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Land Use and Agri-Production Analysis: A Case Study in Western Uttar Pradesh

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Abstract

The study pertains to the characterization of Meerut, Muzaffarnagar and Saharanpur district of western Uttar Pradesh in terms of soil, climate and land use. Based on soil and climate, homogeneous agro-ecological units were developed for these regions and the agri-technical possibilities of improving the productivity of major crops were studied. For land use, IIRS-1D LISS III and IRS P6 LISS III of both *rabi* and *kharif* season of 1998 and 2008 were used and the homogenous units were developed by using ArcGIS. Seventy eight agro-ecological units were identified. Satellite data shows an overall 5.31% decrease in double cropped area with increase in permanent fallow by 2.57% . Shift of land from agricultural to non-agricultural uses were 4.41% in which conversion of agricultural land to built-up areas has been estimated as 2.89 per cent. The yield gaps (potential-current) of rice, wheat, maize and sugarcane for each agro-ecological units (AAU) were calculated. Water and NPK fertilizer requirement for bridging these gaps were estimated.

Keywords : Agro - Ecological Units (AAU), NPK fertilizer.

1. INTRODUCTION

The pressure due to urbanization has vastly increased in recent years, resulting in substantial conversion of cultivated land to other land uses, especially the built-up areas, and further diminishing per capita land holdings. With the advent of remote sensing and Geographic Information System (GIS), it is easier to adopt the available methodologies for the resources management. This is because the remote sensing and GIS technology also allows an efficient manipulation of spatial information for a comprehensive evaluation, planning and management of these resources. The future of a country and its teeming millions depend to a large extent on the conservation of land and water through the proper use and treatment of land (Indian Council of Agriculture Research, 2003). However, the potential resources in the study area is rich, both physical and human which need to be managed efficiently for the region's sustainable development.

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2. MATERIALS & METHODS

The study area is a part of Western Uttar Pradesh and administratively, it covers three districts of western Uttar Pradesh *viz.*, Meerut, Muzaffarnagar and Saharanpur covering 10,372 km^2 with a total population of 1,10,50,238 persons and a decadal (2001-2011) growth of 17.44 per cent (Census of 2011-provisional), were selected. In brief, the primary data (remote sensing imageries of various satellite, IRS-1D LISS III and IRS P6 LISS III) of both *rabi* and *kharif* seasons of 1998 and 2008; ground survey using GPS with 3 m accuracy and interaction with the farmers and the secondary data were collected from various government departments like, Survey of India, National Atlas & Thematic Mapping Organization, India Meteorological Department, All India Soil & Land Use Survey, District Administration, Economics and Statistics Departments, Govt. of U.P.; National Bureau of Soil Survey & Land Use Planning, Census of India and Central Ground Water Board (Lucknow). The satellite imageries were analysed in Erdas Imagine and ENVI softwares for land use/cover mapping and change detection of two time period data. The primary and secondary data is finally put in the GIS environment by using ArcGIS software. The various operations *i.e.*, geo-referencing, digitizing layers, editing, attribute data attachment, mapping etc. were used for finalizing the digital database, which is finally used for the spatial analysis in GIS environment. The information about the soil and climate is further utilized in the crop simulation modelling by using *Infocrop* to generate information on crop yields at various technology levels. Microsoft Excel was used for statistical analyses. In all the cases, computers with Intel Pentium IV with 2GB RAM was used. Different map layers were used for spatial analysis and generates soil units, agro-ecological units, and land units map.

3. RESULTS AND DISCUSSION

Land use/cover change analysis

In the study area, two different changes are identified in different period of time; first is seasonal change in crop area due to difference in rainfall amount, which is temporary in nature. The second is the land use change caused by urban expansion, which is permanent. The spatial distribution of land under agricultural use (as obtained through remote sensing) is depicted in Fig. 1. Change data in agricultural land use (1998-2008) shows that double crop (both *kharif* and *rabi*) area decreased by 7.42 and 10.65% in Meerut and Saharanpur, with negligible area increase in Muzaffarnagar. In Saharanpur, seasonal fallow in *kharif* increased by 9.94%, with a concomitant decrease in *rabi*-fallow (9.82%). In Meeurt, *kharif* fallow decreased by 4%, while the same in *rabi* increased by 8.48%, possibly due to less water available for irrigation. There has been a substantial increase in permanent fallow in Saharanpur (8.18%) and marginal decreased in Muzaffarnagar (1.16%). Areas other than agricultural use has increased by 2.61 and 2.34% in Meerut and Saharanpur districts, while in Muzaffarnagar, the increase was nominal (0.66%).

