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Spatial delineation of new agro-ecological zones of Himachal Pradesh, India, using geographic information systems

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Abstract

The state of Himachal Pradesh was divided into four agro-ecological zones almost two decades ago. But because of large variability within the zones, need was felt for subdividing the zones into smaller zones which are more homogeneous for agricultural planning in the state. In this study, the mountainous state of Himachal Pradesh was divided into nine agro-ecological situations based upon two main biophysical characteristics – elevation and climate. Each new zone map depicted the spatial area covered, range of elevation and rainfall. The methodology was to create geo-referenced state and district boundaries, contours and spot heights for generation of digital elevation model (DEM). Temporal database for climatic variable–rainfall was prepared for number of spatially spread meteorological stations and then generate spatial distribution for rainfall. Thereafter, agro-ecological zones were delineated by integrating DEM and rainfall themes based upon the decision rules developed for the actually occurring agro-ecological situations in the state.

Key words: Agro-ecological zones, geographic information systems.

Introduction

A practical approach for the agricultural planning process in a particular area is to sub-divide the area of interest into homologous areas i. e. with similar sets of potentials and constraints based upon the biophysical attributes of that area. This process is known as agro-ecological zoning (AEZ). The application of GIS in the shape of spatial digital information system has proved to be a useful and effective tool in the frame of area-planning for agricultural development (Burrough, 1989). In the mountain context, where the topography is complex and the areas highly inaccessible, the application of GIS is of great importance (Partap, 2003; Partap *et al.* 1990).

The AEZ method calls for the use of biophysical attributes of the land such as soil characteristics, physiography, climate, land use/land cover, and productivity (FAO, 1997) as input for production models. This is further complicated by the fact that, due to spatial variability, the requirement for data is more demanding than for more spatially homogeneous areas due to several factors such as, increasing population, changing technology and improving infrastructure and global warming. There has been a resurgence of a feeling among the policy makers, scientists and the farmers to re carve out the existing agro-ecological zones and delineate niche based farming pockets. The need to do so has been further reinforced by the growing demand for off-season crops, for products that are chemical free and available throughout the year. Also, in the old zoning exercise (Singh et. al. 1982), while some of the areas were similar with respect to one parameter (say altitude), these were dissimilar with respect to another (say rainfall). There were such wide variations within these zones that no single recommendation can be forwarded to a particular zone (Thakur, 2002). This certainly complicates the process of agricultural planning. Again, these zones were found to be too large when seen in the light of niche based commercial farming. In the present study, an attempt has been made to make it possible to distinguish such places and keep them in different zones.

Methodology

In order to derive agro-ecological zones, basic spatial information files--administrative boundaries (HP bound and HP districts), contours, spot heights, digital elevation model (DEM), and climate were prepared (Bhagat *et.al* 2006). The baseline database layers for agro-ecological zones are given in Table 1 which gives description, map scale and source of the layers. First the administrative boundaries, contours and spot heights were derived from 1:50,000 scale toposheets from Survey of India. Then Digital

Elevation Model for physiographic variable altitude was generated through Inverse Distance weighted (IDW) interpolation method (Childs, 2004, Pradhan *et.al* 2003) in GIS software from the contours and spot heights. Inverse Distance weighted (IDW) interpolator assumes that each input point has a local influence that diminishes with distance. It weighs the points closer to the processing cell greater than those farther away. Time series data for climatic variable – rainfall was generated through secondary sources and then climatic grid was also developed through spatial interpolation (IDW). Criteria rules (Table 2) (Bhagat et.al 2006), to delineate agro-ecological zones were developed for various permutations and combinations of elevation and rainfall actually occurring in the state of Himachal Pradesh. Then agro-ecological zones were delineated performing spatial analysis. The methodology flowchart used to delineate agro-ecological zones is given in Figure 1.

