SUMMARY and CONCLUSION
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Geomorphic features leave their distinct imprint upon the evolution of landforms and create specific terrain conditions. Landforms are the most common features to be considered as 'better clues' for understanding the various land uses / land covers, cropping pattern and crop-production and hydrological conditions. They present a basic plate forms for all human activities including agriculture. The geomorphic features, slope, drainage, etc. help in the demarcation of the characteristics and productivity of soils. The terrain conditions determine land use as well as the growth and distribution of crops in areas where relief encompasses complex and diverse lithology and landforms. Existing land use pattern is the result of a continuous interplay of physical elements like topography, climate, soil and human efforts. It also helps in understanding the causal relationships among physical environment, socio-economic and technological level of society. Keeping in view the above, the present study is an attempt to focus on the different geomorphic features and their relation with agricultural development in Sultanpur district (25° 59’ N- 26°40’ N latitudes and 81° 31’ E - 82° 41’ E longitudes, area: 4436 sq. km., Population: 30, 62,574 persons in 2001).

The present study is based on both the spatial and non-spatial data collected from the primary as well as secondary sources. The spatial data are captured from satellite imagery and SOI topographical sheets while non-spatial data are collected from both primary and secondary sources. The analysis and interpretation of agricultural facts have been based on the different years, viz., 1981, 1991, 1994, 1995, 1996, 2001, 2004 and sample study for 2005-06. GIS and other computer based techniques in the mapping and analysis of spatial and non-spatial data have been applied to justify the hypothesis. The entire study has been organised in the seven chapters.
Chapter I Geo- Environmental Setting is devoted for spatial analysis of Physical Environment (location extents, physiography, geology, drainage, climate, soil, natural vegetation, status of ground water) and Cultural Environment (population distribution, density, growth, rural population, age-sex structure, level of demographic development and socio-economic infra-structure) in the district. Geologically the area is underlain by thick pile of quaternary alluvium, overlying the concealed inferred basement of Bundelkhand granite / vindhyan, forming part of Faizabad ridge which shows gentle northerly slope with depth of burial ranging from 700-1000 m. in Gauriganj - Amethi area and 1000-1500 m. in Musafirkhana-Sultanpur. The quaternary litho-stratigraphic sequence in ascending order of succession comprises Varanasi Alluvium (older Alluvium), Gomati Terrace Alluvium (younger Alluvium) and Gomati Channel Alluvium (Recent Alluvium). The area can be divided into three major physiographic zones, i.e. (i) The Gomati Khadar Tract or new alluvium (ii) The Bangar level plain Tract or older alluvium (iii) The Bangar of chamraura, Mangar and Majhai. The area is drained by three principal rivers forming three catchments areas viz., Gomati, Chamraura river, Majhoi and Mangar river. The district Sultanpur enjoys the sub-tropical monsoonal type of climate. It varies from hot dry in summer to pleasant cold in winter. During summer, especially in the month of May to June the temperature shoots up 44° C or even higher. In winter it drops to about 4°C in last week of December or first week of January. On an average, the region receives annual normal rainfall of 984.5 mm., and the actual annual rainfall of about 576 mm. It is obvious that the rainfall decrease from east (1100.25 mm. in Kadipur tehsils) to west (885.68mm. in Musafirkhana). About 89% of the rainfall is obtained during June to September; about 5% from October to November; about 4% from December to February and 2% from March to May. Soils of the district are generally deep to very deep in depth fine textured, i.e. Course loamy and loamy silty (mainly on active flood plain),
well drained and calcareous in nature. Course textured to medium textured and Moderately drained to poorly drained soils are also observed, mainly in the group of alfisol order. At the several place saline/sodic soils and water logged soils have been observed. The soils in general are fertile. The area under study is poor in natural vegetation. The region consist of mainly, the tropical dry and sub-tropical types of species. The annual ground water recharge of the district is 171308.51 ham. and the net annual ground water availability is 15794853 ham. The existing gross ground water draft for all uses is 114934.09 ham. The net ground water availability for future irrigation development is 38784.67 ham. The stage of ground water development is 72.77%. In post-monsoon period depth to water level varies from 0.98 to 12.12 mbgl. Shallow water level observed at canal command/network area and the deeper water level was noticed at central part NW to SE of the area along Gomati river. Wetlands are very important not only for irrigation and drinking facilities but also for ground water recharge system and development of fisheries. But unfortunately, it has been frequently over looked in developmental activities of the district. The proper utilization of surface water bodies requires better management practices. There are large number of ponds/lake, swamps and water logged areas in the district. The various water bodies like pond/lake, oxbow-lake, swampy/marshy and waterlogged area have been identified on satellite image.

