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Full Length Research Paper

Agroclimatological regionalization: A case study

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There are different types of cropping patterns in the different parts of the world. Possibilistic approach states that with the help of modern technology, any crop can be cultivated any where in the world irrespective of favorable or adverse climatic conditions. However, for economic reasons, crops are cultivated at places where they can give maximum returns. The objective is to develop a GIS base system of classification of climate at micro level and to determined suitable cropping practices to realize full potential of climatic resources without causing stress on environment. The work has been carried out with the help of GIS (ARC INFO) by considering the natural condition. It is done to avoid the environmental deterioration, which ultimately affect upon the crop production and crop yield. In this case harness maximum yield as well as gross production as compared to existing one without disturbing the environment, which is the most needed part of the on going sustainable agriculture.

Keywords: GIS (ARC/INFO); Environment; Agro-climatology; Cropping Pattern; Crop yield.

INTRODUCTION

Climate is one of the major physical factors affecting the cropping pattern as well as yield of the crops. It affects the agriculture through the elements of precipitation, underground water, rainfall, snow, frost, temperature, sunshine, winds and drought. All these elements have direct and indirect influence on the cropping patterns as well as yield of the crops of a region.

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The influence of the climatic factors is mutually interrelated. Daily and annual variations in any one or all of the weather elements are also of great importance in determining the efficiency of crop growth and agricultural output per unit area (Kyuma 1972). The micro climates around the plant are also of vital significance because they affect the output of a crop favorably or unfavorably.

Scope of Agro meteorology

For optimum crop growth specific climatic conditions are required. Agro meteorology thus becomes relevant to crop production because it is concerned with the interactions between meteorological and hydrological factors on the one hand and agriculture, in the widest sense including horticulture, animal husbandry and forestry, on the other (Burgos 1968). Its objective is to discover and define such effects and thus to apply knowledge of the atmosphere to practical agricultural use. The field of interest of agro meteorology extends from the soil surface layer to the depth up to which three roots penetrate (Bourke 1968). In the atmosphere it is interested in the air layer near the ground in which crops

and higher organisms grow and animals live to the highest levels in the atmosphere through which the transport of seeds, spores, pollen and insects may take place.

Inter-disciplinary Aspects

Agro meteorology is an inter-disciplinary science in which the main scientific disciplines involved are atmospheric sciences and soil sciences which are concerned with the physical and chemical environment and the plant sciences and animal sciences (including their pathology, entomology and parasitology, etc.) which deal with the contents of the biosphere. Though inter-disciplinary in nature, agro meteorology is now a well-defined science. It has set approach in theory and methodology. Its subject matter links together the physical environment and biological responses under natural conditions (Yoshino 1974). Using a four-stage approach, an agro meteorologist first formulates an accurate description of the physical environment and biological responses. Secondly it interprets biological responses in terms of physical environment. Thirdly, it takes crop and weather forecasts. Its final goal is the control of physical environment of crop fields and an animal houses.

Practical Utility

The science of agro meteorology has great practical utility in protection against, or avoidance of adverse climatic risks. The dangers to crop and livestock which have metrological content include the incidence and extent of pests and diseases; the pollution of air and soil, crop growth, animal production; all farm operations, the incidence and effects of drought; soil erosion from wind or water; incidence, frequency and extent of frost; the danger of forest or bush fire; and losses during storage and transport (Molga 1962).

Out of the total annual crop losses, a great proportion is due to direct weather effects such as flash floods, untimely rains, hails and storms. Losses in harvest, storage and also those due to parasites, insects and plant diseases are highly influence by the weather. When specifically tailored weather support is readily available to the needs of agriculture, it greatly contributes towards making short term adjustments in daily agricultural operations which minimize losses resulting from adverse weather conditions and improve the yield and quality of agricultural products (Mavi 1974). The weather support also provides guidelines for long range or seasonal planning and selection of crops most suitable to anticipated climatic conditions.

