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Identification of Planning Priority Zones for Land Resource Development Using Remote Sensing Technique: A Case Study

D.K. Tripathi, Sultanpur, U.P.

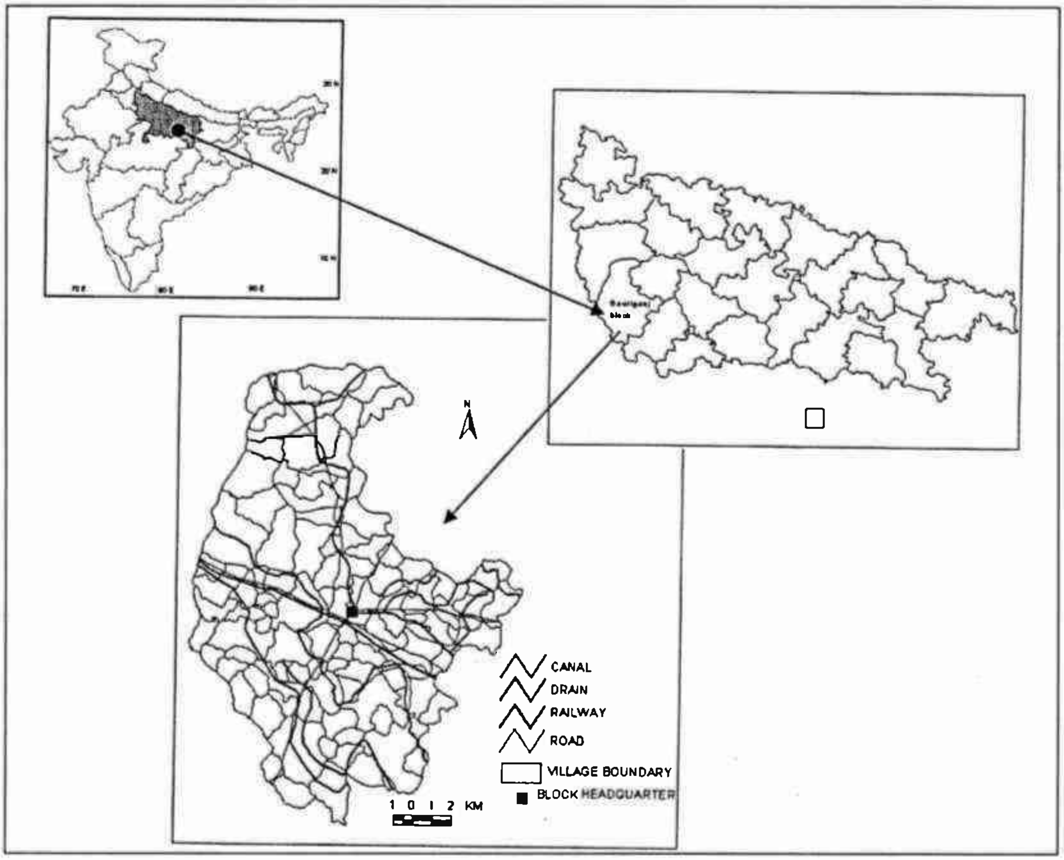
Abstract

The present study is an attempt to identify the planning priority zones (PPZ) for land resource development in Gauriganj Block, Sultanpur District (U.P). The satellite image (IRS P6, LISS III) was processed in digital image processing software ERDAS IMAGINE 9.1 using ISODATA pixel clustering algorithm (unsupervised classification approach) and spectral enhancement (NDVI) techniques for data base generation on land use/land cover and vegetation density. The data generated through remote sensing techniques have been integrated with other non-spatial socio-economic data for identification of PPZ for land resource development. Criterion based technique was used for data integration and PPZ identification. As per analysis out of 100 villages in the study area, 18 villages fall in first priority zone, 55 in second, 24 in third and 03 in fourth PPZ of land resource development. These PPZ may be taken up for developing plan in a phased manner.