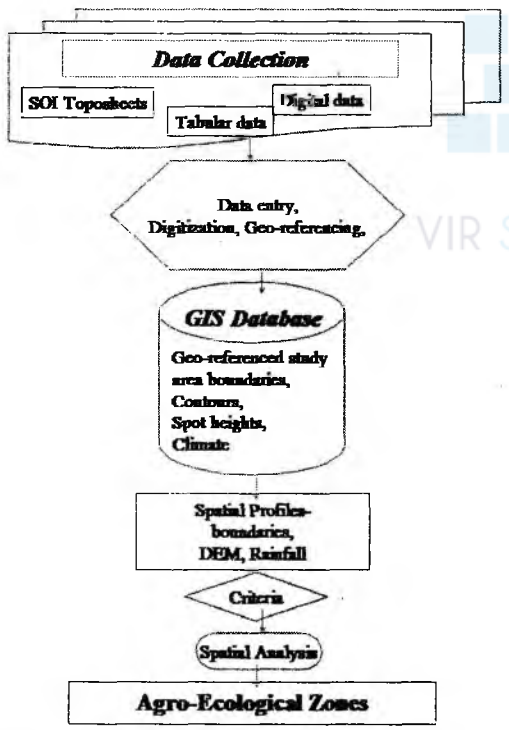


Figure 1: Methodology Flowchart

Results and Discussion

Based upon the developed criteria (Table 2), detailed and informative Nine agro-ecological zones (Fig 2) instead of four for effective agricultural planning were delineated through spatial analysis in this study. Table 2 also presents comparison of the decision rules of the old and new zones. Spatial distribution of these nine zones is given in Table 3, which gives area in sq. km. for each zone along with their percentage coverage. The new zones represent the realistic areas that can be designated as production domains for different crops. Each zone has its own agricultural adaptation which can be harnessed by scientists, agriculture policy planners and decision makers. The relatively flat area in the south western part comprising of zones 1.1 & 1.2 of the state lying between 240-1000 m is known for wheat, barley, rice and vegetable cultivation. In the next elevation, zones 2.1 and 2.2 lying between 1000 and 1500 meter and zone 3.1 between 1500 and 2500 meter; wheat, barley, rice, vegetable and horticultural crops such as tea, peach, pear, plum and apricots are dominant, while potato, cherry and walnut also perform best in these areas. Higher elevations between 2500 and 3250 meter (zone 3.2 and 4.1) are suitable for minor millets, barley, apple, peas, potato, beans and high value cash crops (*kala zeera*, saffron, hops and *kuth*) while in the above 3250 meter zones (zone 4.2 and 4.3) pseudo cereals and only low intensity livestock breeding is possible.

Previous zones dividing the state of Himachal Pradesh into four zones extended to administrative boundaries due to inherent limitations of manual delineation whereas new agro-ecological Zones (Fig 2) clearly extended to the areas fulfilling the physiographic parameters and hence the comparative advantage is quite obvious from the figure 2. FAO (1997) and Quiroz (1999) had underlined the significance of the integration of these new tools (Geographic

Table 1. Baseline GIS database layers for agro-ecological zones

Data Layer	Description	Map Scale /Resolution	Source
Administrative			
State Boundaries District Boundaries	State boundary District boundary	1:50,000	Topograph. Map, Survey of India
Topography			
Contours Spot Heights	Contour 40m interval Random, spatially spread over the whole state	1:50,000	Topograph. map IRS1D-LISS3
Climatic			
	Weather stations Rainfall data	1:50,000	Topograph. Map, Meteorol. Observat.

Table 2. Comparison between the criteria of the previous four zones and the new zones

Previous Zones	Previous Zones Elevation (m)	Previous Zones rainfall (mm)	New Zones Elevation splits (m)	New Zones Rainfall Splits	New Zone Rainfall (mm) or Snow	Elevation and Rainfall Suitable Combinations	New Zones
1.	Below 650	About 1000	240-1000	1	< or =1500	11	1.1
			240-1000	2	>1500	12	1.2
2.	651-1800	1500-3000	1001-1500	1	< or =1500	21	2.1
			1001-1500	2	>1500	22	2.2
3.	1801-2200	About 1000	1501-2500	1	< or = 1500	31	3.1
			1501-3250	2	> 1500	32	3.2
4.	Above 2200	<250	2501-3250	< 700 (1)	-	41	4.1
			3251-4250	Dry/Snow (2)	-	42	4.2
			> 4250	Snow (3)	-	43	4.3