Weather elements which influence agricultural operations and crop production can be forecast for different time spans; however, with an increase in time span, the accuracy of the forecast decreases (Newman 1974).

Other applications through improvement in techniques are based on sound interpretation of meteorological knowledge. These include irrigation; shelter from the wind and cold; shades from excessive sun; anti-frost measures including choice of cite; anti-erosion measures; soil cover and mulching; plant cover using glass or plastic materials; artificial climate of growth rooms or heated structures; animal housing and management; climate control in storage and transport; and efficient use of herbicides, insecticides and fertilizers. Agro meteorological methods can be use in efficient land use planning; determining suitable crops for a region; risk analysis of climatic hazards and profit calculations in farming; production and harvest forecasts; and in adoption of farming methods and choice of farm machinery.

Objectives

The objectives relating to various aspects are as fallows:

i) To develop a GIS base system of classification of climate at micro level to arrive at homo-climate regions, this will be flexible enough to incorporate new information.

ii) To determined suitable cropping practices for indentified homo-climate regions to realize full potential of climatic resources without causing stress on environment, leading towards the long term goal of ecological sustainability as raising of crops in less suitable environments using a technology that bypass ecological processes causes stress on environment resulting in the degradation and depletion of natural resource-base.

METHODOLOGY AND DATA RESOURCE

Methodology

GIS is a powerful spatial planning tool finding application in areas as divers as environmental monitoring evaluation, forestry management, marketing, wastelands planning and change detection (Khan 1992). A GIS is designed to efficiently capture, store, update, manipulate and display all forms of geographical referenced information. It offers greater power for manipulation and analysis of data with higher degree of accuracy (Reddy 1983). Hence PC ARC/INFO GIS package has been employed for agro climatological analysis. The steps followed for the analysis are as follows.

1) Formation of tiles,
2) Digitization,
3) Editing,
4) Creation of polygon Topology, and

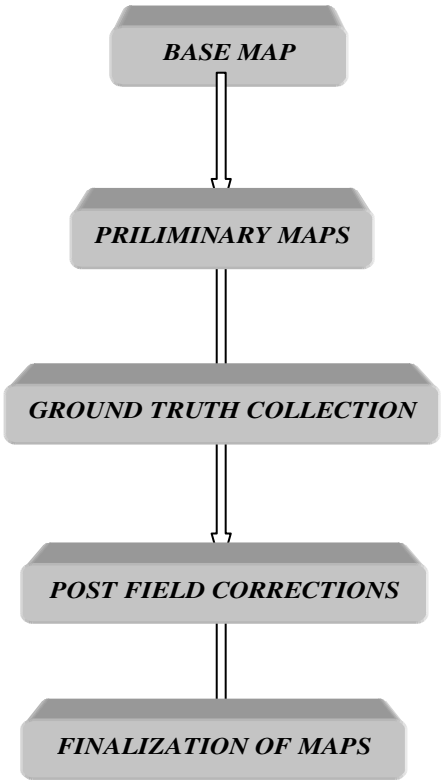

Chart 1. Flow chat of visual interpretation

5) Union Process.

A spatial database was created as per the steps mentioned above. The overall methodology adopted for change detection analysis using GIS is depicted in chart 1-3. This has been done to achieve the set objective of the study.

Database Design

The first step in GIS is to create a database of both spatial and attributed data. This will insure that all the needed coverage features and attributes will be available while performing the analysis for retrieving the desire information and obtaining the final output. A review of literature and preliminary research relating to the subject enable identification of the data layers, geographic features and their attributes along with their sources of information (digital/non-digital) and storage media. The accuracy of the results of any GIS depends on the accuracy and precision on the underlying data set.

Spatial (Geographic) Data Automation

All the maps were drafted fairly and made ready for their automation through digitization and scanning for generating different coverage. Latitudes and longitudes were marked on each map as reference point for registration. These tic points were latter use for projecting the maps into real world coordinates. A data dictionary was framed and the maps were digitized, labeled and edited. Topology of coverage has been built to make the spatial data automation, as shown in chart 2, are briefly described below.