Introduction

Land is the most valuable natural resource for production of food, fuel and many other essential goods required to meet human and animal needs (NRSA, 2007). It embodies soil, water, flora and fauna, and involves the total ecosystem (Krishan *et al.*, 2009). Over-exploitation of natural resources for meeting the needs of ever increasing population and rising expectation of living standards without understanding its sustainable limit has caused extensive land degradation problem. The land degradation is universally recognized as a serious threat to present and future agricultural growth and sustainability. Agenda 21 of United Nations Conference on Environment and Development (UNCES) in 1992 also addressed this problem (Koohafkhan, 2000). Globally, 4705 million hectares of land is affected by land degradation problem (Dregne, 1986). Amongst the developing countries, India ranks very high in respect of both, spatial extent and severity of land degradation. Out of the total geographical area of 329 million hectares of India, about 187 million hectare area is under various stages of degradation (Sehgal & Abrol, 1994). According the latest report of the Department of Agriculture and Co-operation, 107 million hectares of area was classified under various types of degraded lands in India (DAC, 1994). It should be noted that today the population has exceeded one billion and by 2025 at the current growth rate of 1.6 per cent, it would be 1.32 billion (Shafi, 2001). Four hundred million tons of food grain would be needed to feed this population (Patil,2003). Hence, urgent efforts are called for conserving the shrinking land resource base (from the present 145 mill. ha. to an expected 123 mill. ha. by 2030 AD) and at the same time exploiting it to support the exploding population (Ministry of Agriculture,1996). Land resource development planning on

Fig. 1: Location Map of The Study Area



sustainable basis is an important key to meet the above challenge of the present century. Since the whole area may not be taken for land resource development at a time, the prioritization of area is an important part of decision making process (Arun *et al.*, 1995).

The advent of remote sensing technology has paved the way to gather information about the earth's resources more accurately (Karale *et al.*, 1988). Remote sensing (RS) coupled with Geographic Information System (GIS) provides a powerful mechanism, not only to monitor land resources and environmental changes but also permit the analysis of information of other environmental variables (Marble, 1983). The multi-spectral satellite data acquired in the visible, near infrared and short-wave infrared channels provides encouraging results in extracting information about nature, extent and magnitude of degraded lands. These data sets in the core of GIS provide an excellent means of spatial data analysis and interpretation (Reddy *et al.*, 2002). In the present study an attempt has been made to identify the PPZ for land resource development based on environmental and socio-economic conditions in Gauriganj block, Sultanpur district (U.P.) Accordingly, the following objectives were framed

Table 1: Details of data source for selected parameters at village level.

Parameters		*Data source*	*Indicator*
X1	Salt affected lands (as % to total area)	Derived from IRS P6, LISS III data	Higher the proportion, more the priority
X2	Area under Soil wetness (as % to total area)	Derived from IRS P6, LISS III data	Higher the proportion, more the priority
X3	Surface ponding (as % to total area)	Derived from IRS P6, LISS III data	Higher the proportion, more the priority
X4	Vegetation cover (as % to total area)	Derived from IRS P6, LISS III data	Higher the proportion, lesser the priority
X5	Soil erosion (as % to total area)	Derived from map Sharda Sahayak C.A.D. Project, 1988, Lucknow	Higher the proportion, more the priority
X6	Density of Rural population (persons/sq km)	Census of India, 2001	Higher the density, more the priority
X7	Literacy in % to total population.	Census of India, 2001	Higher the literacy, lesser the priority
X8	Irrigated lands as % to total agricultural area	Revenue records, Tahsil Gauriganj	Higher the proportion, lesser the priority
X9	No. of Sources of irrigation	Revenue records, Tahsil Gauriganj	Higher the number, lesser the priority
X10	SC/ST population (as % to total population)	Census of India, 2001	Higher the proportion, more the priority
X11	Population below poverty line (as % to total population)	C. D.O. Office, Sultanpur	Higher the proportion, more the priority

i. to identify and map the various forms of land degradation using satellite data
ii. to integrate the environmental and socio-economic data through criterion analysis
iii. to identify and map the PPZ for land resource development.

The Study Area

The Gauriganj block, Sultanpur District, Uttar Pradesh lies between 26^{0}7' 5'' to 26^0 10' 5'' N latitude and 81^0 36'45'' to 81^0 45' 18'' E longitude (Fig.1). It has an area of 207.56 sq. km. and a population of 120892 (as per 2001 census). The community development block of Gauriganj consists of 100 revenue villages and are covered in Survey of India toposheets number 63 F/11, 63 F/12 and 63 F/16. Physiographically, it is a part of the vast Indo-Gangatic plain which is recent in origin. The study area enjoys the semi-arid subtropical monsoonal climate, characterized by hot summer and cold winter seasons. The predominant soils of the study area are silty loam, loam and clay loam. The block is economically backward and majority of the population (78.50% of the working force) earns livelihood from agriculture and other allied activities. Land degradation is a major agro-ecological problem in the block.