Population growth is a good indicator of overall development of an area. The Bhetua block has minimum (17.51%) rural population growth while Jagdishpur block recorded maximum (47.03%) rural population growth during last decade. The population density was recorded as 724 persons/sq. Km (2001) which is much higher than that of the State (689 persons/sq. Km.). The percentage of literacy is 55.75% (2001), the highest is in Sangrampur (59.33% of the total rural population) and the lowest (39.34%) in Shukul Bazar. Schedule caste constitute
22.26% (2001) of the total population. The percentage of working force in total population is 32.32 per cent (2001). The primary sector engages 69.90 per cent of total working forces. On the basis of three aspects: urbanization, literacy and occupational structure, the level of demographic development has been calculated and on the basis of 13 aspects namely educational facilities, irrigational facilities, transportation facilities, communication facilities, credit and cooperative facilities, ranking and financial facilities, rural electrification, rural drinking water supply, storage facilities, veterinary facilities, agro-service centres, medical facilities and industrial development, the level of socio-economic infra-structural development has been calculated. The very high level of demographic and infrastructural development are found in Dubepur and Jagdishpur blocks while the lowest level in Shukul Bazar and Kurwar blocks respectively.

Chapter- II is devoted to identify the various geomorphic features and their spatial extent based on satellite data analysis. The geomorphic features of the study area were identified and mapped in the eight different classes, viz.(1) New flood plain (2) Old flood plain (3) Back swamps (4) Old meander (5) Oxbow lake (6)Abandoned / palaeo-channel (7) Gullied/ ravenous area and (8)Point bar. These features have largely affected the topography and agricultural practices in the area. Visual image processing method gave good results for mapping of the geomorphic features. The highest percentage of new flood plain was recorded in Kurwar (18.34 % of total geographical area) and lowest in Jaisinghpur (0.21%) blocks. Major portion of the study area comes under old flood plains which is depending on the variations in height and micro-level characteristics. The old flood plain covers an area of 96.25 percent of the total geographical area of the region which varies from 71.80 percent in Kurwar block to 99.32 percent in Sangrampur block. The mapping of earlier course of the river Gomati through satellite imagery has been found encouraging. The major changes in the course of
Gomati towards left hand side can be marked from Thauri to Mohuddinpur and Keta to Jajior villages. The highest percentage of area under palaeochannel/Abandoned channel is recorded in Gauriganj and lowest in Sangrampur.

In the chapter III Land and water resource and their utilization pattern have been described. The quality of agricultural land in Sultanpur district is generally influenced by various physic-cultural factors. Physiography, drainage, geomorphic features, soil etc. are the controlling factors which contribute enough to govern the nature of agricultural land and the intensity of cultivation. The cultural aspects, on the other hand, are related to the establishment of settlements and their expansion, canal and road network, garden/groves/tree plantation, choking of natural drains and resulted problems of water logging and Usar formation etc. In the existing investigation, attempt has been made to evaluate the land resource of Sultanpur district and examine the relationship between the landforms of the region and various categories of land utilization with special references to agricultural land.

