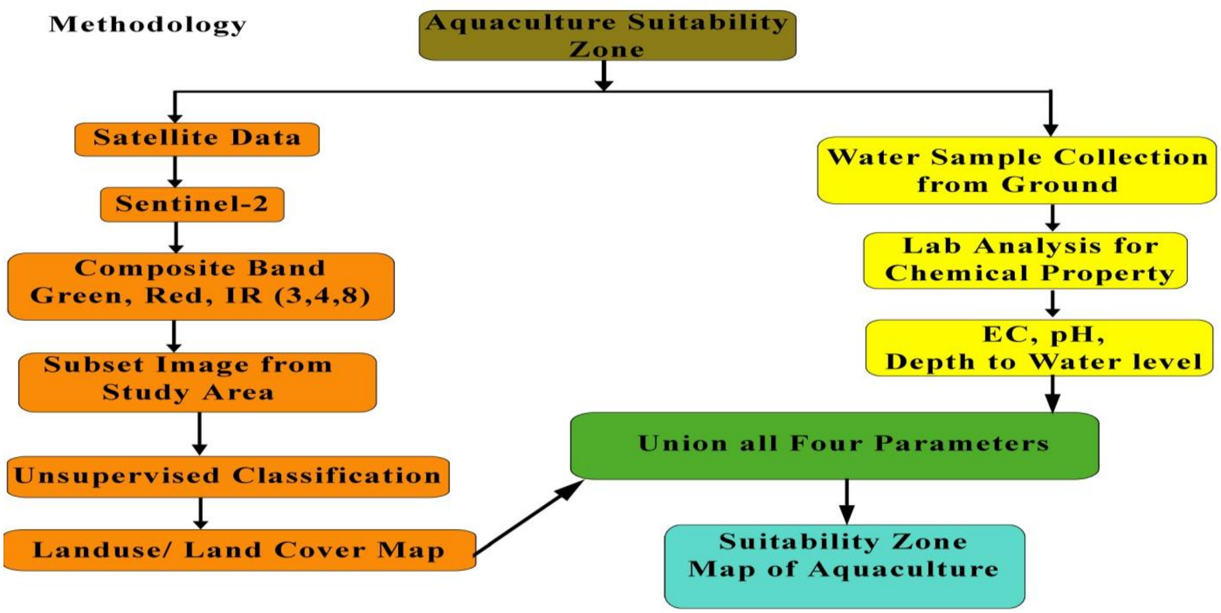

Figure-2: Methodology chart

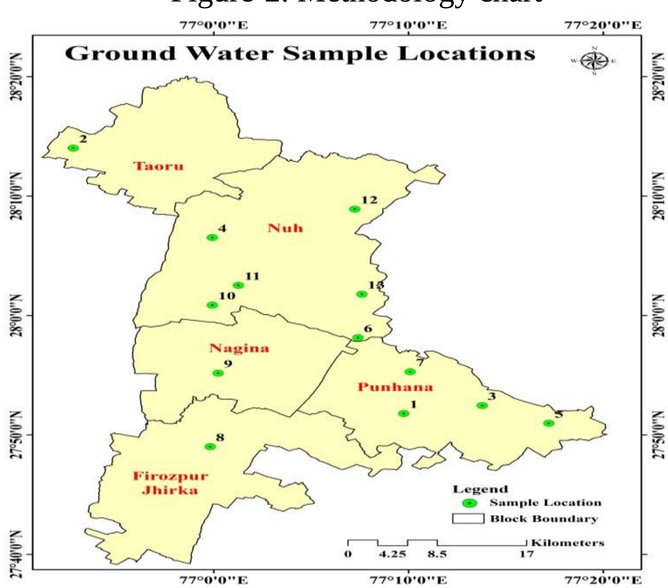

Figure-3: Ground Water Sample Location map of Nuh District.

