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ASSESSMENT OF FARMING RESOURCES AND CHALLENGESIN NAINI, INDIA USING LANDSAT AND GIS

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ABSTRACT

The present study investigates farming resources and challenges in the Naini region in Allahabad, India, using Landsat satellite data and Geographical Information Systems (GIS). About 66% of the Naini region is agricultural land, and kharif and rabi are the major seasons for growing crops. The Ganges River is the main source of irrigation and provides water to the nearby agricultural lands in the form of canals and reservoirs.The data in this study come from satellite data analysis, intensive field visits, and data collection from the regional office of the Central Ground Water Board in Allahabad. Orthorectified Landsat data were utilized to determine the crop distribution and soil types in theNaini area. Crops grown and their irrigation sources were determined from farming site visits. In addition, water table conditions in pre-monsoon and post-monsoon seasons were analyzed and mapped. A continuous depletion of groundwater in the Allahabad region was detected becausemost people depend on groundwater for their daily purposes. The decline in groundwater levels averaged 0.62 meters annually and led government officials to initiate the use of a rooftop rainwater harvesting plan. The main challenge for farming remains the usage, quality, and management of water resources. Rivers are polluted by industrial waste, municipal sewage, chemical fertilizers, and human remains. To mitigate the problem, the use of fertilizers should be controlled and farmers should be encouraged and educated about organic farming, which increases crop production without depleting natural resources. Human corpses should be burned or buried, not thrown in the rivers. Finally, in order to

make the best use of water resources in Naini, the region must undergo watershed management, rainwater storage, and water recycling and reuse.

KEYWORDS- FARMING RESOURCES, GIS, LANDSAT, SUSTAINAILITY, WATER SUPPLY

1. INTRODUCTION

Agriculture playsan important role in the economic development of a country. In Naini, farming is of vital importance because it is the main source of food production and food security. Agriculture production varies depending on the geographical location, climatic uncertainty, irrigation system, land use practices, and types of soil. In this study, farming resources such as crop distribution, soil types, water resources, and irrigation methods in Nainiwere investigated. Challenges to farming practices such as land pollution, surface water contamination, and groundwater over exploitation were examined. Kharif and Rabi are the two major seasons in the area and their crop lands dominate the study.

The Naini area is located in the Allahabad region, in the state of Uttar Pradesh. It has an area of about 43,900,000 square metersthat is considered underdeveloped. Roughly 66% of the areais agriculture, 0.22% is built up land, 15% is scrub, about 12% is water, and the remaining 6.78% is waste and fallow land. The built up land consists of urban development and rural villages. Fallow lands are lands left empty by the farmers for fertility recovery. Waste lands are barren and uncultivable areas, whereas scrub lands are vegetation-and shrub-dominated lands. Figure 1 displays the land distribution of the Naini region using Landsat ETM+ data downloaded from the USGS site [1] and interpreted in Arc GIS 9.2. The average elevation of this area is 96 m, and the temperature drops to 15 ^{o}C in December and January and rises up to 35 ^{o}C in May and June. The maximum rainfall in the area is in the month of July and reaches up to 310 mm [2].

Crop distribution of the study area is assessedusing Landsat imagingwith extensive field visits. On-screen visual interpretation techniques using tone, texture, association shape, size, pattern, shadow and locations are used to classify the area in different crops. Rabi crops are known as winter crops and Figure 2 displays the major crops of the area: mustard, sugarcane, vegetables and wheat. Sugarcane is widely grown in the crop land in the west region of Naini, whereas vegetables are least grown in Naini as compared to other crops. Crops are provided with canal, river and groundwater sources of irrigation to thrive. Figure 3 displays the kharif crop land in the Naini area. Kharif crops are also known as monsoon crops. These crops are grown in the beginning of July, and include maize, rice, and legumes

as the major crops grown in this season. Other crops grown in this season are pearl millet, cereals and sorghum, which require high amounts of water to thrive. Farmers depend on the monsoon climate for irrigation ofthese crops, but in some cases farmersprovide irrigation byother means such as canals, groundwater and rivers.

2. RESOURCES

2.1 Soil Types

A hard copy soil map of India was downloaded from maps of India [3]. Each map is scanned and georeferenced with respect to the earth surface. A georeferenced map provides the information about the features prevailing in the area and details of latitude/longitude for the study area. The latitude and longitude were further used to subset the study area. After that, various shape files were created and attributes to the various soil types were assigned. Arc GIS 9.3 Software has been used for this work. The main soil textures found in Allahabad are sandy clay, sandy clay loam, silt and silt loam.Sandy clay soils are fertile and acidic in nature but are poor in water drainage capacity. These lands are well irrigated for agriculture.Sandy clay loam soils are dominating in nature,and clay and loam give sufficient structure to the soil. These lands need frequent irrigation and fertilization in order to support the crops grown in these areas.Silt soils have smaller pore spaces thatdo not support the biological activities present in soil or water and air infiltration. In silt loam soils, silt has the most dominating characteristics and the soil shows sufficient attributes of structure and integrity. Figure 4 displays various soil textures in Allahabad region including Naini.

