Mapping waterlogging and salinity using satellite data and Geographical Information System (GIS): A Case Study of Nawabshah city Sindh Pakistan

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Abstract— Waterlogging and salinity have become major issues in Nawabshah. Geographical Information System (GIS) and Remote sensing (RS) methods were very helpful in mapping and representing regions of waterlogging and salt-affected soils. Various data sets derived from satellite data were employed to carry out this investigation. This study also utilized index-based techniques that combined remote sensing data with GIS. Salinity and waterlogging were identified using images band ratios with predetermined combinations of several spectral parameters. Salinity Index 1 (SI1) and NDWI (Normalized Difference Water Index) were used to generate satellite image-based induces to determine the right pattern of soil salinity. The influence of waterlogging and salinity on agricultural fields was investigated in this study. Data from Landsat 5TM from several years was used for this purpose. In addition to using remote sensing data Landsat 5TM 2009 and 2011 images for this purpose, find salinity and waterlogging affected areas in nawabshah's Pakistan where approximately 0.7% and 11% are waterlogged and unproductive lands, and the size of salt-affected areas is increasing, posing a threat to agricultural sustainability. The maps and research approaches may also be utilized for a more in-depth investigation of any location with the same problem using specified criteria.

Keywords: Satellite Data, GIS, Soil Salinity, NDWI, Waterlogging, SI_1

I. INTRODUCTION

Waterlogging and Soil salinity are both major environmental issues in many nations across the world, particularly in dry and semi-dry regions such as Sindh, Pakistan. These issues have a significant impact on soil fertility, which has a substantial impact on soil productivity. Pakistan covers 79.6million hectares, including 22.0 million hectares under cultivation. Within the irrigation zones, there are 6.28 Mha impacted by salinity and waterlogging. Soil salinization is a contemporary global concern that is wreaking on our limited soil resources and damaging ecosystem health. The rapid evaporation rate, the high water table, and the high water-soluble salt concentration because the rapidly rising population's desire for food and living materials put an enormous strain on already damaged soil resources, salty lands have been recovered for agriculture activities, and the requirement for irrigation water has surged.

Remote sensing data has enormous potential for monitoring dynamic processes such as salinization. The capacity to reliably identify soil salinity from remote sensing data is crucial since it saves labor, time, and effort. In comparison to traditional approaches, satellite remote sensing technology offers significant benefits in viewing the ground at vast geographical scales and high temporal resolution. It can also offer spectral information on soil salinization and waterlogging at short temporal intervals. Many satellite remote sensing data with moderate to high geographical and temporal resolution are available, opening up new possibilities for mapping the spatial distribution features of soil salinization employing soil mapping techniques. The integration of satellite data from several years with considerable variation in salinity and the waterlogging region was obtained.

The study may be used as a reference for further research on salinity and waterlogging in the area, and it can be performed in other places. Various scientific characteristics will be necessary for a complete research mapping and monitoring of the influence of salinity and waterlogging on agriculture, which will involve time, money, and workforce.

II. METHODOLOGY

A. Study Area

Nawabshah is a city in Sindh province, Pakistan, and the administrative center of the Shaheed benazirabad district between the longitude of 68°24'35.95"E and latitude 26°14'39"N. This city is located in the heart of Sindh province. The total geographical area of the city is 4,239 km^2. Nawabshah receives 129 mm of precipitation every year.

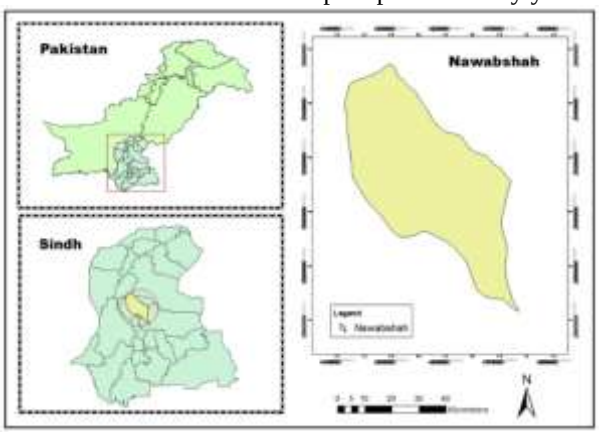

Fig. 01: Location map (Nawabshah)

B. Satellite Data

This study made use of two Landsat 5 TM images taken in years 2009 and 2011. the images path/row ratios were 152/42 and 152/42, respectively, and cloud cover was much less than 10% in both satellite images and spatial resolution approximatively 30m used in this research. The atmospheric correction using ArcGIS was used to reduce the influence of atmospheric scattering on the quality of satellite imagery.

C. Indices

Indices were used to identify the spectral bands in general. It is a very effective technique for classifying aspects of interest. The indices of salinity and waterlogging used for change in salt-affected and waterlogged areas were determined.

The following key indicators were calculated to identify waterlogging and salinity:

$$SI1 = Salinity\ Index\ 1 = \left(\sqrt{R + NIR}\right)$$

$$NDWI = Normalized\ Difference\ Water\ Index = \frac{(G - NIR)}{(G + NIR)}$$

D. Image classification

The classification was to distinguish between salt-affected regions and cropped areas in various years to eliminate the impact of the environment sun zenith angle, and sensors on reflectance, each image was identified separately using training specimens were collected from relevant statistics.