During sampling, mobile GPS was used to record the GPS latitude and longitude of the sampling sites for spatial reference records and building a database for the creation of spatial distribution maps for different ions (Figure-3). Within three hours of the collection, the groundwater samples were transported to the lab and kept chilled at three degrees Celsius until the chemical analysis was finished.

S. No	pH Value	EC (µS/cm at 250C)	Water Depth m(bgl)	Latitude	Longitude
1	8.07	803	6.5	27.8806	77.1742
2	8.56	635	14.6	28.2334	76.8797
3	8.39	2301	13.9	27.8568	77.2322
4	8.79	3987	8.7	28.1086	76.9988
5	8.08	901	7.3	27.8685	77.3068
6	8.97	3196	2.9	27.9465	77.1426
7	8.99	1594	1.2	27.9213	77.1681
8	8.43	6598	17.6	27.9125	77.0227
9	8.01	14607	8.2	27.9194	77.0037
10	8.92	2900	7.6	28.0143	76.9988
11	7.43	8540	3.6	28.0420	77.0211
12	8.02	2904	1.6	28.1841	77.1049
13	9.60	9068	6.8	28.0295	77.1267

Table-1: Sample Collection & Chemical Analysis Record of Nuh District.

Electrical Conductivity (EC) in Aquaculture:

A solution's electrical conductivity (EC), a measurement of how effectively it conducts electricity, is connected with the amount of salt in the solution. Usually, conductivity is expressed in units of mSiemens/cm (Micro Siemens per centimeter).

Fish from freshwater habitats typically flourish in a variety of electrical conductivity levels. To aid fish in maintaining their osmotic equilibrium, a minimum amount of salt content is preferred.

Fish species have an impact on the upper range. For instance, channel catfish can survive salinities of up to half the strength of seawater. The conductivity of seawater ranges from 50,000 to 60,000 mSiemens/cm.

The total dissolved solids (TDS) in water can also be roughly estimated using electrical conductivity (EC). The TDS value in mg/l is often close to half of the EC (mSiemens/cm).

pH in Aquaculture: The majority of ammonium in water is transformed to poisonous ammonia (NH_3), which can kill fish, at high pH levels (>9). Moreover, fish populations can be greatly impacted by cyanobacterial toxins. In aquaculture, pH is crucial as a gauge for how acidic the water or soil is. Fish cannot endure prolonged exposure to waters with pH values over 11 or below 4. Fish require a pH of between 6.5 and 9. At continuously higher or lower pH values, fish will grow slowly and their ability to reproduce will be hampered.

The Effects of pH on Warm-Water Pond Fish	
pH Value	**Effects on fish**
4	Acid death point
4 to 5	No reproduction
4 to 6.5	Slow growth
6.5 to 9	Desireable ranges for fish reproduction
9 to 10	Slow growth
≥11	Alkaline death point

Table-2: The Effects of pH on Warm-Water Pond Fish (Source -5)

Depth to Water Level: In order to estimate the value of ground water level, we use sample collecting data that was collected from the ground. Depth to water level is a highly significant characteristic for determining suitability for aquaculture (Table-6). The extremely upper level water is ideal for aquaculture since it is often available, while the lower level water is rarely available because it is not ideal for aquaculture.

Classification of Satellite Images For LULC: Using pixel-based categorization, the Sentinel-2 2021 satellite image was added to the active ArcGIS and Erdas Imagine environment to determine the land use and cover of the research area. Since the Sentinel imagery used included the entirety of Palwal, Nuh and Gurugram, the research area (Nuh District) had to be separated from it.

The "extract by mask" option in the spatial analysis tool was used to extract the study region from the shapefile of the boundary. The retrieved Landsat imagery, which only covered the research area, was hazy though due to the 10 m spatial resolution of the Landsat image. In order to improve the spatial resolution of the image, a higher-resolution panchromatic image (or raster band) was fused with it using the "make Pan-sharpen Raster Dataset" function in Arctoolbox. This procedure of enhancement aids in raising the quality of the feature as well as the image quality. The classification (ISO Cluster Unsupervised Classification) was then performed on the generated raster image, which was a multiband raster dataset with the resolution of the panchromatic raster and where the two rasters entirely overlapped. Without using any training samples, this classification assists in extracting information from satellite images. Although incorrect training samples cannot be chosen, this is quicker and much more accurate. Moreover, accuracy assessment was no longer essential because of this.