The utilization of land resource has been divided in five categories, i.e. land under forest, uncultivated land, land not available for cultivation (including land under non-agricultural uses, land under grass land, land under miscellaneous trees, groves and orchards), Cultivable waste land (including barren land and fallow land) and Cultivated land or Net Area Sown, which occupy 1.50, 3.33, 13.77, 17.82 and 64.59 percent of total geographical area of the district respectively. The spatial distribution of cultivated area, cropping intensity, land not available for cultivation is largely controlled by the various geomorphic features. Among these attributes, the variation in cropping intensity is largely associated with the geomorphic features of the area. The cropping intensity index values have been recorded higher in Dostpur and lower in Shukul Bazar, Kurwar and Baldirai blocks. The blocks of Jagdishpur, Jamo, Gauriganj, Bhadar, Sangrampur,
Dhanpatganj, Jaisinghpur, Bhadaiya, Lambhua and P.P.Kamaicha have registered Moderately low intensity. High to Moderately high intensity of cropping intensity may be marked in those blocks where good quality of agricultural land along with better irrigation and other infra-structural facilities are available.

The utilization of sub-surface water is being done mainly for irrigation purpose. In 2005-06, the highest irrigated area was recorded in Bhetua (99.32 % of NSA) and lowest in Baldirai (52.35%). The river Gomati is the main source of surface water. Canal and tube-well are the main source of the irrigation in the district. The highest canal irrigated area was recorded in Jamo, Dhanpatganj, Jaisinghpur, Gauriganj and Kurebhar blocks while lowest in Bhetua, P.P.Kamaicha, Kadipur, Amethi and Sangrampur blocks. The intensity of irrigation is observed 126.99 % in the district. It varies from 180.06% (Amethi) to 76.23% (Baldirai).

Chapter- IV is devoted to evaluate the cropping pattern and agricultural productivity. The distributional pattern and spatio-temporal changes in food grain, food crops other than food grains and fodder crops are included under cropping pattern study. Physiography, soil and water are the main physical elements that affect the cropping pattern. The kharif crops in Sultanpur district as a whole occupy 46.13% of total cropped land. The highest share of kharif crops is recorded in Gauriganj while lowest in Dhanpatganj block. The Rabi crops occupy 48 % of total cropped land. It is highest in Dhanpatganj and lowest in Jagdishpur block. Wheat is the first most important crop of the area under study which occupies 39.26% of TCA in 2005-06.

Wheat cropped area is influenced by the geomorphic features and availability of irrigation. The lower area of new floods plains and palaeo-channels which are generally inundated during rainy season are hardly used for wheat cultivation because such fields may take time to dry up till February/March. The maximum concentration (above 44.27% of TCA) is found in Shahgarh and lowest
(below 33.77%) in Musafirkhana and Baldirai blocks. Paddy is the first most important crop under the kharif crop but it has second place after wheat cultivation in the district. It was produced on 155041 ha. (36.44%) in 2005-06. Paddy is grown in about all the blocks of the district. The maximum concentration (above 46.99% of TCA) is found in Gauriganj and the lowest (below 29.74%) in Baldirai, Sangrampur, P.P.Kamaicha and Kadipur blocks. Sugarcane is also an important crop which occupies third place among the all crops and second place among the Kharif crops. It is grown on 9823 ha. (2.31%) of the total cropped area in 2005-06. The pulse crops provide major portion of protein in the vegetarian food. About 9.77% of TCA (41588 ha.) is engaged for the cultivation of pulse crops in 2005-06. The proportion of Rabi pulses (5.28 %) is higher than the Kharif pulses (4.33%). Non- food crops occupy only 3.66% (15590 ha.) of TCA in 2005-06. The negative change in non-food crops has been registered (- 2.88%) during 1995-96 to 2005-06.

The analysis shows that the impact of physiography, geomorphic features, drainage etc. may be observed on the spatial distribution of the crops in all three seasons, i.e. Kharif, Rabi and Zaid. Impact of landforms on crop- combination and crop- ranking is also found very crucial. The topographic conditions and geomorphic features largely affect the nature of soil, mode of irrigation to be adopted, canal and road network and general mobility of farmers. As such, they largely control the selection of cropping systems.

The measurement of agricultural productivity has been attempted to find out the regional imbalances in crop production. Bhatia's 'Efficiency Index Methods' has been used to compute the agricultural productivity. Per hectare yield express all the physical and human factors connected with the production of crops and the distribution of area under cultivation among various crops. The result indicates that the very high (above 320.81) category of productivity can be observed only
in the Baldirai block followed by Jagdishpur and Kadipur blocks. Because of less percentage share of salt affected and water logged areas in these blocks whereas Bhetua, shahgarh and Gauriganj blocks comes under low category (below 155.24) of agricultural productivity.