In the study area, there has been an overall 5.36% decrease in double cropped area. The fallow land in *kharif* increased by 2.50% due to less rainfall 2008, while *rabi* fallow area decreased by 1.46%, indicating better irrigation facility for *rabi* season crop developed over the time. The permanent fallow area increased by 2.57% and area put under uses other than agriculture increased by 1.75%. Over the years, shift of land from agricultural to non-agricultural uses were 4.41% in which conversion of agricultural land to built-up areas has been estimated as 2.89%. This change was specifically visible in Meerut district, where built up areas increased by 2.01% over the years. Some crop land has also changed to wasteland (0.88%) and under forest/plantation (0.22%).

Spatial maps of soil parameters sand, silt and clay contents, available water capacity, salinity, and major nutrient elements like N, P, K, S etc. were generated in ArcGIS. The soil unit map for the study area was prepared by overlaying layers of soil pH, organic carbon content and soil texture in GIS. Four classes of soil pH (slight acidic, neutral, slightly alkaline and moderately alkaline) were identified in the study area. Similarly, eight textural classes were demarcated and two categories of organic carbon located. The overlay analysis generated 38 different classes of soil units, distributed over 183 polygons. The maximum area (35.2 per cent) in a soil unit was identified with slightly alkaline pH (7.5-8.5), low organic carbon content (0.1-0.4 per cent), and loam in texture. This is wide-spread in the central and western parts of Meerut district, north-western and eastern part of

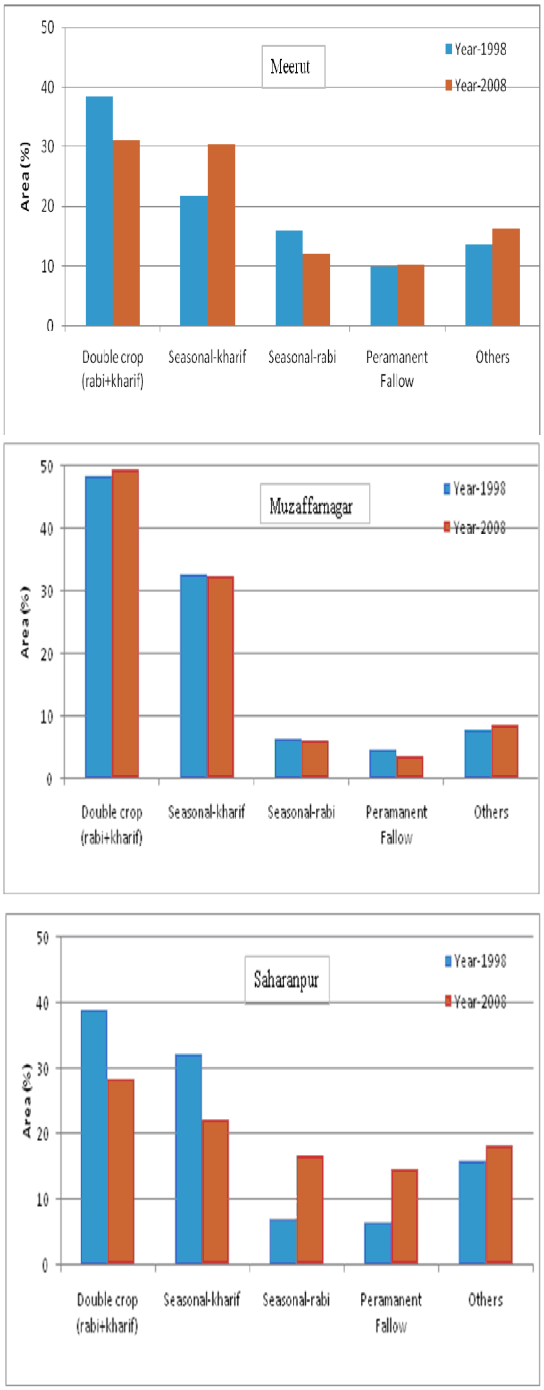

Fig. 1: Change in agricultural area (1998-2008) in Meerut, Muzaffarnagar and Saharanpur *Soil units*

Muzaffarnagar district and south-west part of Saharanpur district.