The study region has four different forms of land use/land cover: Built Up, Canal / Drain, Crop Lands, Desertic Sandy Area, Forest Plantation, Grasslands and Grazing Land, Lake / Pond, Mining / Quarry, Salt Affected Land, Scrub Land, Transportation and Waterlogged Area. Since the site's topographic suitability is the element being taken into consideration, the water body was omitted.

Creating suitable Zone maps: Four parameters were employed in the weighted overlay analysis for the suitability map: land cover/land use classification, EC, pH, and a map of the research area's water depth. In this scenario, choosing an appropriate site for aquaculture, weighted overlay analysis allows factors to be integrated and weighted to solve multi-decision issues. The values assigned to the EC, pH, water depth, and LULC classifications were used to create the suitability map (Table 7). The appropriate map was converted from raster to polygon using the "conversion tool" in order to extract the region covered by each class. To aid users in locating the locations that are ideal for aquaculture, the detail map was also placed on the suitability map.

Result and Discussion:

Charts of the study area's suitability, land use, and land cover:

The study region was divided into several categories based on the land cover/land use classification scheme: Builtup, Canal/Drain, Crop Fields, Desertic Sandy Area, Forest Plantation, Grasslands and Grazing Land, Lake/Pond, Mining/Quarry, Salt Affected Land, Scrub Land, Transportation, and Waterlogged Area (Fig-3). The built-up areas reflect land use areas, while the barren land symbolises abandoned paddy fields and agricultural regions. The dense vegetation depicts dense jungles with tall trees, the light vegetation represents grassland areas, and the built-up areas represent areas that have been abandoned. Because it did not play a significant role in the study, the water body was not classified.

