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PATTERNS OF LAND UTILIZATION IN SUB-WATERSHEDS OF MOREL SUB-CATCHMENT (RAJASTHAN)

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Abstract

The paper deals with aggregate land use/land cover classification based on screen visual interpretation on digital FCC on the scale 1:50,000 and finally logical merging of Kharif (summer) and Rabi (winter) crop season classes. The area (2946.57 km2) under arable land category is just half of the total study area (5892.78 km2). Rabi cropland use predominates among all the 14 classes of land use/land cover sharing 34.69 per cent of the total Morel sub-catchment during the agricultural calendar 2001-02. The ravine land cover shares 15.30 per cent of the total study area ranking second to the Rabi cropland use. The area mapped under Kharif crop is less due to rainfall received 20 to 28 per cent less than the annual mean rainfall amount in the semi-arid Morel sub-catchment during the 2001.It may also be less due to bajara and pulses might have been harvested earlier than the date of satellite pass over the study area. Besides, mixing of spectral signatures could be overcome by collecting sufficient ground truths pertaining to doubtful classes along with other classes of land use/land cover and subsequently correcting bit maps prior to the final aggregation of land use/land cover for the study area.

Introduction

The relation between man and land determines all the productive and economic activities. Land is not only a resource but also a resource base in itself. Hence, the land use concept has been broadened 'many of the major controversies surrounding rural land use in western countries in recent decades have involved the concept of land as landscape (Mather, 1986). The term *land use* refers to the human activity or economic function associated with a specific piece of land. The term *land cover* refers to the type of feature present on the surface of the earth. Both the terms are collectively referred as patterns of land utilization in this study. A drainage basin is considered as a natural integer of all hydrological and environmental processes active within the boundaries, and therefore, it is considered as the appropriate physical unit for resource planning and management. There is a growing demand of the spatial information of existing land use/land cover for many planning activities.

It is indicated that 'remote sensing' has an important role to play, since it provides information on landforms, drainage systems, near surface geology and vegetation (Drury, 1990). One of the problems commonly faced is that 'same objects may show different reflectance or the different objects may have the same reflectance' (Joshi and Gairola, 2004). However, 'the rapid advancement in remote sensing technology and continuous inflow of satellite data has given input and realization for periodic updating of the priority status of sub-watersheds' (Suresh, et. al. 2004). In fact, 'with the further development in sensor technology, it may be feasible to generate more detailed information on degraded lands that may help implementation and monitoring the progress and success of reclamation and conservation programmes' (Rao, et. al. 1997).

Aggregation of two seasons data provide more precise data as indicated in map output pertaining to patterns of land utilization in a given study area. Marginal areas under the cropland use are more susceptible to erosion in the event of rainfall received much higher than the normal rainfall occurrence in semi-arid conditions of Morel sub-catchment. Undoubtedly, 'land use/land cover assessment is one of the most important parameters to meaningfully plan for land resource management' (Jayakumar and Arockiasamy, 2003).

The main objectives of the study are:

(i) to obtain aggregated land use/land cover based on interpretation of two different seasons' satellite data,

(ii) to generate statistics pertaining to different categories of land use / land cover and

(iii) to comprehend patterns of land utilization at sub-watershed level.

Study Area

The Morel river sub-catchment is one of the sub-catchments of the Banas river catchment. The Banas catchment is a part of Chambal basin and in turn the Chambal basin belongs to the Ganges region as indicated in the Watershed Atlas of India (Government of India, 1990). This Watershed Atlas of India provides a practical and uniform base for watershed characterization. As per the nomenclature used in this Atlas, the Morel river sub-catchment is coded 2D2A. The Morel river finds its origin from the north east side of Jagamalpura village located in Bassi tehsil of Jaipur district. Its major tributary Dhund meets Morel river near village Sumel in Lalsot tehsil of Dausa district. The study area witnesses predominance of semi-arid climatic conditions exhibiting a fluviatile landscape super-imposed by an aeolian landscape (Doi, 1991).

The Morel sub-catchment is situated between latitudes 26° 6' 19" N to 27° 9' 28" N and longitudes 75° 44' 19" E to 76° 58' 49" E, and has an area of 5892.78 km2 covered in 19 SOI topographical sheets on the scale 1:50,000. Parts of five districts of Jaipur, Dausa, Sawai Madhopur, Karauli, Tonk and 17 tehsils are covered under the study area.