Building a Data Dictionary

The data dictionary contains a complete description of each layer in the database. The data dictionary of a GIS project is a valuable document as a reference during the on going works and for transferring the information to others.

The data dictionary for this work was prepared, workspace was created and storage allocation was done for each category.

Digitization

Different coverage`s identified in each layer were digitized.

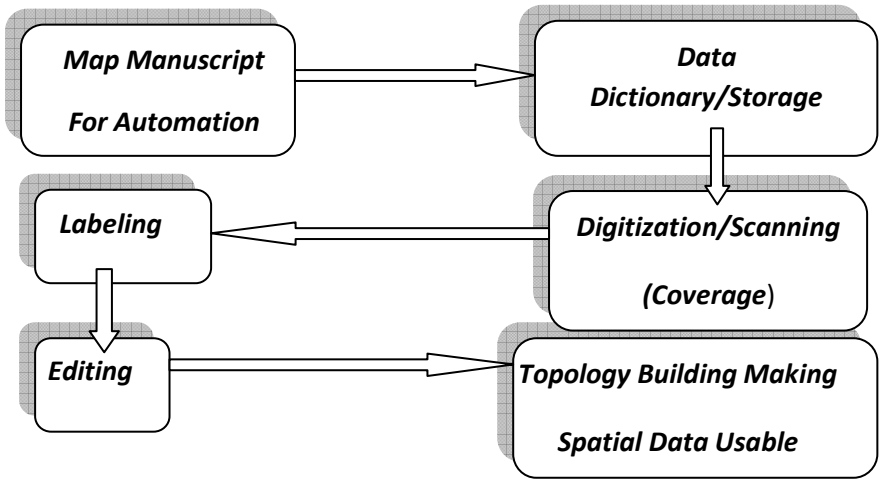

Figure 2. Spartial Data Automation

Labeling

Each feature of the point, line and polygon digitized was labeled, as defined in the data dictionary. These labels were used, as identifiers to link the attributes of each feature.

Editing

After digitization, a plot was taken at a scale of the original MSS from the plotter and matched. The error of the digitization were marked and then corrected on screen.

Building Topology

GIS topology makes the spatial data usable. After all correction were incorporated and the digitization process completed, the coverage were cleaned land a topology was formed for each coverage using BUILD and CLEAN commands in ARC/INFO. It is a mathematical procedure that defines the spatial relationship between connecting and adjacent coverage features (arcs, nodes, polygons and points). This allows processing of larger data sets and faster processing. It is useful in GIS, because many spatial modeling operations require only topological information and not coordinates (ESRI 1990).

GIS Operation

The automation of spatial as well as attribute data was followed by the GIS operations to extract the desired information and demarcate areas of spatial interest for the study. A combination of a few coverage`s resulted in the creation of some new coverage. The steps are briefly highlighted in chart 3, which gives the idea about the GIS operation. Different overlay commands were used in various steps. Then the areas covered by different crops under existing condition of climate, rainfall, soil etc. were drawn.

Analysis of Agro climatic Regions

The total area of study region (Western Uttar Pradesh) is 62590.49 $^{sq.}$ km. A perusal of table 1 shows existing crop land use. The percentage share of land under *Kharif* crops are 33.78 per cent of total cultivated area. In which *Bajra* is the most important crop covering 10.14 per cent of the total cultivated area. It is followed by paddy, sugarcane, maize, *Jowar* and cotton which occupy 8.94, 7.09, 6.34, 1.07 and 0.20 per cent of total cultivated area of *Kharif* season respectively.

The percentage share of land under *Rabi* crops is about 50.92 per cent. The study region is an exclusively wheat growing area, where percentage share of wheat cultivated area is about 34.55 per cent. The other crops like oilseeds, barley, gram, potato, pulses and peas, which occupy 5.45, 3.06, 2.70, 2.20, 1.70 and 1.26 per cent of the total cropped area respectively.