2.2 Irrigation Methods

Irrigation is one of the most important factors for agriculture. Irrigation methods used in the Naini area varydepending on the types of soil and crops grown. Sources of irrigation include canal irrigation, rainfall, open sewage water, closed sewage water pipes, river irrigation, and groundwater with submersible pump. Table 1 shows the different crops grown on different types of soil and the irrigation method used. This data was collected from a personal inspection of the areas.

2.3 Groundwater

In the water cycle, groundwater is an important constituent. Groundwater helps in the formation of sedimentary rocks by acting as a cementing agent. It isa major source of drinking water in urban as well as rural parts of India. Apart from the drinking water use, it is an important source for the agriculture and industry sector. The ground elevation and the

groundwater present in this area in pre- and post-monsoon conditions also are included and the flow of groundwater in both pre- and post-monsoon conditions is describedin order to study the groundwater scenario in Naini.

Ground elevation data of the study area were collected by using handheld 12 channel GPS (Global Positioning System) equipment during surveying of the site. Figure 5 displays the ground elevation points in the Naini region. These elevation points play an important role in the study of groundwater since groundwater flows from high elevations to low elevations. The two points in the south of the Naini region (157 m and 123 m) are at a higher elevation than the rest of the area because of the Suhagi hills. Most of the low elevated areas are present in the middle part of the Naini region.

Water table depth during pre-monsoon and post-monsoon periods for different places was collected from the Central Ground Water Board in Allahabad. The well locations were plotted on the map. The wells should be adequate in number and well distributed within the area. Therefore special interpolation techniques through Inverse Distance Weighted (IDW) approach using Arc GIS 9.3 wereused in the present study in locational distribution of water depth for pre- and post-monsoon. This method is used to select sets of sample points for estimating the output grid cell value. Afterwards, water table maps were developed.

Figure 6 shows the pre-monsoon groundwater level in the Naini area. In the given figure, the groundwater flow is the greatest from the south region to the middle region of Naini. In the north, south and east regions, the river flows along the edges of the Naini area. As the groundwater flows from these regions to the middle part of the area, the groundwater level decreases. A large amount of groundwater comes from the south due to the junction of the Tons and Belan Rivers. In the case of pre-monsoon, the groundwater is moving from high to low levels towards the major rivers in the north, the Ganges and Yamuna Rivers. The elevation points are much closer in the south than in other areas,which means the flow of groundwater is greater in the south. The source of groundwater in pre-monsoon season is from the south region of Naini.

In case of post-monsoon (Figure 7), the groundwater level increases more than in the case of pre-monsoon in the middle part of the Naini area. In post-monsoon conditions, the groundwater comes from the south and north too, but the flow of the groundwater decreases in the south compared to the pre-monsoon case. In most of the areas, the groundwater flow from high to low is decreased. The middle part of the Naini area receives groundwater from both the south and north in the case of post-monsoon conditions.

3. CHALLENGES

Farming practices in Nainiare subject tomajor challenges. Land pollution, surface water contamination, and ground water overuse threatens the sustainability of farming in the area. Land and water sources of pollution include heavy metals, animal bathing, excess use of fertilizers and human remains.

3.1 Land Pollution

Currently, there are many crop-growing farmlands in Naini that continuously receive sewage water for irrigation. Sewage water contains appreciably high amount of nitrogen, phosphorous, and potassium, which significant increaseslevels of these chemicals in the soils. Similarly, agricultural lands thatare being irrigated by these waters show the presence of micronutrients like iron and zinc, and an increase in the concentration of heavy metals like lead (Pb) and cadmium (Cd).In addition, farmers in direct contact with sewage water can be affected through facial or oral transmission pathways and also can have contact with disease vectors. People consuming such crops can be at risk of developing a foodborne illness such as E. coli, Salmonella spp., and Cryptosporidium [4].

3.2 Excess Use of Fertilizers

Nitrogen, phosphorous, and potassium (NPK) doses are given in excess to the crops in Naini and the surroundings to maintain fertility of the land and to provide rapid growth and high yield of crops [1]. However, in some cases, these fertilizers arewashed away due to excess irrigation, which causes the nitrogen present in the NPK dosesto settle near the plant roots. When NPK doses are given in large amounts to the plants, they can alter the chemistry of the soil. In fact, nitrogen levels affect soil pH because the ammonium ions increase soil acidity. Therefore, a greater nitrogen fertilization rate causes greater acidification as ammonium is converted to nitrate in the soil and hydrogen ions are released [5].Higher levels of acid make the soilless fertile. In such cases, the soil should be neutralized often in order to maintain its fertility. Additionally,these heavy concentrations can reach the groundwater and pollute it. Similarly, heavy rains can carry the excess amount of NPK and runoff can contaminate the surface waters [1].