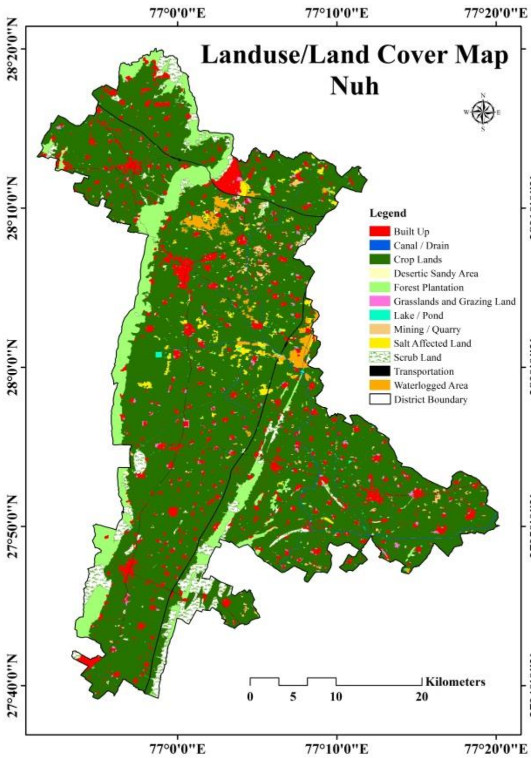

Figure- 4: Landuse/ Land Cover Map

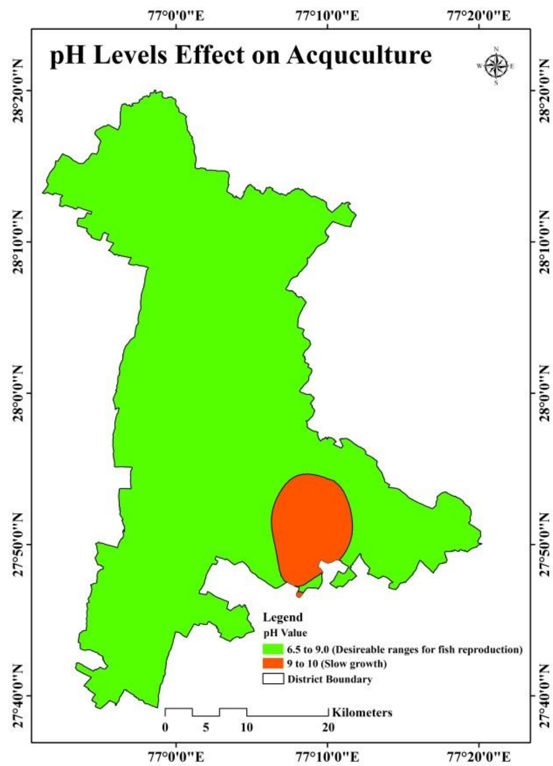

Figure- 5: pH Level effect on acquculture Map

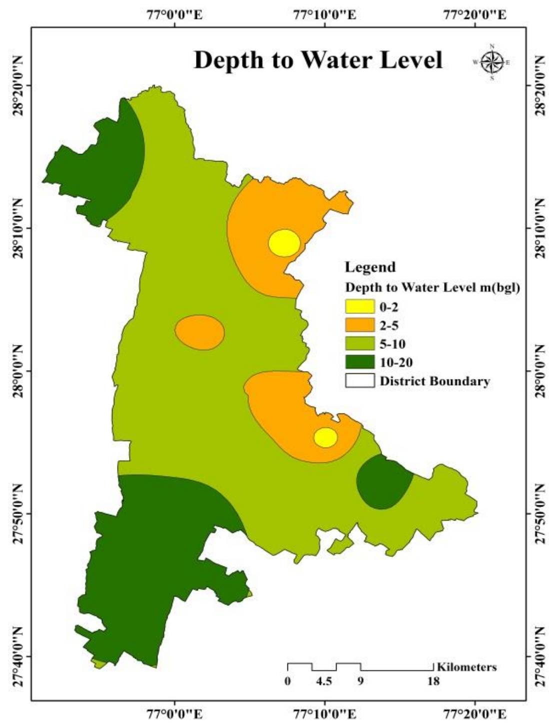

Figure- 6: Depth to Water Level Map

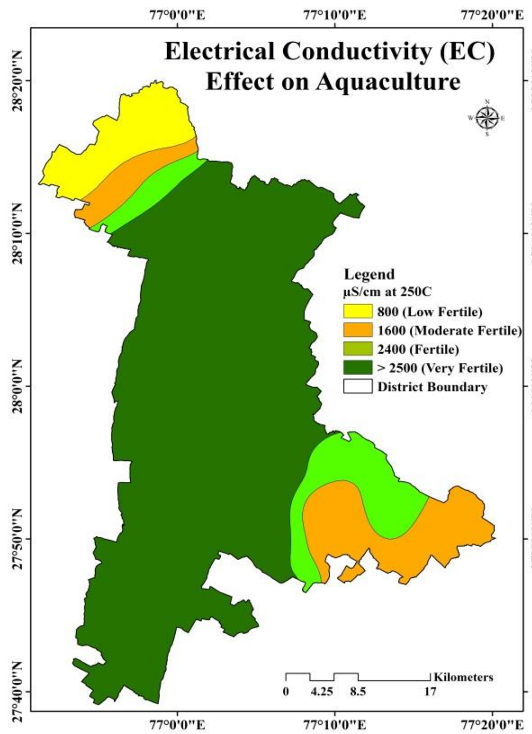

Figure- 7: EC effect on Aquaculture Map

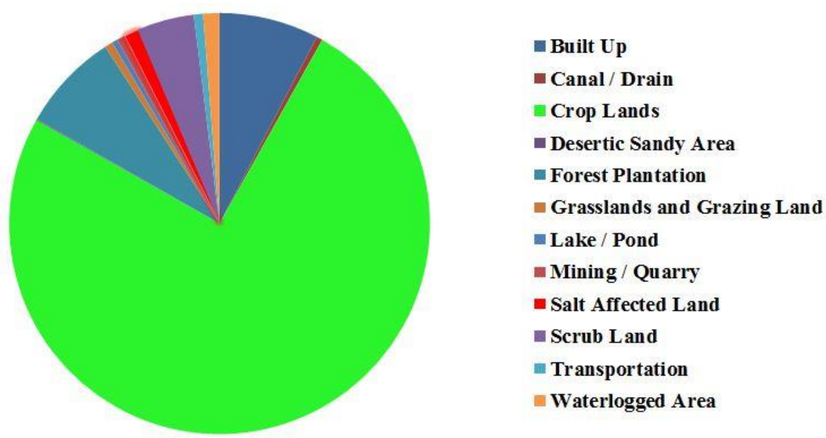

Figure-8: Landuse Land Cover Area pie Diagram.

Landuse/Land Cover Class	Suitability	Area (In Hectare)
Built Up	Not suitable	11479.87
Canal / Drain	Not suitable	705.29
Crop Lands	Suitable	112664.12
Desertic Sandy Area	Suitable	115.42
Forest Plantation	Not suitable	11413.18
Grasslands and Grazing Land	Not suitable	910.36
Lake / Pond	Suitable	675.39
Mining / Quarry	Suitable	918.83

Salt Affected Land	Suitable	1657.40
Scrub Land	Suitable	6624.02
Transportation	Not suitable	1067.26
Waterlogged Area	Suitable	1865.58

Table-3: Suitability Zone according to Landuse/Land cover

On the other hand, Table 3 displays the types of land use and land cover. The highest amount of agricultural land is 112664.12 hectares, while the built-up area is 11479.87 hectares. Waterlogged area is 1865.58 hectare which the very usefull for the aquaculture. Other category is very small in amount.

EC Value (µS/cm at 250C)	Class	Area (in Hectare)
800	Low Fertile	9905.43
1600	Moderate Fertile	17809.28
2400	Fertile	13326.00
>2500	Very Fertile	109050.44

