GIS Application for Landuse/Land Cover Management in Context of Wasteland – A Case Study of Ferozepur Jhirka Block in Haryana State*

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ABSTRACT

Since land use is a spatial subject, the approach to reclamation of wasteland too has to be spatial. The spatial approach takes into consideration problems of integration among all the elements of agriculture and, their space affinity, and, in turn, the spatial dimension of agriculture. Agricultural productivity is dependent on physical, economic and institutional factors and the genesis of wasteland also bears a close relationship with these principles. Recognizing this principle, the Planning Commission has adopted regional approach to agriculture by grouping districts into 15 agro-climatic regions and within them 74 sub-regions or zones, on the basis of the three parameters mentioned above. Because of regional contrasts in physical conditions, it is possible to identify typologies of wasteland in their physical setting, e.g. saline wasteland which occur in contiguous tracts close to the meeting place of the river with the sea, as in delta areas along the east coast or in the alluvial plains of U.P. and Bihar where exploitation of underground water and water logging have rendered large tracts of good agricultural lands wasteland. Foothill areas brought under cultivation by improper terracing and indiscriminate exploitation of the vegetal cover have also contributed to increase in area under wasteland. These reflect economic factors, as they influence land use and land productivity. There are institutional factors, such as land tenures and fragmentation of land holdings, which also contribute to gradual reduction in land productivity especially in semi-arid regions where dry farming is practiced; and over the years these lands have been rendered waste.

Environmental conditions differ widely within and between different agro- climatic regions of the country. Deterioration of land quality resulting in wasteland due to either environmental or socio-economic factors cannot be left to persist. Aggregate statistical figures at the national and state levels about the success achieved in wasteland reclamation vary widely as they are not based on scientific evaluation of wasteland as a spatial phenomenon to the extent they reveal ground truth. Wasteland coexist spatially along with lands put to different uses; and hence they have to be identified and evaluated using a holistic or spatially integrated approach lest they become problem areas for other land uses.

Increase in agricultural output and productivity in India has been achieved primarily through intensive cultivation utilizing modern methods of farming, increase in area under cultivation and to a small extent by effecting changes in cropping pattern. Expansion of cultivated land beyond limits imposed by environmental factors and indiscriminate exploitation of groundwater have contributed substantially to the land becoming waste.

The watershed approach (at both micro and macro levels) recommended for integrated land and water management portrays the principles of land use planning with vertical zonation of land use according to altitude or slope (specially in hilly and mountainous regions) according to ground reality. At the cadastral level the land use, land productivity and the gap between land capability, existing cropping pattern and productivity portray the interplay of physical, economic an institutional factors between land holdings and households which own the land or lease out to the landless and marginal owners. Since socio- economic conditions of the households in the village vary sharply it becomes essential to evaluate human response to land use-choosing household as a location entity and landholdings made up of groups of plots as areal units.

Keeping in view the hierarchic space relations from the district to village level as a part of the strategy for integrated area planning from below, the design and analytical framework of the present study covers three area levels - the village, village cluster approximating to a watershed and the Development Block as a unit of planning adopted in the context of the approach to decentralized planning. District plan and that of sub-regional plans within the States (e.g. Mewat region in Haryana) could then be more realistic for integration of environment in the development strategy. The present paper is based on the results of a pilot project study on landuse/land cover management in context of wasteland which has been taken up in Ferozepur Jhirka Block of Gurgaon district of Haryana (**Map 1**) at the behest of the National Wastelands Development Board (NWDB), Ministry of Environment & Forests, Government of India.

The main aim of the pilot study was to test the capability and utility of GIS technology in the preparation of micro-level action plans for development and management of land use, with particular reference to wasteland. Within this broad objective, the first major objective of the study was development of procedures and systems based on spatial and non-spatial data modeling using GIS for operative uses of wasteland development planning at block and village levels. Another objective was to assess the utility of satellite data in identification and mapping of various land use practices, and categories of wasteland, and to update the information contained in wasteland maps. The specific objective in this respect was to analyze critically the pattern of natural use at block level highlighting spatial variations and their types; and to establish their suitability classification, analyzing their respective scope, and limitations and potentialities for agricultural and non-agricultural uses followed by identification of wasteland and its types such as degraded forests, waterlogged areas, salt affected areas etc