3.3 Surface Water Contamination

Surface waters are not only contaminated by fertilizers from runoff; social and religious practices are also major contributors of river pollution. Animal bathing activities in the river release various species of intestinal worms, bacteria, fungi and viruses into the

water. Their presence in water remains unnoticed in many cases. In humans these pathogens can cause infectious diseases [6]. Another source of surface water pollution is human remains, which are being dumped in surface waters as a ritual. These rituals are performed in order to purify the soul of a deceased person. These activities also release harmful pathogens into the water. As a result their use can spreadinfectious diseases to humans and also cause harmful effects to the soil [7].

3.4 Groundwater Exploitation

With most peopledepending on groundwater for their daily purposes, a continuous depletion of groundwater in the Allahabad region was observed.There are a total of 2,680 locations of groundwater extraction present in the Allahabad area. The decline in groundwater levels ranged from 0.6 to 1.2 meters, with 0.62 meters decline annually on average. Due to the poor groundwater situation in these urban lands, government officials have initiated the use of a rooftop rainwater harvesting plan [8]

FIGURES AND TABLES

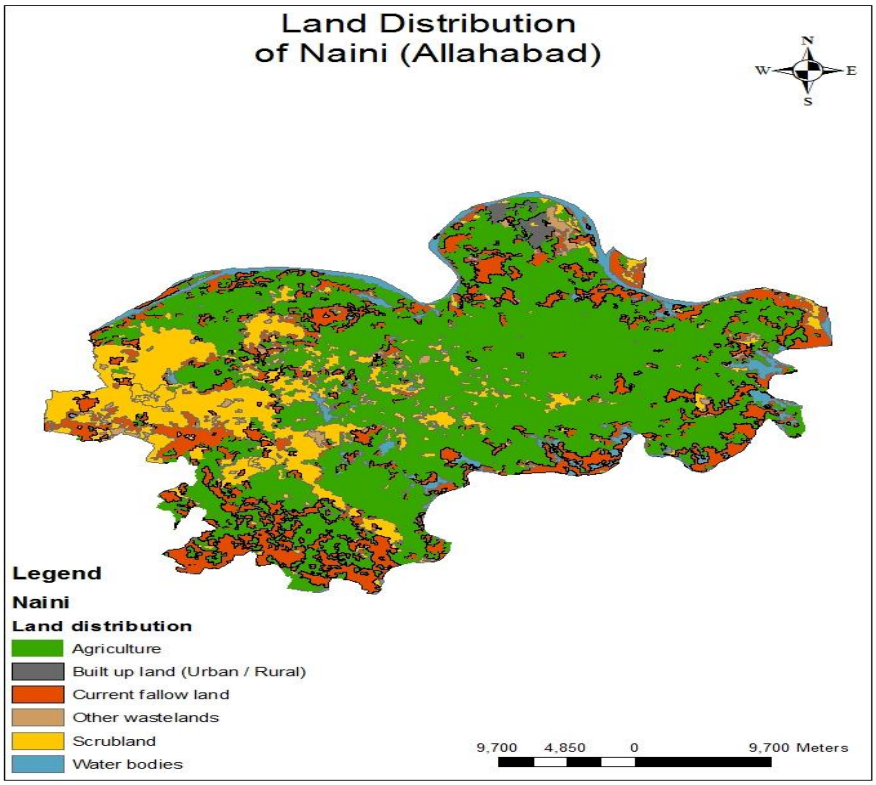

Figure 1 - Land Distribution of Naini

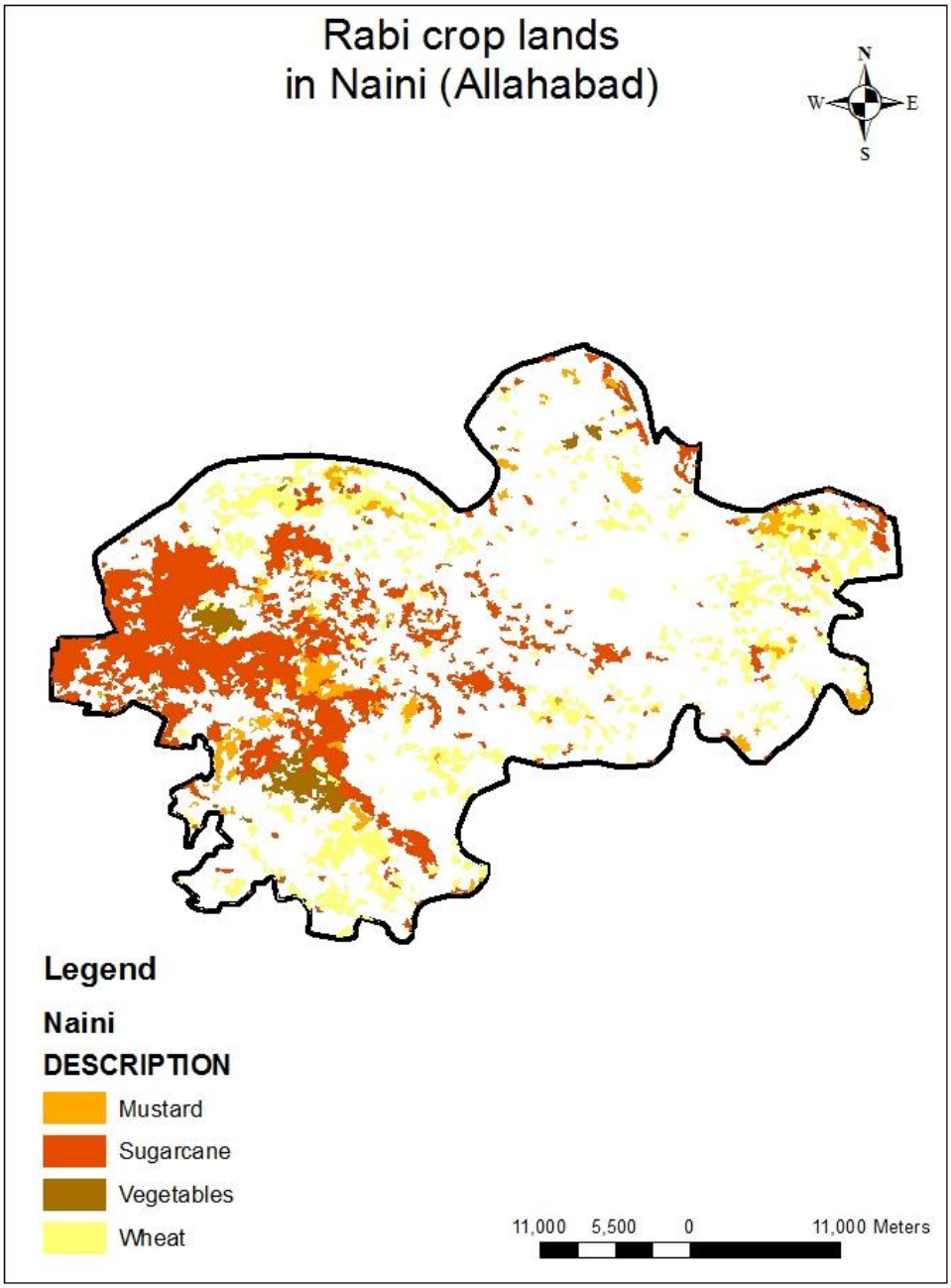

Figure 2 – Rabi Crop Land in Naini Region

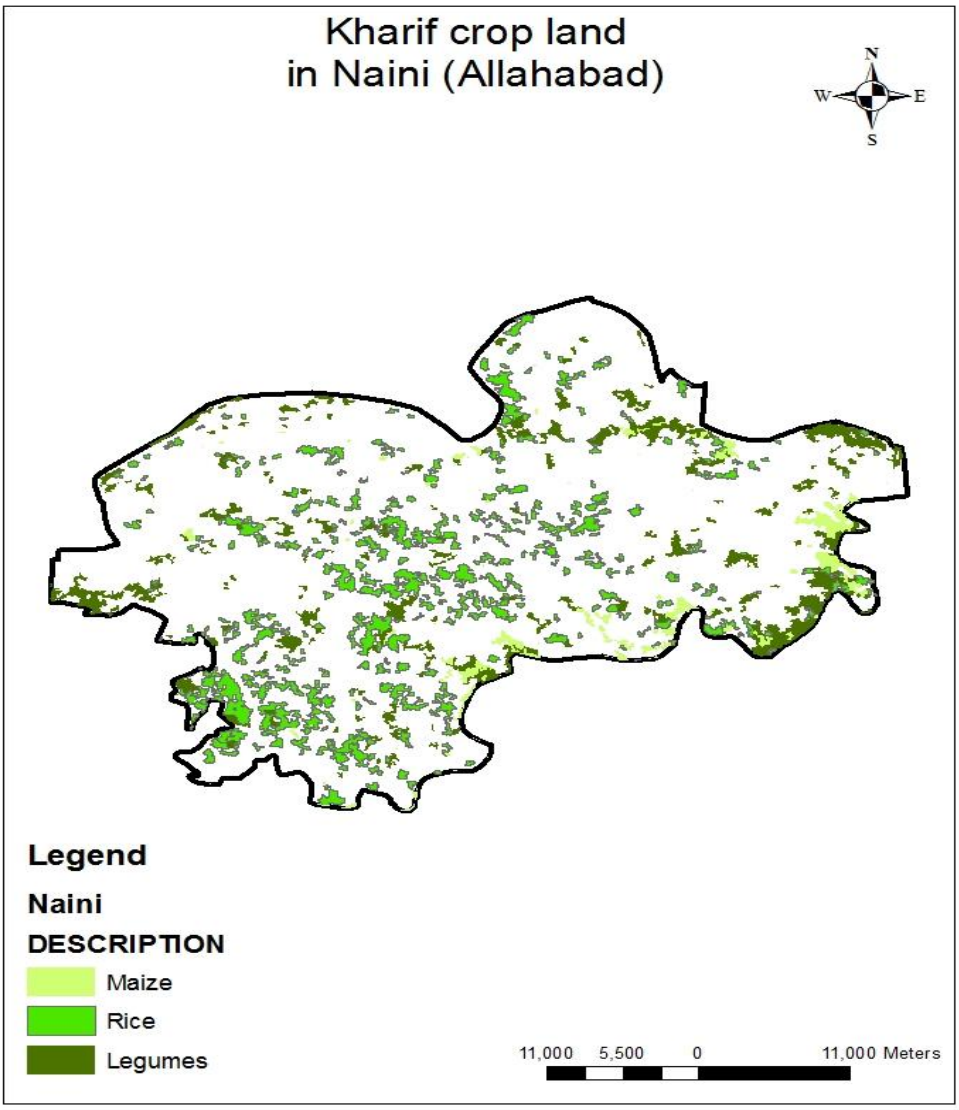

Figure 3 – Kharif Crop Land in Naini Region

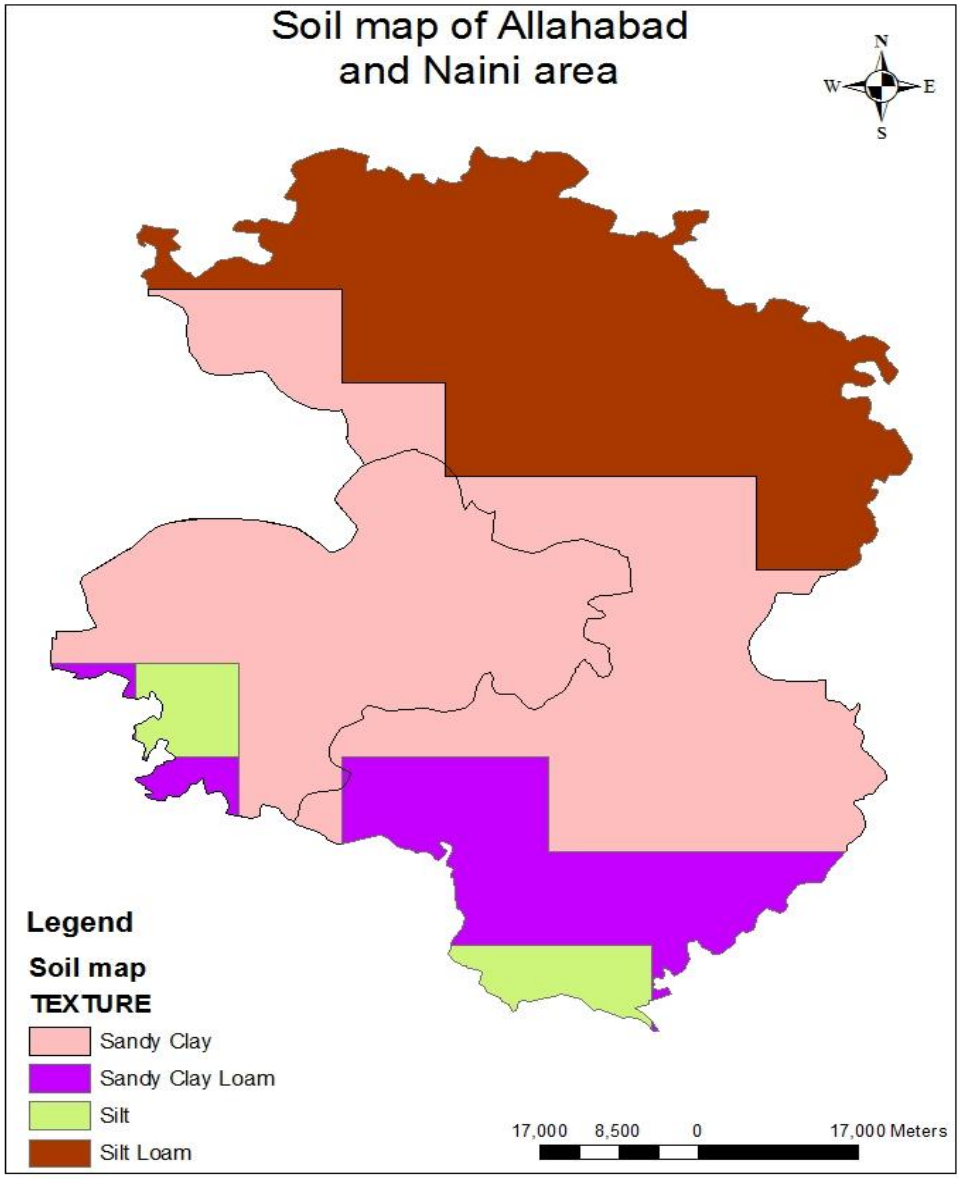