Materials and Methods

Data Used

In the present study, environmental and socio-economic parameters were considered for identification of PPZ for land resource development. The data pertaining environmental parameters except soil erosion (salt affected lands, soil wetness, surface ponding, and vegetated lands) were derived from satellite data of IRS-P6 LISS III (path-101 and row-53, Band- Green, Red, NIR and SWIR ,Resolution-23.5 M, January, 2006). The Google Earth high resolution images (source- http //www. Google Earth.com) and field check data (collected through field in the month of January, 2009) were used for validation of generated map. The village level data on soil erosion was extracted from thematic map prepared by *Sharda Sahayak* C.A.D. Project,1988, Lucknow (U.P.) The socio-economic data pertaining density of rural population, literacy, irrigated lands, source of irrigation, SC/ST population, population below poverty line were drawn from census of India, 2001 and office of Chief Development Officer, Sultanpur (Table-I). Survey of India Topographical sheets and Village boundary map prepared by NNRMS, Sultanpur (U.P.) were used for geo-referencing and base map preparation. The digital image processing software Erdas Imagine 9.1 and GIS package of ArcView 3.2a. were used for data analysis and mapping.

Data Base Dvelopment

Initially, the base map of study area has been prepared from SOI toposheets and block boundary map on 1:50,000 scale and saved in computer environment. This map was imported into image processing software ERDAS IMAGINE 9.1 and geo-referenced by taking various control points. The projection type used is polyconic with the spheroid and datum an Everest. The satellite image was registered through image to image registration and processed using Iterative Self-Organizing Data Analysis –ISODATA algorithm of unsupervised classification approach in ERDAS Imagine 9.1 for data generation on land use/land cover. To evaluate the classified image files (thematic raster layer) accuracy of classified map was assessed taking random sample of 250 points on reference image and analyzed in ERADAS IMAGINE software using Accuracy Assessment option in the Classification dialog. The classified layers were compared with ground truth data and Google Earth high resolution image and error matrix was prepared. To generate the data on vegetation cover, spectral enhancement technique of Normalized Difference Vegetation Index (NDVI) was attempted.

The land use/land cover raster layers and NDVI image were vectorized using raster to vector conversion tool available in ERDAS IMAGINE vector utility option and exported to GIS environment (ARC VEIW 3.2a) for data base generation at village level. The polygons corresponding salt affected lands, wet soil area and surface ponding were taken directly from the land use/land cover map and analyzed in ARC VIEW 3.2a environment. The socio-economic parameters such as rural population density, Table-II Weighted values assigned to the parameters

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
1	< 6.65	< 18.92	< 0.06	> 46.79	< 0.86	< 573	> 64.40	< 51.73	C, T,Tk,P	< 13.70	< 18.75
2	6.65 – 12.90	18.92- 29.74	0.06-0.16	32.74- 46.79	0.86-3.45	574- 1014	53.40- 64.40	51.73- 66.41	C,T, Tk	13.70- 26.50	18.75- 31.50
3	12.90 – 20.86	29.74- 40.10	0.16-0.33	20.00- 32.74	3.45 -6.33	1015- 2228	41.40- 53.40	66.41- 78.08	C,T	26.50- 41.90	31.50- 46.90
4	< 20.86	>40.10	> 0.33	< 20.00	> 6.33	> 2229	< 41.40	> 78.08	C	> 41.90	> 46.90

C =Canal , T= Tube well ,Tk= Tank, P= Pumping set

irrigated area, and source of irrigation and SC/ST population were also mapped at village level.