In order to introduce space element to the study of the dimensions of natural environment, resource endowment and its utilization with reference to factors contributing to wasteland formation, spatial variations in human response and its impact on land use at three scales of areas mentioned above, topographical maps and satellite imageries of the scale of 1:50,000 and secondary data with village as the areas unit have been used. For spatial analysis, Geographical Information System (GIS) having the capability to handle both spatial and non-spatial data and integrated modeling plays an

important role in evolving and implementing a Decision Support System (DSS). The present paper presents some of these issues in detail.

INTRODUCTION:

The study area i.e. Ferozepur Jhirka Block is located between latitudes 27° 39' N and 27° 53' N and longitudes 76° 54' E and 77° 9' E. It is situated in the southern-most part of Gurgaon district and Mewat region. Delhi metropolitan city is about 120 kms from the area. Important towns around the area are Alwar, Kaman, Tijara (in Rajasthan), Kosi, Chhata and Ghaziabad (in UP), Hodal, Palwal, Nagina, Nuh, Sohna, Gurgaon, Faridabad and Rewari in Haryana. The total geographical area of the Block is 302.89 km^2. Delhi-Alwar National Highway No.8 passes through the Block. It is also a part of the National Capital Region of Delhi. The Block has 81 villages and Ferozepur Jhirka is the only town in the area. Physiographically, the area is characterized by gently sloping hills and undulating plains. Prominent topographical features of the area are elongated rocky ridges running north south on the western border and northeast to southwest on the eastern border. The hillocks on the western side are sloping towards the east and hilltops can be easily seen to rise high above the alluvium. On the eastern side, the hills slope towards the east. There are also some isolated denuded hills in the eastern part of the Block and those also show the general north-south trend of the Aravalli range.

Spatial patterns and variations of different attributes relating to landform, land use, wasteland and demographic characteristics and their spatial association are brought out in the study. Genesis of wasteland and their typologies into degraded forests, undulating land, gullied and ravinous land, degraded pastures, waterlogged, salt-affected and sand-affected areas etc. have been mapped and analyzed with special reference to their relationship to natural environment, other land uses, human response and the problems and potentialities for reclamation.

Qualitative data retrieved from satellite imageries in the form of maps have been quantified and brought to the administrative mode using village boundary to facilitate its effective use in planning. Choropleth maps generated by this exercise have been compared with those based on revenue data compiled from patwari records. The anomalies have been very effectively brought out; and potential use of remote sensing techniques in building up a resource inventory in all its spatial pattern and association with several attributes relating to the resources base illustrated with the help of maps.

Village clusters have been identified based on homogeneity criteria. This is an attempt in regional synthesis based on the spatial patterns of distribution and association of important attributes of land quality and land use analyzed during the study. Pending the application of quantitative techniques of spatial association of attributes and grouping of villages according to similarity in the pattern of association village clusters are identified by map overlay technique. This approach, elementary as it would appear initially, is suitable in micro level planning where all the patterns of distribution reveal realistically the ground reality as implied in hierarchic concept of space and spatial generalization.

METHODOLOGY:

Methodologically speaking, the approach to spatial analysis involves the evaluation of natural resources in terms of its potential, limitations etc. and assessment of felt needs and priorities of the

local people. Mainly map data was used for natural resources analysis and socio-economic data for need aspect analysis. Since the data sets were available in different forms, to standardize them, these were reformatted and suitably converted to a form amenable for data storage in GIS.

In this study ARC INFO GIS package was used. This package offers the capability to analyze multiple and wide-ranging types of spatial map data and attribute statistical and tabular data. The graphic (ARC) and tabular database management (INFO) components of this system combine together to offer a complete set of tools to store and handle geographical data. It can compare, as the maps and analysis illustrate, integrate and analyze different data sets in polygon, line or point form. The system provides basic software tools for interactively inputting the map data via digitization, and the tabular data via alphanumeric terminal. Integrated land system analysis approach was employed to determine the capability of the land - a measure of what the land can be best used for, and based on the capability, to recommend the developmental measure for the wasteland patches. Land evaluation through parametric approach was adopted for land capability classes to indicate the land potential. The land was classified at various levels which helped in identifying the homogeneous areas by ways of determining the internal homogeneity and heterogeneity quantitatively and validating the boundary between; the adjacent units. Attributes relating to land capability were mapped and analyzed to build up a land capability map.