Figure 4 – Soil Map of Allahabad Area and Naini

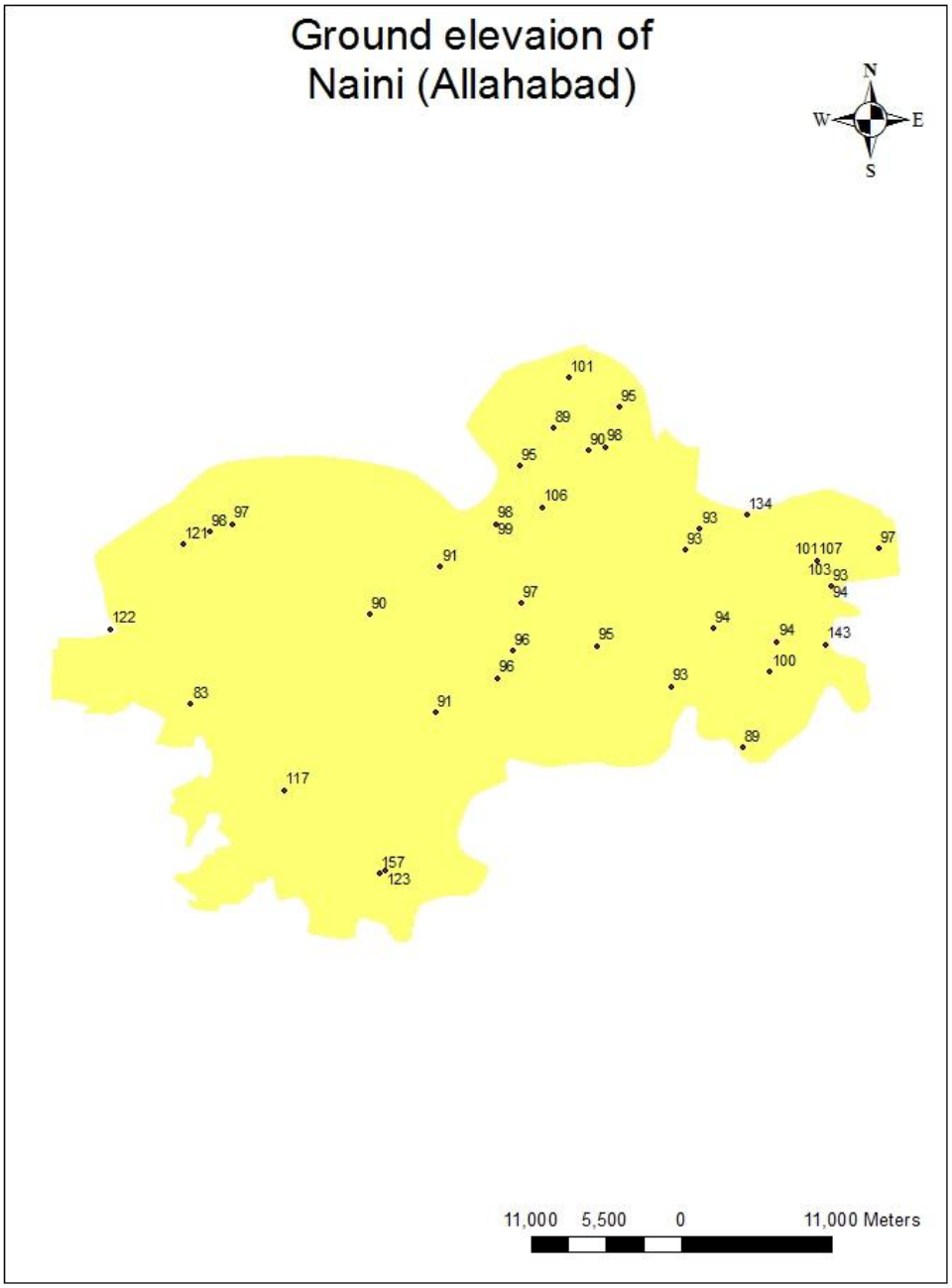

Figure 5 – Ground Elevation of Naini Area

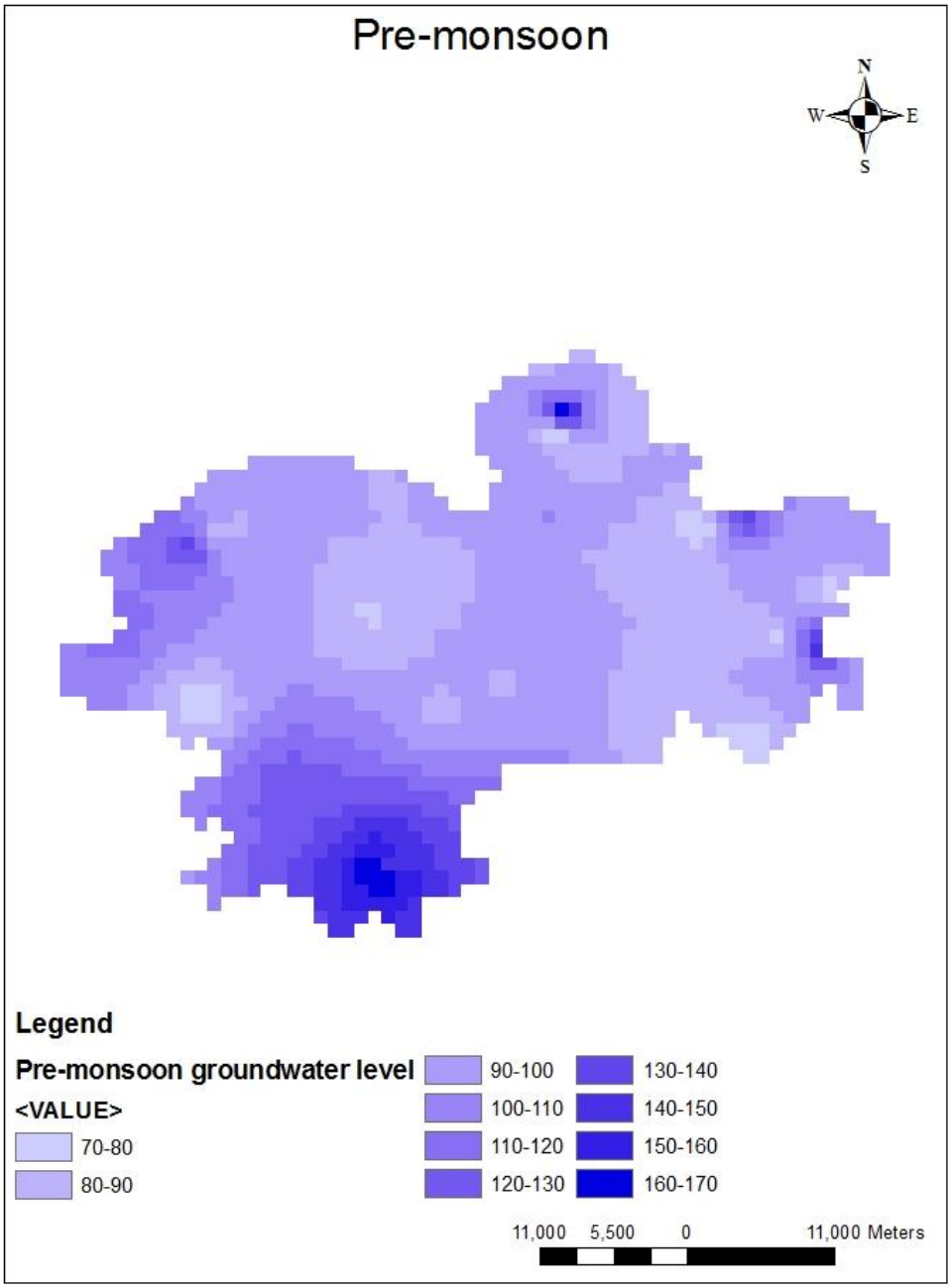

Figure 6 – Pre-monsoon Groundwater Levels in Naini Area

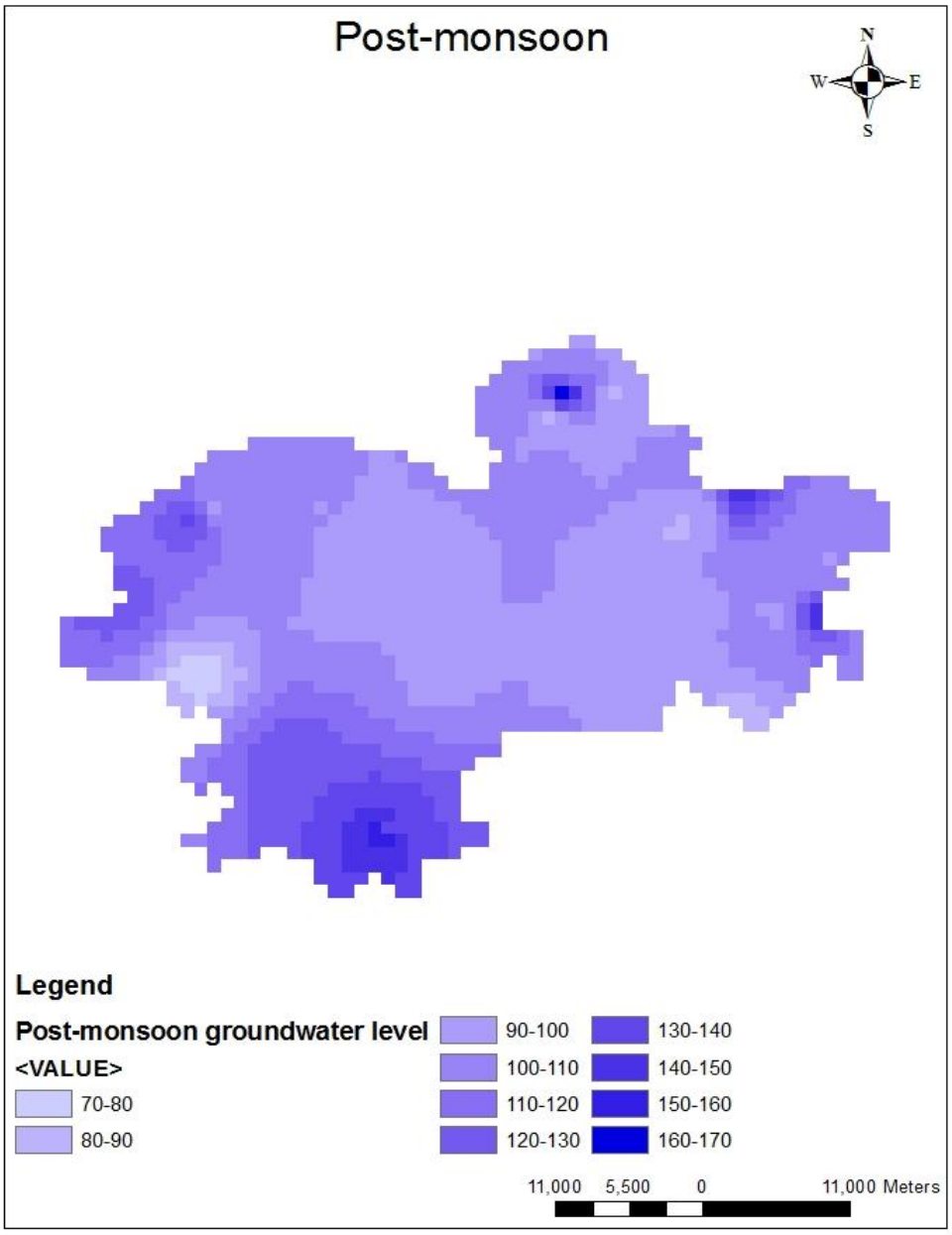

Figure 7 – Post-monsoon Groundwater Levels in Naini Area

Table 1 – Crops Grown in Different Areas of Allahabad

Locations	Crops grown	Source of irrigation	Soil types
Maduka (MeedakpurMahewa)	Wheat and Rice	Closed sewage water pipes	Mixture of alluvial and sandy loam
Dandi	Roses, guava, wheat or rice	Closed sewage water pipes	Alluvial soil
Yamuna corner	Wheat and mustard	Yamuna river	Alluvial soil
PhuulBagiya	Spinach, potato, reddish, and other vegetables.	Underground sewage water	Alluvial soil
Arail	Potato, roses and other vegetables	Open sewage water	Alluvial soil