III. RESULTS AND DISCUSSION

Spatial Trend in Soil Salinity:

Salinity showed high reflection in the red band and lower reflection in the near-infrared band of the imagery in the saline locations. The salinity index 1 (SI_1) accurately recognized salt-affected soils. Soil salinity trend increases concerning time. In 2009 salinity values were low in the study area in 2011 salinity increased. The Salinity Index 1 accurately recognized salt-affected soils. Salinity Index 1 map of the area is shown in Fig. 3

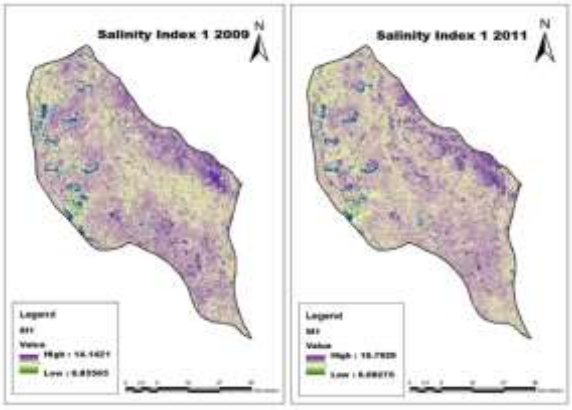

Fig. 02: Salinity Index 1 map of (2009-2011)

SNO:	Year	Minimum	Maximum	Mean
1	2009	6.8	14.1	10.45
2	2011	6.0	16.7	11.35

Table 01: SI_1 Values

A. Spatial Trend in Waterlogging

The NDWI index is best suited for mapping water bodies. The water body is very absorbent and emits little radiation in the visible to infrared wavelength range. Based on this occurrence, the index employs the green and near-infrared bands of remote sensing images. In most circumstances. The NDWI may successfully increase water information. It is sensitive to build-up terrains and frequently leads to overestimated water bodies.

Figure 3: was used to identify maps of the NDWI in water bodies in the research region. The values in 2009 were 0.28 and -0.60, respectively, and increased 0.48 and -0.64 in 2011. That means the water bodies increased in the time during 2009-2011. Waterlogged areas doubled due to the increased salinity and poor drainage system in the study area and also vegetation is decreased.

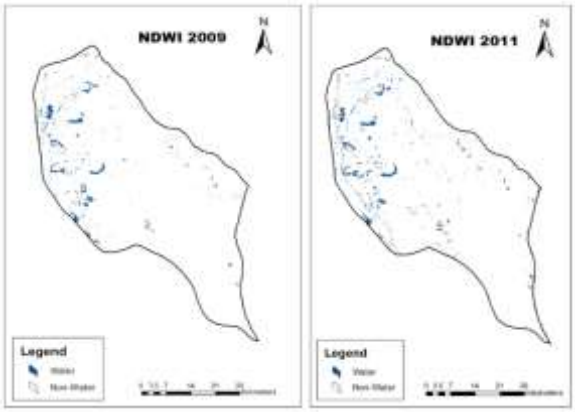

Fig. 03: Classified Satellite Images of NDWI (2009-2011)

SNO:	Year	Minimum	Maximum	Mean
1	2009	-0.60	0.28	-0.16
2	2011	-0.64	0.40	-0.12

Table 02: NDWI Values

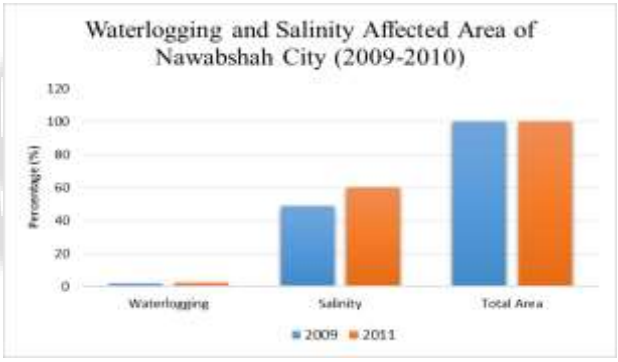

Fig. 04: Waterlogging and salinity Affected Areas (2009-2011)

Figure 4: displays the temporal trends in waterlogged regions in (Nawabshah) from 2009 to 2011. There is a significant tendency in waterlogging, with the waterlogged area increasing from 1.8 percent to 2.5 percent between 2009 and 2011. This signifies that the amount of waterlogged expanded within one year.

Validates the variety in a temporal change in salinity in the studied region (Nawabshah) between 2009 and 2011. There is a significant variance in soil salinity. Salinity climbs 49 percent to 60 percent, implying that salinity grows after one year.

IV. CONCLUSION

Waterlogging and Soil salinity are severe environmental issues, particularly in dry and semiarid regions.it can occur spontaneously or be produced by a human. Soil salinity has a detrimental impact on crop growth and production, ultimately leading to land degradation. According to the findings, the total salinity in the area has increased by 11% the NDWI reveals that the index of 0.7% increased wet area, supporting the classification's validity. Landsat level-1 aerial imagery

from 2009 and 2011 was used to detect any temporal fluctuations in the soil salinity and waterlogged regions in the study area under salt-affected soil. Salinity and waterlogging indices were calculated using ArcGIS 10.8.1 software. Based on an examination of the years 2009 and 2011, it is clear that the tendency of saline regions in the research area has been increasing over time. Salinity peaked in 2011 as a result of salt range and saline water. The proposed study's major goal is to control waterlogging and salinity.

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