Table-4: Suitability Zone according to Electric Conductivity (EC)

If we see the table-4, At 250°C, the range of EC, a key indication of dissolved mineral content, is 800 to >2400 S/cm. Just 9905 hectare area with EC Less than 800 s/cm, compared to 109050.44 hectare area with EC between >2500 s/cm.

pH Value	Class	Area
6.5 to 9.0	Desirable ranges for fish reproduction	141030.13
9 to 10	Slow growth	9060.99

Table-5: Suitability Zone according to pH Value

If there are enough hydrogen ions (H+) in the water, it will either be acidic or basic. The pH scale, which spans from 1 to 14, is used to measure the level of acidity. Values below 7 are regarded as acidic; values above 7 are seen as basic. A value of 7 is considered neutral, neither acidic nor basic. Normal pH tolerances for fish culture are in the range of 6.5 to 9.0 (Table-5).

Water Depth	Class	Area (in Hectare)
0-2	Very High Suitable	1519.13
2-5	High Suitable	21904.16
5-10	Moderate Suitable	86477.61
10-20	Low Suitable	40190.21

Table-6: Suitability Zone according to Water Depth.

Since it is frequently available, the considerably upper level (1519.3 Hectrare) water is appropriate for aquaculture while the lower level water (40190.21) is less suitable and is therefore rarely available (Table-6).

The suitability map (Figure 8) displays the areas that are most suited for aquaculture (in yellow colour), Moderate suitable (in Orenge colour), Low suitable (Green colour).