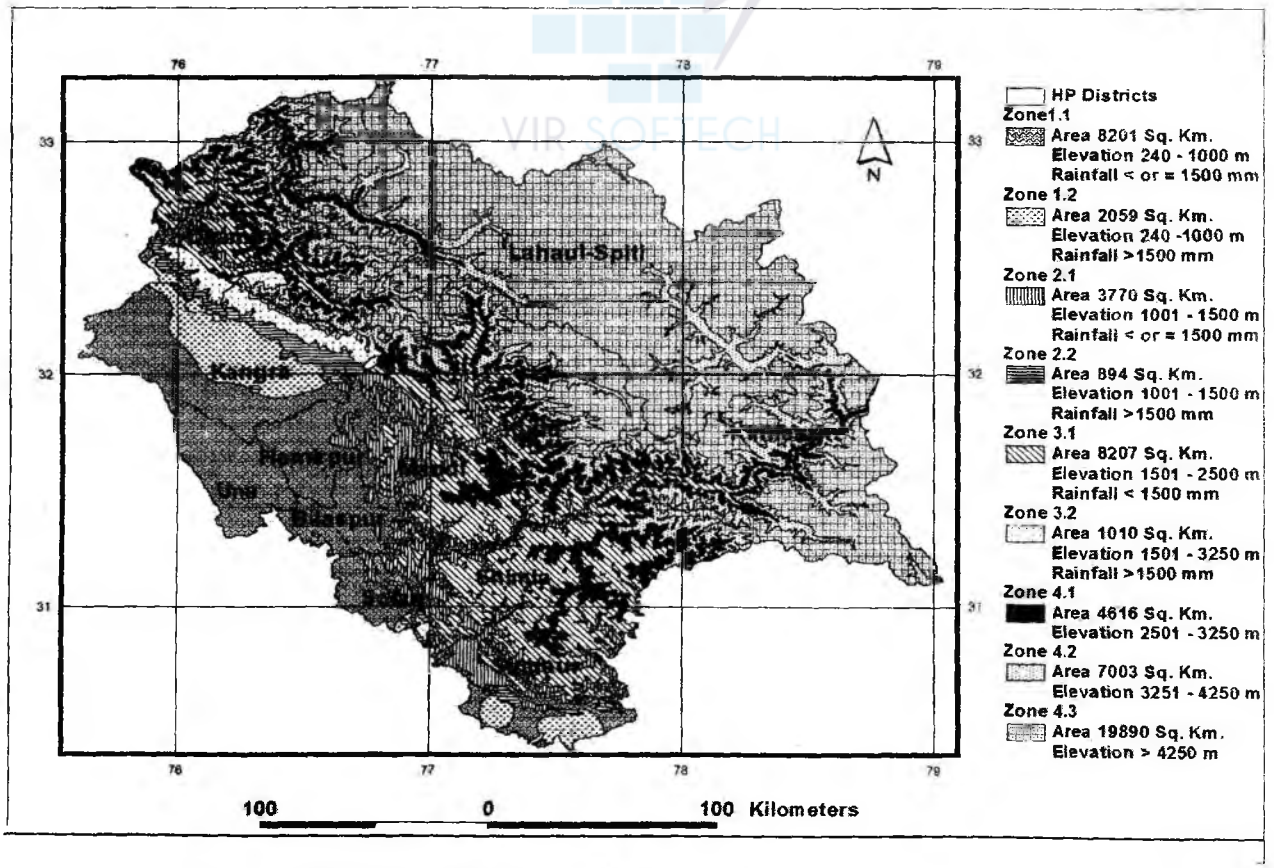


Figure 2. Combined map of new agro-climatic zones of Himachal Pradesh

Table 3. Spatial distribution of new agro-ecological zones

New AEZs	Area (Sq.Km.)	Per cent
Zone 1.1	8201	14.73
Zone 1.2	2059	3.70
Zone 2.1	3770	6.77
Zone 2.2	894	1.60
Zone 3.1	8207	14.74
Zone 3.2	1010	1.81
Zone 4.1	4616	8.29
Zone 4.2	7003	12.58
Zone 4.3	19890	35.74
	55,650	**100**

Information Systems) for the delineation of area specific homogeneous zones for location specific policies for better agriculture planning. The study shows that with the use of GIS, it has been possible to further refine the agro-ecological zonation of Himachal Pradesh. This has enabled a more precise delineation of production domains of different crops across administrative boundaries and would enable policy makers to fine tune their programmes.

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