Data Use and Methodology

A total of 49 sub-watersheds are delineated in five watersheds (2D2A1 to 2D2A5) of the Morel sub-catchment based on drainage pattern on the scale of 1:50,000 (Fig.1). For example, as per the hierarchical coding system for hydrological units such as 2D2A1a, the first *Arabic* numeral 2 refers to region, the second place letter D represents to basin, again the *Arabic* numeral at the third place refers to the catchment and the fourth capital letter A indicated the sub-catchment. The fifth place *Arabic* numeral is indicative of watershed and the last small alphabet denotes the sub-watershed. The largest sub-watershed (2D2A2h) and the smallest sub-watershed (2D2A1f) comprise area of 380.64 km^2 and 33.63 km^2, respectively. The average size of sub-watersheds is 120.26 km^2. Watershed 2D2A3 has the maximum of 15 sub-watersheds (2D2A3a to 2D2A3o).

Geocoded false colour composite (FCC) of IRS - 1D LISS - III (October 2001 and January 2002) of path 95, 96 and row 52 have been used on the scale 1:50,000. A flow diagram of the steps involved in finding the final aggregate land use / land cover has been given in Fig. 2. *Geomatica* software V 9.0 has been used to classify or aggregate land use/land

Fig. 1

cover following visual screen interpretation technique based on the elements of image interpretation and available standard interpretation keys in conjugation with Survey of India topo-sheets as ready reference and subsequent training sites taken from the field in two stages. Classified outputs of *Kharif* and *Rabi* seasons have been aggregated to obtain final land use/land cover map of the Morel sub-catchment. For this purpose, a *Look Up Table* (LUT) has been written as per the various combinations available in the two classified images. Aggregated classes have been assigned as per logical analysis of general land use/land cover characteristics of the study area. Some examples are listed in the Table 1.

Results and Discussion

A total of fourteen classes of land use/land cover have been identified and interpreted in the Morel sub-catchment. These aggregated classes of land use/land cover (2001-02) have been put under three broad categories such as non-arable, arable and others