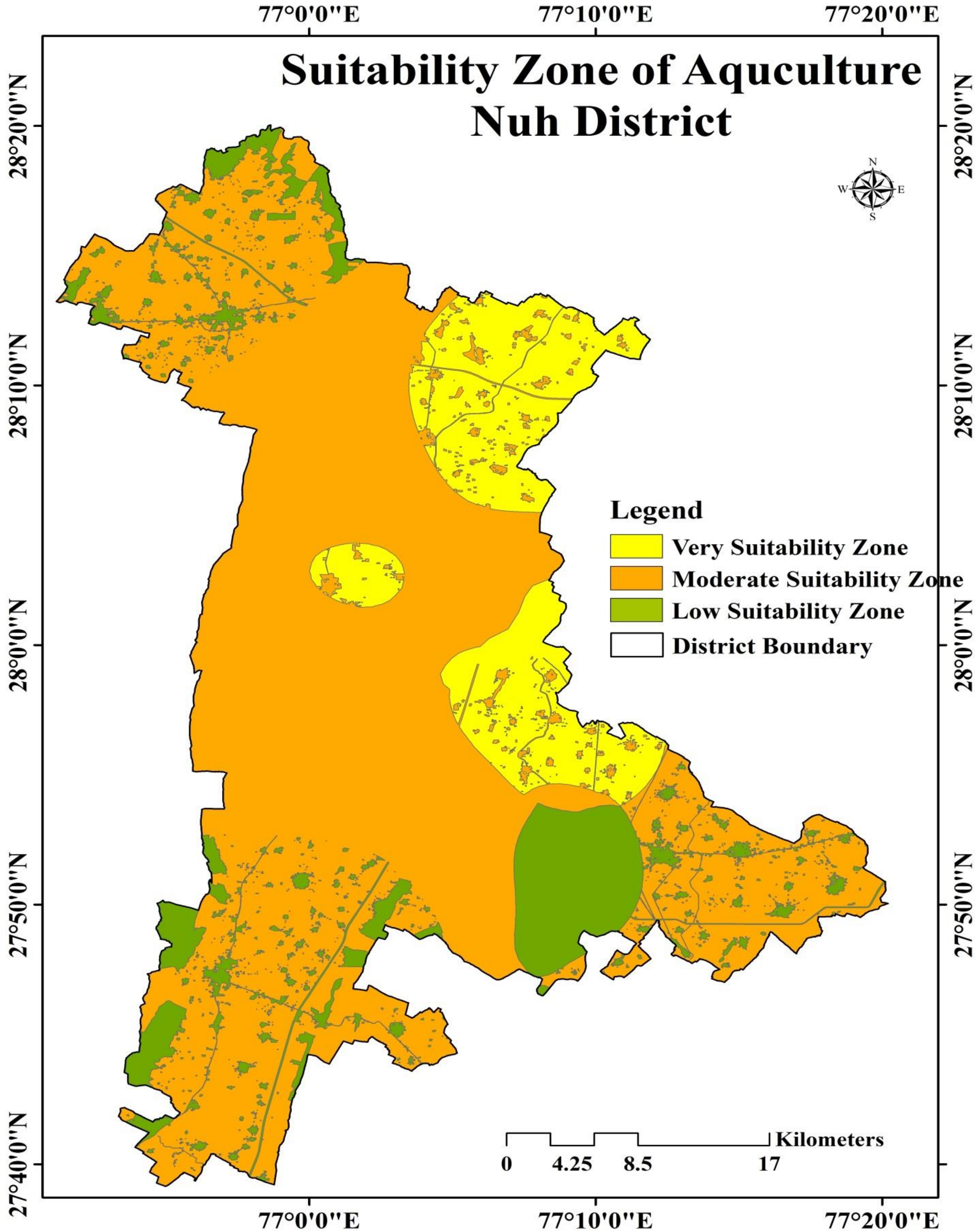

Figure-9: Suitability Zone of Aquaculture Map of Nuh District.

Class	Suitability Zone	Area (in Hectare)
1	Very Suitability Zone	20373.60
2	Moderate Suitability Zone	112341.87
3	Low Suitability Zone	17376.94

Table-7: Suitability Zone for Aquaculture area of Nuh District.