The association of landforms with agriculture has been examined for the two major geomorphic units in chapters V and VI. The agriculture in new flood plain has been explained in chapter V while chapter VI is devoted for such study in the old flood plain. The farm level observations under these two chapters have largely been based on sample data, collected through questionnaires. The selection of farmers was randomly done taking into account the location of their plots. Based on the response the farmers were arranged in two groups as the farmers belonging to new flood plain and old flood plain.

Ranking of the sample farms (villages) in new flood plain (chapter V) is found to be appropriate to get the idea regarding the significance of villages in terms of farm-return. The result of annual return is largely influenced by Kharif crops in most of the cases. For example, Basantpur Tiwaripur village have registered highest per ha. annual return while it was at 2nd place in Rabi and at 1st place in Kharif season. Soil fertility although has a direct control on crop-production but it fails to provide higher per ha. yield in certain geomorphic locations. For example, fertile soil affected by surface ponding in Mahmudpur and Amkol villages, could not provide better return while the sandy soil of Basantpur tiwaripur and Naugawati villages has raised the values of farm-return in these villages. Technological impact has also been observed in farm-level operations and in raising the crop production. For example, Pipri village has under gone some effects of sandy patches of soil but due to better irrigation facilities, better per ha. production of paddy has been possible while Nakrahi village despite fertile soil, fail to attain higher production due to lack of irrigation. The study of eight sample
villages of old flood plain (chapter VI) evinces that per hectare annual farm-
return has been recorded as highest in Tikar (Rs. 23,303.14) followed by Bhati,
Tulsipur, Hasanpur, Sevra, Pandri, Banbaha Sirkhipur and Dobhiyara (Rs.
9748.41).

The village as well as farm-level study in both of the geomorphic units, i.e.
new flood plain and old flood plain have presented a very fruitful results. The
impacts of technology on agriculture can be seen only in those villages which
are not affected by flood/water logging problems or undulating surfaces.
Technological development and their impact are fused by physical aspects and
natural calamities. Per hectare average farm – return in new flood plain have been
observed higher (Rs. 18102.5) than old flood plain (Rs. 16011.53). The use of
modern techniques of remote sensing with selective field check and ground data
has proved very fruitful in the present investigation.

Chapter VII addresses the importance of geospatial approaches in
sustainable agro-ecosystem management in Sultanpur district. Since the whole area
may not be taken for sustainable agro-ecosystem management at a time, therefore,
the several parameters were processed and analyzed for identifying and delineating
the sustainable agro-ecosystem management priority zones in the study area. The
analysis of physical and socio-cultural environmental conditions was largely based
on geospatial tools of remote sensing and GIS. The measures are also suggested for
sustainable agro-ecosystem management in the study area. The blocks of the
district were grouped into four priority zones viz. (i.) first priority zone includes
four blocks namely Gauriganj, Bhetua, Shahgarh and Bhadar (ii.) second priority
zone is consists of four blocks namely Kurwar, Amethi, Akhand Nagar and Kurebhar
(iii.) third priority zone includes Jamo, Bhadaiya, Lamhua, Dhanpatganj, Baldirai,
Dostpur, Motigarpur, Dubepur and Musafirkhana blocks and (iv) forth priority
zones includes Shukul Bazar, Sangrampur, Jaisingpur, Kadipur, Jagdishpur and P.P
Kamaicha blocks. This result may prove a better input in designing strategies and decision making for sustainable agro-ecosystem management in the study area.

The result of existing investigation reveal that landforms do have a deep association with agricultural practices, cropping pattern, crop ranking, land use/land covers, land quality, irrigation and transport network etc. and determine prosperity level of agrarian society by controlling per hectare farm-return. The spatial variation in geomorphic conditions as well as hydrological and pedological conditions should be considered in plans and decision making process for sustainable agro-ecological development in the district.