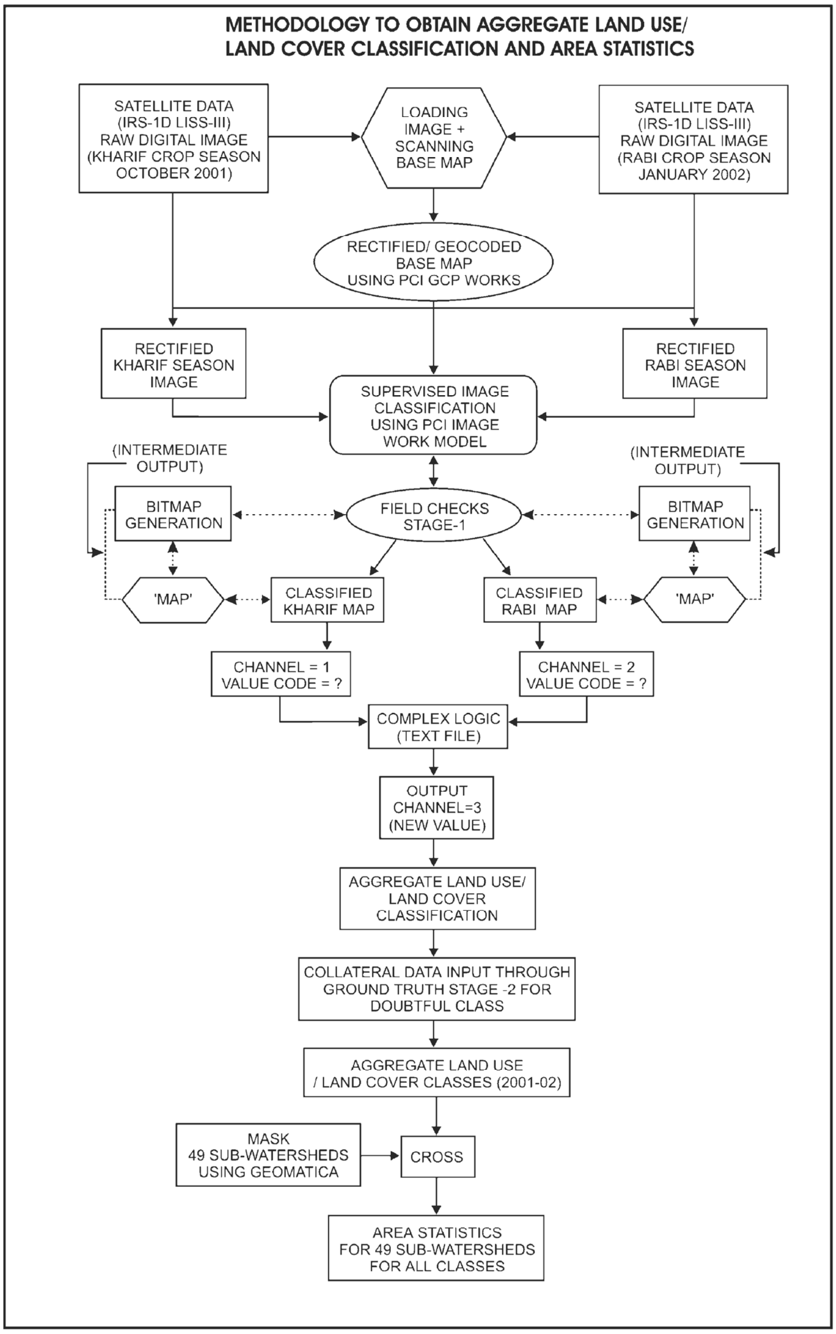

Fig. 2

Table1

Morel Sub-catchment: Selected Input / Output Classes of Land use / Land cover

Kharif input class	Rabi input class	Aggregated output class
Crop	Crop	Double crop
Crop	Fallow	Single kharif crop
Scrub	Scrub	Scrub
Crop	Sandy	Single kharif crop

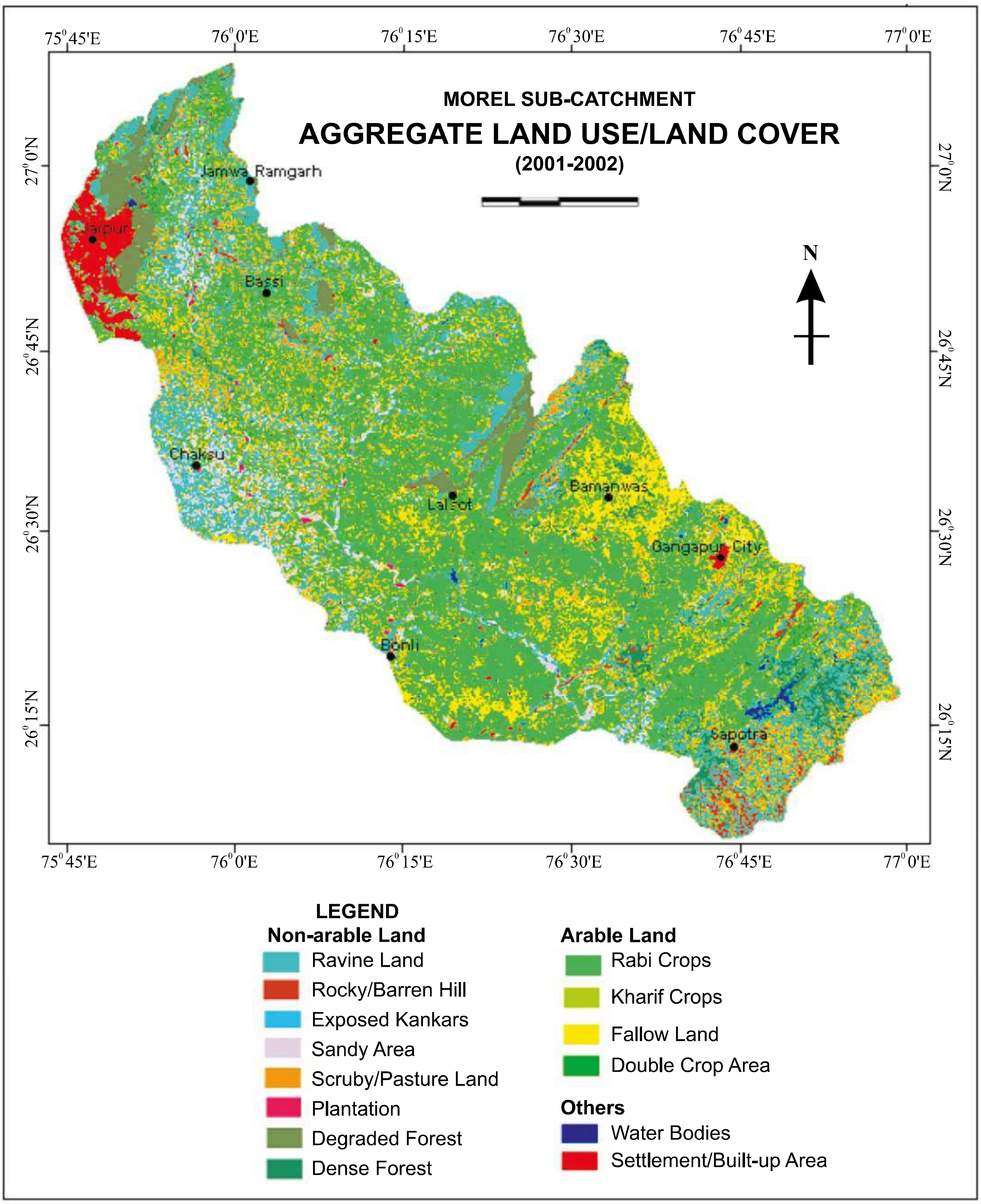
75°45'E
76°0'E
76°15'E
76°30'E
76°45'E
77°0'E
27°0'N
26°45'N
26°30'N
26°15'N
MOREL SUB-CATCHMENT
AGGREGATE LAND USE/LAND COVER
(2001-2002)
N
Jamwa Ramgarh
Jaipur
Bassi
Chaksu
Lalsot
Bamanwas
Gangapur City
Bonli
Sapotra
LEGEND
Non-arable Land
Ravine Land
Rocky/Barren Hill
Exposed Kankars
Sandy Area
Scruby/Pasture Land
Plantation
Degraded Forest
Dense Forest
Arable Land
Rabi Crops
Kharif Crops
Fallow Land
Double Crop Area
Others
Water Bodies
Settlement/Built-up Area