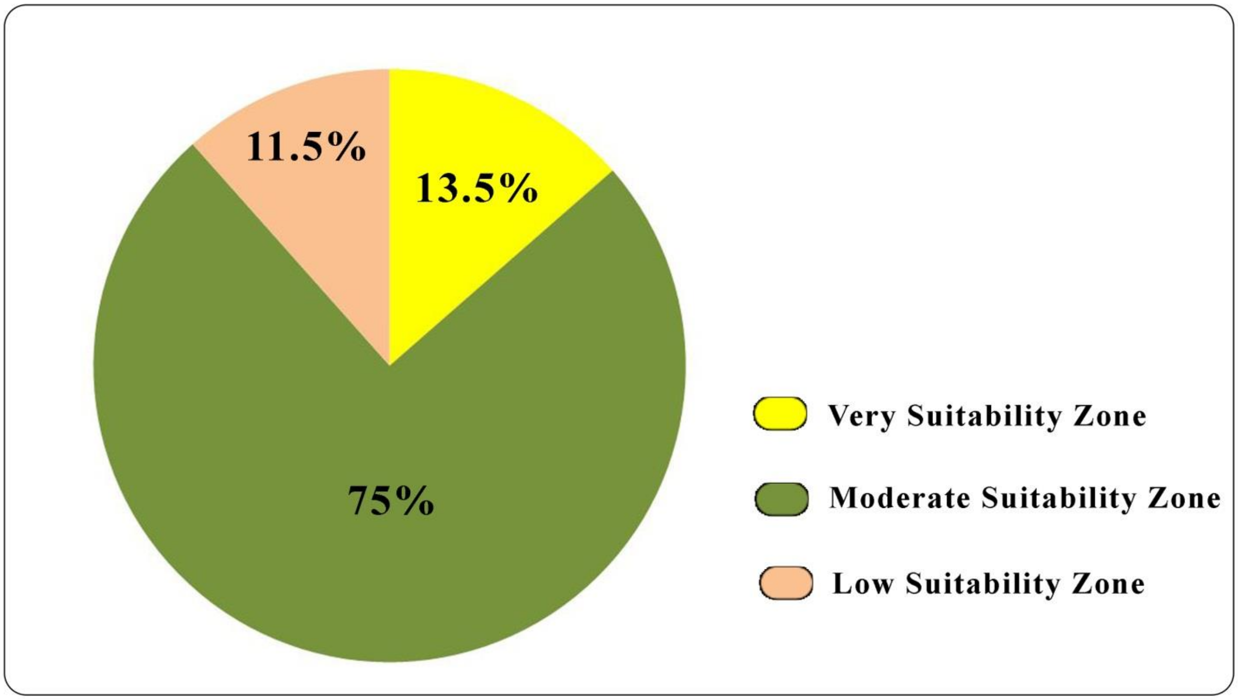

Figure-10: Suitability Zone for Aquaculture pie Diagram.

Figure 10 displays the research area's appropriateness as a percentage. The areas that are very suitable covered an estimated area of 20373.6 hectares (13.5%) of the total area (150092.4 hectare), the areas that are Moderate suitable covered an estimated area of 112341.8 hectares (75%), the areas that are Low suitable covered 17376.9 hectares (11.5%), mostly in and around the built-up area that serves as the area where academic activities are performed most frequently and areas of thick vegetation and rocky area (Figure 4).

Because the built-up area is also intermingled with other landcover classes, it is noticeable that all classes of suitability—from the least to the most—are present.

Conclusion:

The appropriateness of the study region for aquaculture was assessed using the integration of GIS and remote sensing technology. Planning and decision-making for the construction of aquaculture ponds for aquaculture as a means of making money can be aided by the numerous geospatial data generated and the analysis offered. These data serve as resources for numerous studies aimed at enhancing aquaculture in the study area.

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