Study of wasteland cannot be isolated from other lands and their uses as they are organically related. The relationship is best expressed in the causal relationship - structure <---> process <---> stage. In the context of natural environment it conveys the interdependence in the form of environment <---> land use <---> land productivity as the resultant or the state of land. Since land use and land productivity are influenced by socio-economic condition of the people it is man-made environment or human ecology that was taken the basis of resource evaluation and formulation of the development strategy. Techniques of spatial analysis adopted for the study of spatial distributional pattern of different attributes and their association were mainly cartographic using relatively simple quantitative techniques such as conversion of absolute values into ratios and areal concentration indices - with reference to medium values for the study area.

Quantification of qualitative data based on the spatial pattern of distribution of attributes relating to land quality such as conversion of relief map into slope map, drainage density as a value for the measurement of ruggedness of the terrain, estimation of land use under various categories and wasteland types was attempted. Measurement of the extent of association was done by preparing thematic maps of various attributes, superimposition of related spatial patterns, tabulation of the frequency distribution of different attributes into High, Medium and Low categories, grading them further according value range among each categories e.g. High values into Extremely High (EH), Very High (VH), High (H), High Medium (HM) etc. Similar grades of frequency were adopted among low values (EL, VL, L, LM, etc). Medium value was the average value for the study area. Secondary data on land use and population attributes were compiled from patwari records and census volume related to the study area. Village has been adopted as the areal unit for data compilation and generating the spatial pattern with cartographic techniques as mentioned above.

Broad land use comprising dense forests, degraded forests, barren and unculturable lands, land under pastures, areas not available for cultivation (settlement sites, communications, water bodies etc.) and cultivated areas have been identified from the satellite imageries of 1:50,000 scale and

mapped on the same scale of topographical maps to facilitate interpretation of the spatial patterns of land use against the background of topographical and cultural features.

Wasteland is an integral part of all the land uses. The secondary data on seven attributes of broad land use compiled from patwari records were subject to similar processing for converting them into appropriate percentage values as shown on the maps and these percentage values were grouped around the medium value according to different frequency ranges. All the percentage values such as of net sown area, land put to non-agricultural use, barren and unculturable land and culturable waste were calculated with reference to total geographical area while spatial variations in the intensity of cultivation were brought out by mapping the percentage value of the area sown more than once with reference to net sown area.

Work participation rate was arrived at by calculating the percentage of workers to total population. Similarly land-man relationship was analyzed by calculating the percentage of workers in agriculture, industry and other services as defined in census. Spatial variations in the extent of workers in agriculture was studied by calculating the percentage of cultivators to total workers in agriculture and of landless people i.e. agricultural labourers.

Based on the study of landform - land use associations villages have been grouped into contiguous clusters according to homogeneity criteria and their characteristics stated with focus on area approach to problems in land use planning. These served to identify and evaluate the types of wasteland as they occur under different physical conditions.

For the evaluation of non-commercial energy, endogenously available resources were analyzed taking into consideration fuel wood, fodder, crop residue and dung. Database is very scarce and norms and ratios for converting raw materials into energy units are not available through very few empirical surveys. These have been applied to workout surplus/deficit scenario at village level and mapped for understanding the spatial variations and the backward linkage of non-commercial energy to the endogenously available resources (forest, grass, livestock, crops grown etc).

RESULTS & CONCLUSIONS:

As far as main results of the study are concern, these includes that four distinct clusters of villages emerge with one more groups of villages, which are transitional between any two types. These are (i) Steep Slopes and Dense Forested Hill Ranges, (ii a) Alluvial Plains - Mainly Agricultural, (ii b) Alluvial Plain - Agricultural Area with Wasteland due to Water Logging, (iii) Dissected Hills and Degraded Forests, (iv) Alluvial Plains with Residual Hills, and (v) Transitional Area.