Ghurpur	Arhar (pulses), wheat and mustard	Submersible pump	Sandy soil
Karma	Wheat, arhar (pulses) and mustard	Canal irrigation	Mixture of red and black soil
Dandupur	Rice, wheat and arhar (pulses)	Canal irrigation	Sandy soil
Jasra	Wheat and vegetables	Canal irrigation	Black soil
Karchana	Rice and wheat	Canal irrigation	Sand soil
Saidabad	Rice and wheat	Canal irrigation	Mixture of red and black soil
Phulpur	Wheat, rice and vegetables	Canal irrigation	Black soil
Jhunsi	Mustard and wheat	Canal irrigation	Sand soil
Shankargarh, Koraon, Manda and Meja	Apple, beans, aster, astilbe, basil and beets	Depends on rainfall	Mixture of sand silt and clay
Chaka and Kaundhiara	Potatoes, raspberries, black berries, asparagus and cereal rye.	Rainfall	Alluvial soil with a mixture of loamy and sandy
Pratappur and Handia	Rice	Submersible pump	Sandy loam soil with sodic properties
Soraon	Potatoes, peas and leafy vegetables (eg: cabbage)	Submersible pump and rainfall	Mixture of sandy loam and clay

CONCLUSION

The Naini region in India is a major agricultural area and farming is widely practiced.GIS was used intensively in this research to map the farming resources in the region. Asagriculture isthe largest sourceof water consumption in the area, there are many challenges facing water supplies. Despite the availability of water, its quality and management remains a big issue. Surface waterispolluted by industrial waste, municipal sewage, and chemical fertilizers. Ground water is overdrawn and the water table is declining at an alarming rate of 0.62 m annually on average. In order to remediate these problems, farmers need to be educated on the hazardous health impacts of improper farming techniquesand the advantages of controlling pesticide usage and implementing organic farming. Animal bathing should be prohibited, since it is a leading source of pathogens. Human corpses should be burned as the ash can decompose easily compared to human skeletons that can take several years to decompose in waterways. Wastewater treatment plants should be built to properly treat contaminated water so a higher percentage of wastewater can be reclaimed and reused before it is released. Finally, in order to make the best use of water resources for farming, it is essential to undergo watershed management, rainwater storage, water recycling and reuse, and conjunctive use of water for sustaining water supply.

ACKNOWLEDGEMENTS

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