Integration of Data

The criterion based analysis was performed for integration of the all types of data pertaining environmental and socio-economic parameters at village level. According to spatial extent of each parameter all villages of the study area were grouped into four categories using natural breaks option of legend editor in ARC VEIW 3.2a. and each category was assigned different weighted value (Table-II). The higher weight values are given to the villages falling within higher categories of the parameters of salt affected lands, wet soil, surface ponding, eroded soil, rural population density, SC/ ST population, and population below poverty line while, higher weight values are assigned to the villages falling within lower categories of the parameters of irrigated lands, source of irrigation (number), literacy, vegetation cover and vice-versa. Total weight score for each village has been computed by aggregating the weight values of all parameters and finally all villages were grouped in to four categories of PPZ according to the total weight score.

Result and Discussion

In the study area, six land use /land cover categories i.e. i. salt affected lands ii. wet soil area iii. Surface ponding/water bodies iv. dense vegetation cover v. agricultural area and vi. bare soils/built-up were mapped using unsupervised classification (ISODATA algorithm) approach (Fig.2, See page 163). The accuracy assessment result is obtained about 0.7983 overall Kappa and 88.32 percent of overall accuracy. The land use/land cover analysis result have shown that out of total image classified area of 21216.33 ha., 36.35% of the area is under bare soils/built-up area, 20.97% is under wet soil, 18.82% under agriculture,12.56% under salt affected lands, 9.38% under surface ponding/water bodies and 3.3% is under dense vegetation cover (Table III). Normalized Difference Vegetation Index (NDVI) values are found in range of -0.54 to 0.69, having mean value of 0.07 and standard deviation of 0.36 for January, 2006 image. The study area was mapped classifying NDVI into two broad categories using threshold of 0.20. Below 0.20 NDVI values are observed over salt affected lands, built-up area, water bodies and open soil while above 0.20 NDVI values are seen over agricultural, sparse vegetated and dense vegetated area (Fig. 3, See page 164) .

Table III: Land use / land cover statistics in the study area –January, 2006

Sl.No.	*LU/LC classes*	*No. of Pixels*	*Area (ha.)*	*Area (%)*
1	Salt affected lands	41072	2665.75	12.56
2	Wet soil area	72245	4449.31	20.97
3	Surface ponding /water bodies	34576	1991.58	9.38
4	Dense vegetation	12174	701.28	3.3
5	Agricultural area	69347	3994.39	18.82
6	Bare soils / built-up area	133924	7714.04	36.35
	Total	***368339***	***21216.33***	***100***

(Based on unsupervised classification of IRS P6, LISS III data)

Table IV: Land resource development planning priority zones in Gauriganj block, Sultanpur district (U.P)

Priority Zones	*No. of Villages*	*Area (In %)*	*Population (In %)*	*Name of the villages*
First	18	28.67	19.08	Benipurbaldev,Gulalpur,Bastidei, Majhawara, Bhatgawan, Mau, Gopalipur, Shujanpur, Guwawan, Sarai Hirdai Shah, Jethauna, Chhitepur, Saintha, Lugri, Katra Lalganj, Madhopur, Sultanpur and Jaymalpur.
Second	55	52.06	51.28	Rauza,Bhanmatipur,Tulsipur,Basupur,Oripur,Narauli,Rohnikhurd,Gauripur,Jagdishpur,Anapur,Bisundaspur,Dostpur,Harakhpur,Saraibhagmani,Mahimapur,Garhamafi,Khajuri,Jethumawai,Tikaria,Misrauli,Asaidapur,Babupur,Gudur,Gudunpur,Lalshahpur,Pandri,Pathanpur, Aintha,Ismailpur,Saripur,Antanagar,Bhanpur,Sakarwan,Ramaipur,Argawan,Amiya,Palia,Paharpur,Raghipur,Rohnibuzurg,Bhawanshahpur,Chandaipur,Biswan,Pachehri,Dharupur,Sogrha,Gujartola,Painga,BarnaTikar,Rampur,Kanarwa,Kazipatti,Sembhui,Pure Fazil, Sarauli, Itaunza, and Pachhim.
Third	24	18.57	16.29	Shahbajpur,Saraibakhandsingh,Behta,Darpipur,Baburitola,Lilatikar,mednamawai,Belkhaur,Basaikpur,Annibaizal,Sambhawan,PureUdhau,Paharganj,Kharawan,Chauhanpur,Banwaripur,Dhanapur,Asura,Balipur,,Khurdawn,,Rajgarha,,Sehipur, ,Madhpur , ,Dhani Jalalpur,and Basthan.
Fourth	03	2.45	0.43	Sujapur,Rajapatti, and Mohanpur.
Total	*100*	*207.56 km2*	*120892*	

To find out the village wise statistics the raster NDVI map was vectorized and analyzed in GIS environment.