Land capability map and village clusters are found to be very valuable in planning, particularly for identifying development schemes, which are area specific. This lends objectivity and selectivity in preparing a shelf of development schemes aimed at creation of durable assets as a part of the ecologically sound employment generating programmes.

Approach to the study of wasteland studied has covered extensively various attributes of land; an imprint of the complex association among the three important dimensions, namely, natural environment, land resource endowment and human response to its utilization. The approach adopted is holistic in its vertical (structural) and horizontal (spatial) relationships. To this end,

landscape approach is attempted. For example, analysis of spatial distribution and the patterns and processes of interaction of the natural elements enabled classification of land units and their capability. This formed the physical-spatial framework for highlighting the causal relationship between landform, land use and the impact of indiscriminate use of land leading to degradation of forestland and impoverishment of soil. The following are the other important findings emerging from the study.

Under-utilization of all types of land, particularly in semi-arid areas with sharp contrasts in topography, is quite common and wasteland is an extreme example of land once cultivated having gone out of use, or its not been put to one or the other use. Genesis of wasteland attempted in this study provided ample illustration of the effect of hydrogeomorphological processes as well as human response to land use under varied socio-economic conditions of the community that have accentuated the process of land degradation and increased the area under waste. The degraded forest, particularly along the eastern part of Ferozepur Jhirka block, is a good example of this. Equally important is the extensive waterlogged and marshy area in the alluvial plain, which has rendered a relatively good agricultural area into waste. Similarities in land quality and spatial pattern of their distribution from the crest line of the Aravalli range to the alluvial plain has brought out vividly the relationships among different land units that are identified by altitudinal zones, resultant drainage, soil, and vegetal cover. The contact zone between the alluvial plain and sloping land up to 8° appears to be very crucial and needs priority among measures to check soil erosion by bunding drainage channels, afforestating degraded areas and converting some of the land into pastures for the much-needed livestock improvement and increase in their numbers. This is because the ratio of livestock per household and cultivated area is far below the minimum requirement for land cultivation and employment generation programme for the landless households involving rearing milch cattle and sheep. Physical-spatial planning of land use and its forward linkage with livestock is an integral part of agriculture and programmes relating to provision of infrastructure and inputs for increasing land productivity. Location of a network of service/market centers within Ferozepur Jhirka block and the surrounding region with which the area interacts as a part of the social and economic organization of the activities spatially could be an important strategy in area development planning.

The holistic spatial approach to land capability classification is adopted in agricultural development planning from the macro level. Since the beginning of the Seventh Five Year Plan, a scheme has been adopted for formulating a regional agricultural development strategy for different agro-climatic regions. Success of such a strategy would lie in translating various approaches into regional agricultural development plans for zones and sub-regions within the states and, in turn, identifying area-specific agricultural development programmes at the micro level.

To this end, the attempt towards identifying hydrogeomorphological units, evaluating their relationship with the existing land use and land capability classification has been a logical step towards evolving a normative spatial framework for resource utilization as a guide to the formulation and implementation of development schemes of local importance and their integration with regional plans and, wherever applicable, to national level plans. Wasteland and its reclamation for alternative uses can thus be an integral part of the overall land use plan. At the moment, even the preparation of a resource inventory and identification of area-specific development schemes aimed at creation of durable assets at and below the district level have not been attempted systematically let alone studying the linkage of this exercise at regional level, such as agro-climatic

zones or sub-regions within the states of which the district and development block, etc. are related parts. Methodology for land capability classification and the results obtained for the study area could form the basis for replication mutatis mutandis under similar conditions in various parts of Haryana.

Land resource inventory prepared using topographical map of 1:50,000 scale and updated from the satellite imagery data on the same scale is essentially qualitative, though it reveals ground truth to the extent the scale of the map permits. A quantitative database has been created with village as the areal unit by measuring the areas covered under different land form-land uses. Spatial patterns of land use, wasteland and its seven typologies have been generated by mapping village-wise data using an appropriate cartographic technique. These maps are not only analytical but rich in information content in respect of the concentration of different types of land uses and wasteland in village clusters which show high, medium or low levels of concentration. This is an important step in identifying village clusters (as opposed to individual villages) having similar problems or potentials relating to land use planning. The importance of GIS has been amply demonstrated in the approach and findings of the study.