Agro-ecological and land units

Agro-ecological region maps were prepared from soil units integrated with rainfall theme (5 classes; <650, 650-750, 750-850, 850-950 and >950 mm) in GIS environment, resulting in 78 agro-ecological regions (homogenous units), distributed in 234 polygons. The calculation of area for each agro-ecological unit revealed that the agroecological region with highest area (17.6 per cent) is slightly alkaline pH (7.5-8.5), low organic carbon content (0.1-0.4 per cent), and loam in texture and rainfall varying between 750 to 850 mm. This agroecological unit is located in the central part of the study area (Daurala, Rajpura, western part of Machhra, and southern part of Mawana, north- east Meerut blocks in Meerut; Khatauli, western part of Jansath, Morna, Charthawal blocks in Muzaffarnagar; central part of Nanauta, Rampur Maniharan and Sarsawan, south-western part of Punwaraka blocks in Saharanpur districts).

The smallest homogeneous manageable unit was termed as land unit map, which was prepared by integrating agrocological unit and blocks boundaries maps of study area. A total of 417 land units were generated. The western and central part of the region consisted of mostly homogenous agroecological units, while there are considerable variations in the eastern and northern parts.

Agro - Technical Possibilities

Five technology levels were selected for which possibilities of increasing yields more than the present, using advanced agri-technological support might be possible. Technology level 1 and 5 refers to the current practice and the potential yield of that region, respectively. Technology levels 2, 3 and 4 refer to bridging yield gaps to the tune of 25, 50 and 75 per cent of the difference between present and potential yield levels.

Yield gaps (potential-current) for four major crops, rice, wheat, maize and sugarcane were estimated. In rice, the gaps ranged between 3.87 to 6.64 t/ha, with nearly 6 t/ha yield gap is projected for maximum number of land units. In wheat, the range was 2.85 to 4.89 t/ha and 4.8 t/ha yield gap was identified for most of land units. In maize, the estimated yield gaps ranged between 4.09 to 6.02 t/ha with 6.02 t/ha accounting for maximum number of land units. In sugarcane, the yield gapswere estimated as low as 5 t/ha for a few land units, and as high as 30 t/ha for a majority of land units.

The irrigation and fertilizer inputs required to bridge the estimated yield gaps in rice and wheat in the land units were worked out for the five agri-technological levels. The irrigation requirement corresponding to a particular crop was the same in all these land units, but fertilizer requirement significantly varies. As an example to communicate here, one land unit from each district was selected and the input requirements are presented. Irrigation water requirement in rice has to be increased from a current level of 860 mm to 1176 and 1492 mm at technology level 2 and 3, respectively, thereafter the irrigation requirement does not vary. In wheat, the irrigation water requirement was computed as 160 mm at current and 457 mm at potential yield levels, indicating a gross loss of applied irrigation water as today. This calls for an immediate attention to maximize the irrigation efficiency, so as to improve the crop water use efficiency. The fertilizer N requirement need to be increased by 1.8, 2.6, 2.9 and 3.2 per cent from its current dose in order to reach to technology level 2, 3, 4 and 5, respectively. The P-fertilizer dose of application has to be increased by 1.6, 2.1, 2.5 and 2.7 per cent for levels 2, 3, 4 and 5, respectively. However, the dose of K fertilizer may remain the same up to technology level 3 and thereafter it may be increased by nearly 1.5 times the amount at current level.

4. CONCLUSION

The geo-spatial technologies including remote sensing and GPS along with the field investigation provide the ample amount of information for the spatial analysis in the GIS environment for assessment and management of natural resources. The analysis reveals that the study area has an enormous potential for the further development of the resources for the agricultural purpose. The present study will contribute to required input for policy makers and other agencies for planning the best use of the available resources in order to improve the socio-economic and environmental conditions of the region as well as developing new policies and strategies for sustainable development.

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