PPZ Analysis

The study reveals that the salt affected poor soil cover, soil wetness, surface ponding, sparse vegetation cover, low level of literacy, wide spared poverty and improper utilization of natural resources characterize the area under study. The study emphasized on prioritization of zones for the land resource development on a sustainable basis, based on environmental and socio-economic conditions. The prioritization results reveal that the study area is divided into four classes of PPZs (Fig. 4, See page 165). Out of 100 villages 18 (Area 28.67 %, Population-19.04 %) ranks highest in villages and are considered under first PPZ (Table IV). They can be taken up for the land resource development plan on sustainable basis with immediate effect. A large number of villages (55) of the block fall under second PPZ which covers 52.06 % area and 51.28 % population of the study area. Out of remaining 27 villages, 24 fall in the third PPZ while only 03 villages fall in the fourth PPZ . The third and fourth PPZs cover 18.57 and 2.45 percent area and 16.29 and 0.43 percent population of the study area respectively. These PPZs may be taken up for development of land resource in a phased manner.

Counclusion

The present study showed that satellite remote sensing data (IRS P6, LISS III) analysis based on ISODATA clustering algorithm and spectral enhancement (NDVI) techniques is found very useful in identification and mapping of various types of degraded lands and vegetation cover at village level. . The reveals that the salt accumulation on the surface, soil wetness and deforestation are the main agro-environmental problems in the study area. The faulty land use practices, improper utilization of water resources, canal seepage, obstruction of natural drainage due to construction of man made features and low level of awareness among farmers are found to be the major causative factors for the above agro-ecological problems. The PPZ map demonstrate that the maximum number of the villages (73%) of the study area fall under higher PPZs (First and Second) which indicates the severity of the problem. It would be therefore be necessary to plan for sustainable land resource development in these villages on priority basis considering overall environmental and socio-economic conditions of the study area .The identified PPZs can be also useful in environmental planning and restore fragile ecological balance at micro level in the study area.

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Dr. D.K.Tripathi
Associate Professor
Department of Geography
Kamla Nehru Institute of Physical &
Social Sciences, Sultanpur (U.P.) India,
tripathidk.geoinformatics@gmail.com