Village clusters having relative homogeneity in respect of certain spatial attributes have been identified and mapped. An attempt is also made to state their characteristics. As a follow-up of this exercise, it would be valuable to take up an in- depth study of at least two village clusters, which have contrasts in respect of the above characteristics, for formulating development schemes specific to them. Considering the process of district planning that is presently in vogue with reference to a general list of development schemes falling under the "District Sector", this study has served to identify the development problems selectively according to the problems and potentials specific to village clusters. Such a step would lend objectivity in financial allocation to schemes of development and also 'tie them' to area- specific programmes. The types of wasteland differ spatially. Yet the approach could be similar for formulating and implementing wasteland reclamation as a separate but related programme in district planning.

Problems in land form-land use planning at the micro-level have to be evaluated in the context of the felt needs and priorities of the people living in the area. From this consideration, selected demographic attributes, such as population size and density (per km^2), work participation, occupational pattern, concentration of cultivators or landless agricultural labourers, etc. were mapped to bring out the land- man relationship spatially and to relate the emerging patterns to land use, land capability etc. However tentative, some of the findings are of direct relevance to attempts at reclamation of wasteland or afforestation as a means of generating employment, and reducing dependence on agriculture by developing off-farm activities like livestock rearing. These aspects need consideration while formulating development schemes.

The inherent limitations of land records data for portraying ground reality in micro-level planning are by now well recognized and measures are afoot to update them by adopting a more efficient and rapid method for building up such records.

In the present study, an attempt has been made to make use of selected attributes of land use, such as net area sown, area sown more than once, culturable waste and barren and unculturable lands. It is quite revealing how the spatial patterns generated with the help of satellite imagery and data from land records are at wide variance, the latter confusing and even misleading the facts related to ground reality. Data on net area sown obtained from these two sources show less variation, while

within them; details of land use, crops and wasteland differ very sharply. This is understandable, because field checking with the help of cadastral maps rarely updates the data on land use available in land records.

With regard to data retrieved from satellite imageries too, accuracy at the ground level is far from reality. In a separate exercise, this has been brought out by identifying all patches of wasteland through field observations and mapping plot- wise using cadastral map. Resolution on 1:50,000 scale of the satellite imagery is not adequate to match ground truth by field survey. Moreover, the area covered by minimum mappable unit on 1:50,000 scale is 2.25 hectares, while plot sizes of less than even one-fourth the area covered by the imagery are locally important for the landowners, in particular, for integrated land and water management for the village as a whole (e.g. use of common property land for social forestry, pastures, etc.).

KEYWORDS:

Land Use/Land Cover
Land Management
Wasteland Development
Ferozepur Jhirka Spatial database

REFERENCE:

This paper is based on final project completion report titled, "GIS Applications for Rural Land Management – Case Studies in Gurgaon (Haryana) and Alwar (Rajasthan) Districts"-NISTADS-REP-130 (RP) 93, prepared by Dr. Subhan Khan for the sponsored project of National Afforestation & Eco-Development Board, Ministry of Environment & Forests, Govt. of India at National Institute of Science, Technology and Development Studies (NISTADS), New Delhi – 110 012

BIBLIOGRAPHY:

Abrol, I.P. and Dhruva Narayana, V.V. (Technical Eds); 1990; Technologies for Wasteland Development; Publication and Information Division, ICAR, New Delhi

Agarwala, V.P. and Chadha, P .C. (1984); Greening the Aravallis: Sehsola (Gurgaon) Experiment, SPWD, New Delhi.