This system of crop land use has been prevailing since a long time without considering soil types as well as climatic conditions, which ultimately affect on the yield production in long run. A keen observation has been carried out, which shows a decreased yield production as well as the farmers are moving towards highly specialized type of cropping system, which in due time would be very harmful in every sense spatially on soil fertility which ultimately affect yield production. So, it is necessary to consider the major problems of sustainable production. That should be done by considering the climatic

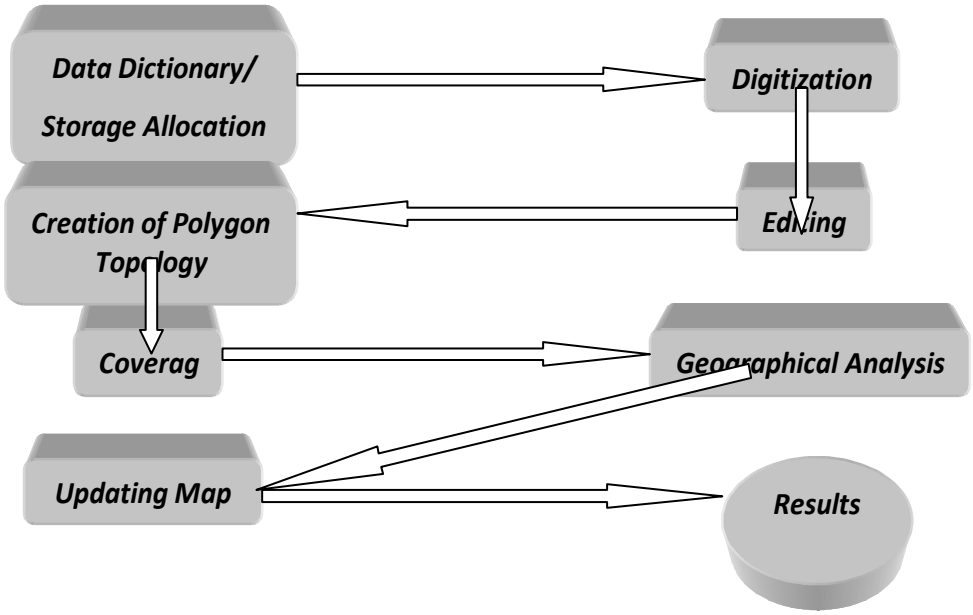

Figure 3. GIS Operation

Table 1. Percentage share of different crops to grossed cropped area in Western Utter Pradesh 2005

Kharif Crops	Percentage Share	*Rabi* crops	Percentage Share
Paddy	8.94	Wheat	34.55
Jowar	1.07	Barley	3.06
Bajra	10.14	Gram	2.72
Maize	6.34	Peas	1.26
Sugarcane	7.09	Pulses	1.70
		Potato	2.20
		Oilseeds	5.45

Source: Estimated from data of agriculture bulletin of Uttar Pradesh (2005), Directorate of Agriculture, Lucknow, U.P.

elements, soil types and other factors, which are best suited for best crop production. Here it is done with the application of computer (ARC/INFO). The changes in crop land use in the area under study on the basis of spatial data base, which was created as per the steps mentioned previously. Then the areas covered by different crops under naturally existing conditions of climate, rainfall, soil etc. (table 2) were drawn by making the agro climatic region, which provide the acreage value of different crops, which is best suited for production under existing physical conditions (table 3). The percentage share of land by paddy, *Jowar*, *Bajra*, maize, sugarcane, wheat, gram, mastered, pulses, sesamum, potato, oilseeds and pigionpea, which occupy 45.47, 03.64, 32.21, 39.70, 32.42, 56.52, 32.21, 45.51, 42.84, 37.42, 29.59, 25.46 and 17.05 respectively. It shows that almost all the crops individually occupy more cultivated areas. The other crops, which occupy less than 3 per cent share of cultivated land are not considered here because of much more choice of crops covering more than 15 per cent cultivated land in both the seasons.