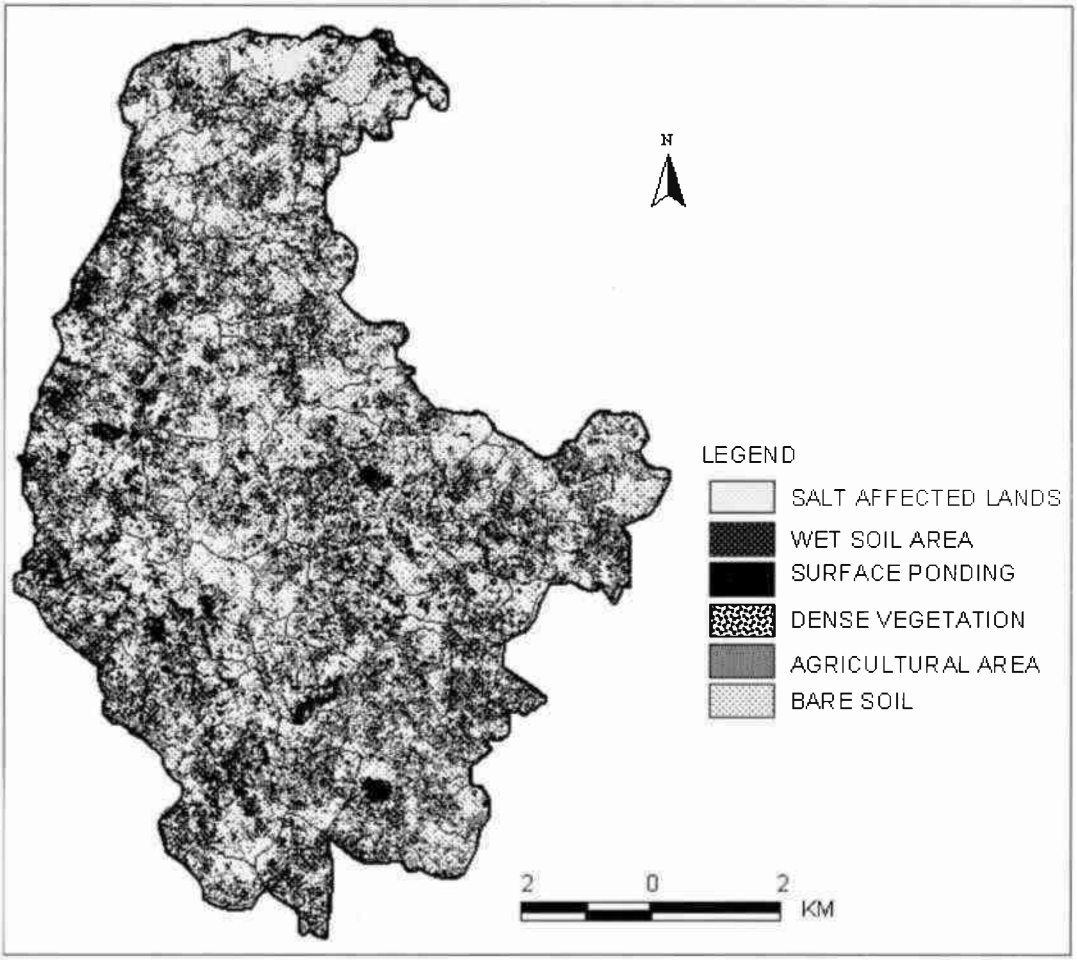

FIG. 2

LAND USE / LAND COVER
BASED ON IRS P6, LISS III DATA, JAN., 2006

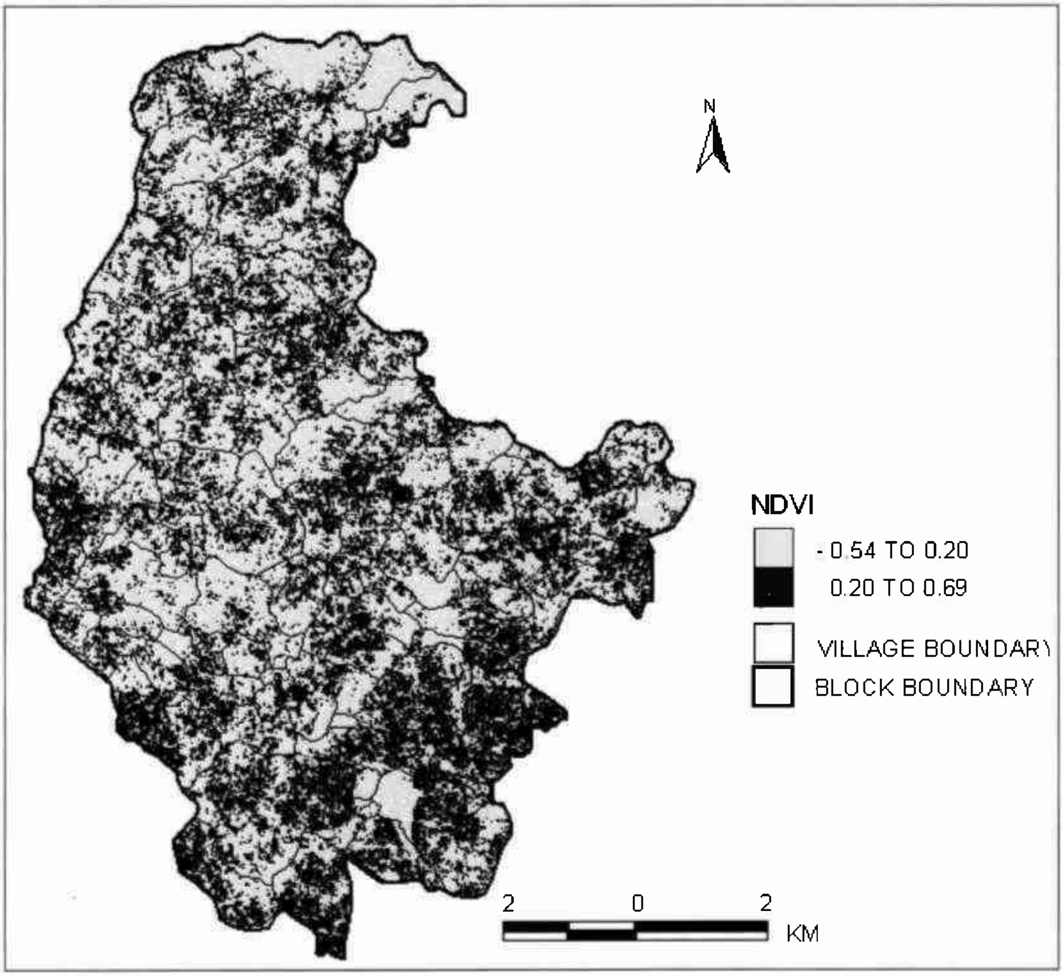