Belward, Alan S. and Valenzuela, Carlos R. (Ed.); 1991; Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries; Kluwer Academic Publishers, Dordrecht

Commission of the European Communities, Directorate General for Development; 1989; Rehabilitation of Common Lands in the Aravalli Hills, Haryana, India; Appraisal Report; code 450009

Department of Space, GOI; 1990; Manual of Nationwide Land Uses/Land Cover Mapping Using Digital Techniques; Part II; Regional Remote Sensing Services Centre, Nagpur

Land Use/ Land Cover & Management Practices in India- Proceedings of the National Conference held on August 21-22, 2003, Hyderabad, AP, (Ed. by N.C. Gautam and V. Raghavswamy), BS Publications, Hyderabad

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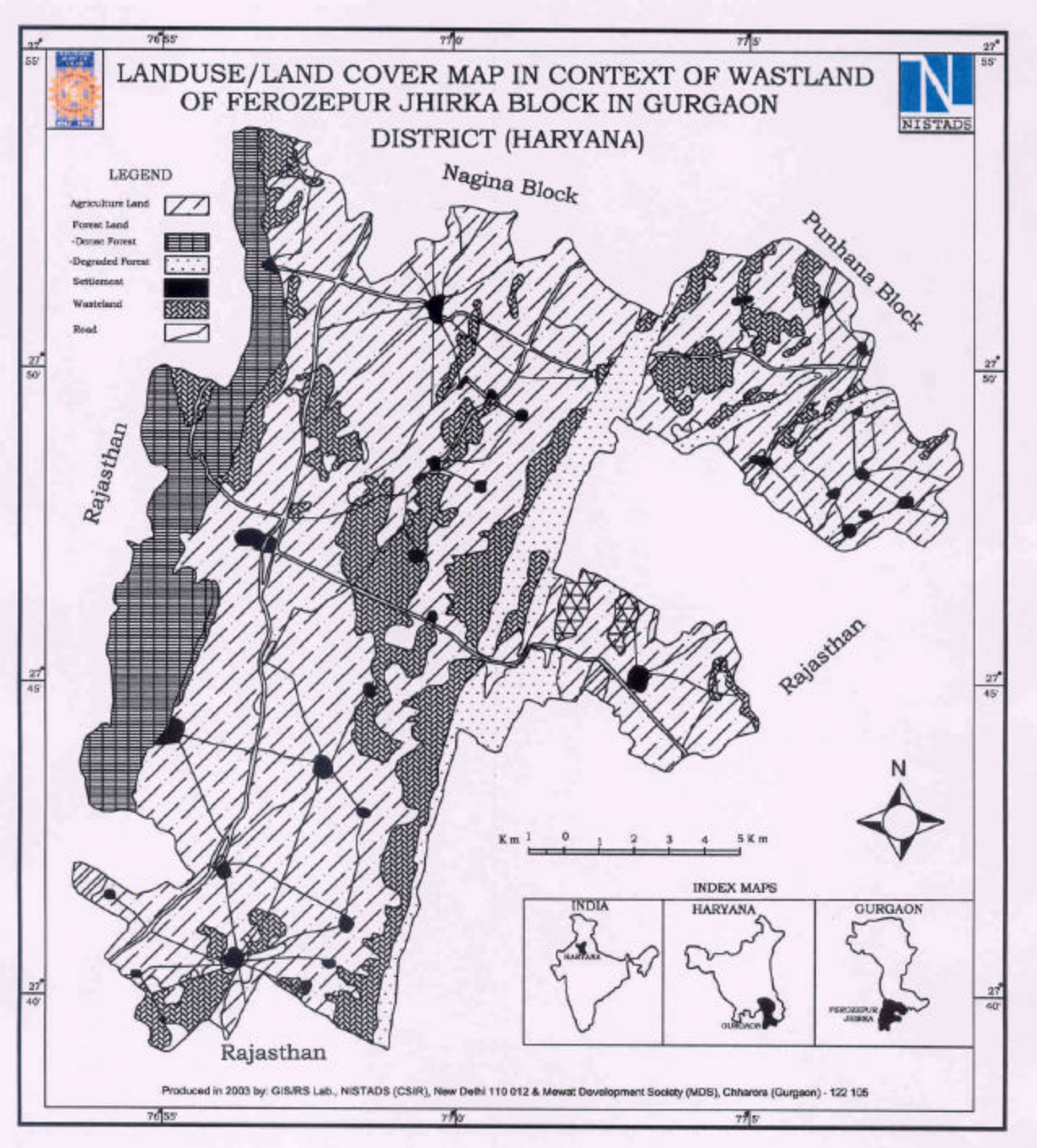

Map 1