A perusal of table 3 shows that by considering all elements there is highly diversified choice of cropping system in *Kharif* as well as *Rabi* season. It is better to go through paddy, *Bajra* and maize in *Kharif* season. In *Rabi* season there is much more choice, almost all the crops share a good percentage of area, although wheat cover the highest percentage share of land cover. Hence it is preferred to go through the proposed structure of cropping pattern because of the some reasons. Firstly it provides the much more gross production and yield of the crops as compared to the existing one. Secondly it is not affecting the environmental condition. Thirdly it is also not affecting the nature of the soil spatially fertility because of the diversified nature of cropping system instead of specialized cropping pattern.

Table 2. Suitable Condition of Different Crops

S. No.	Crops	Rainfall	Temp. in ℃	Soil Types
1	Paddy	60-150	32-42	Alluvial
2	*Jowar*	25-40	20-30	Sandy to Sandy Loam
3	*Bajra*	20-35	22-30	Light Sandy Loam
4	Maize	60-120	25-32	Light to Heavy Loam
5	Sugarcane	75-120	20-50	Light Sandy Loam (with irrigation in heavy clay
6	Wheat	25-40	15-25	Light alluvial, Light to Heavy Loam
7	Gram	42-75	15-19	Sandy and Sandy Loam
8	Mustard	25-45	12-20	Light to Heavy Loam
9	Pulse	18-32	13-18	Sandy to Sandy Loam, Alluvial
10	Sesamum	45-70	27-32	Light Sandy to Loamy
11	Potato	20-40	17-25	Sandy and Medium Loam
12	Oilseeds	25-45	12-19	Sandy and Sandy Loam
13	Pigeon Pea	19-33	12-17	Alluvial

Table 3. Suitable Gross Cropped Area of Different Crops

S. No.	Crops	Area in Sq. Km.	% Share of Area
1	Paddy	28707.85	45.87
2	*Jowar*	2279.75	03.64
3	*Bajra*	20159.15	32.21
4	Maize	24850.43	39.70
5	Sugarcane	20294.83	32.42
6	Wheat	35376.80	56.52
7	Gram	20159.15	32.21
8	Mustard	28488.00	45.51
9	Pulse	26815.35	42.84
10	Sesamum	23421.75	37.42
11	Potato	18524.78	29.59
12	Oilseeds	15936.98	25.46
13	Pigeon Pea	10669.79	17.05

Summary

Agriculture is the backbone of the economy of the study area. Nearly 75per cent of the total population is engaged directly in farming. Hence, any sign of improvement in the system of agriculture positively correlated with the upliftment of socio-economic condition of the 75 per cent of the rural population. Hence, it requires a keen observation and attention of the scholars, planners and Arial administrators of a particular area who are engage in various fields of research and who can provide bases for the improvement in agricultural system of the area. Earlier, only the theoretical statements about the distribution of crops were the common practice amongst scholars. However, later on, the applications of statistical models became a fashion for the study of the cropping system in a region. Thus the present research work has been carried out with the help of GIS (ARC INFO) by considering the natural condition i.e. temperature, rainfall, humidity, soil moisture, water vapour, types of soils etc. It is done to avoid the environmental deterioration, which ultimately affect upon the crop production, crop yield as well as health. In this case harness maximum yield as well as gross production as compared to existing one without disturbing the environment, which is the most needed part of the on going sustainable either agriculture or livelihood.

Since the supply of the land is inelastic it could not be expanded, and the same time, the population is increasing at an alarming rate. It, therefore, becomes very difficult to cope up with the growing annual food requirements of the increasing population unless double or multiple rational cropping is adopted. Hence, an appreciable improvement in the cropping patterns and cropping sequence is very much needed and that is only possible in this case without disturbing the environment, which is very much needed in present scenario of war of development without considering environment.

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