FIG. 3

VEGETATION COVER
BASED ON IRS P6, LISS III DATA, JAN., 2006

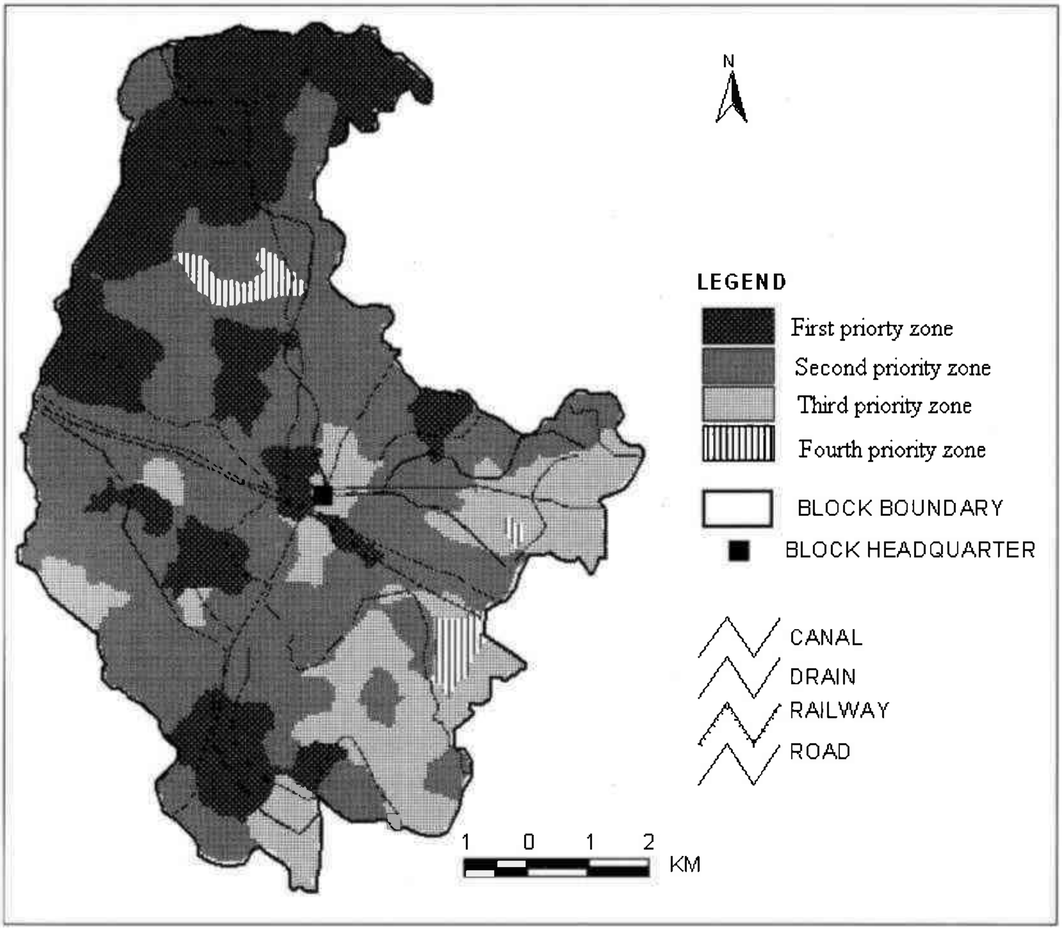

FIG. 4

DEVELOPMENT PLANNING PRIORITY ZONES