Fig. 3

(Fig. 3). Areal statistics pertaining to the fourteen classes of land use/land cover for 49 sub-watersheds provides a ground for comparative analysis.

Non-Arable Land

There are eight classes under non-arable land use / land cover category. The ravine land cover class dominates among the classes of this category. Ravine land shares 15.3 per cent area of the total Morel sub-catchment followed by scruby/pasture land (12.48 per cent), dense forest (8.03 per cent) degraded forest (5.75 per cent), sandy area (3.09 per cent), rocky/barren hill (1.48 per cent), exposed kankars (0.33 per cent) and plantation (0.16 per cent). Thus, all the non-arable classes share 47.5 per cent of the total geographical area of the Morel sub-catchment. Following classes of non-arable land have been identified:

Ravine land: The extent of ravine land area varies between the minimum of 2.2 km² (2D2A4c) and the maximum of 71.2 km² (2D2A4i) constituting 1.6 and 35.78 per cent of the total geographical area of respective sub-watershed in the Morel sub-catchment.

Scruby / pasture land: The area under scruby / pasture land ranges between the minimum of 3.0 km² (2D2A1f) and the maximum of 43.7 km² (2D2A1h) comprising 8.84 and 20.78 per cent of the total geographical area of the respective sub-watershed.

Dense forest: The area under dense forest cover ranges between the minimum of 0.68 km² (2D2A4h) and the maximum of 63.4 km² (2D2A1g) constituting 0.91 and 32.42 per cent of the total geographical area of respective sub-watershed.

Degraded forest: Degraded forest land cover class area ranges between the minimum of 0.4 km² (2D2A1f) and the maximum of 44.12 km² (2D2A2d) sharing 1.22 and 22.46 per cent of the total geographical area of these sub-watersheds.

Sandy area: This sandy cover area varies between the minimum of 0.24 km² (2D2A1f) and the maximum of 36.22 km² (2D2A4i) comprising 0.73 and 18.14 per cent of the total geographical area of the respective sub-watershed.

Rocky / barren hill, exposed kankars and plantation: Rocky / barren hill cover is not mapped at all in 17 sub-watersheds out of the total 49 sub-watersheds. The maximum area under rocky/barren hill cover is 37.7 km² (17.93 per cent) in the 2D2A1h sub-watershed. Similarly, area under exposed kankars and plantation is not reported in 7 and 21 sub-watersheds respectively. The maximum area covered under exposed kankars and plantation classes are 4.39 km² (5.85 per cent) and 1.36 km² (1.29 per cent) in sub-watersheds 2D2A4h and 2D2A5g respectively.

Arable Land

Arable land implies that 'it is the land suitable for ploughing. However, the term is commonly used to describe land actually ploughed and cropped, including fallow, short ley grassland and market gardens, grassland, pasture, tillage etc. (Goddal, 1987). But in the present study, actually ploughed and cropped area including fallow land has been considered. Thus, four classes are included in the arable land category are:

Rabi crops: Rabi crop area dominates among all the four classes of this category of land use sharing 2044.31 km² (34.69 per cent) of the total geographical area of the Morel sub-catchment during the agricultural calendar 2001-02. The area under this class ranges between the minimum of 4.86 km² and the maximum of 137.99 km² comprising 4.31 and 36.25 per cent of the geographical area of (2D2A1i) and (2D2A2h) sub-watersheds.

Fallow land: It is only the current fallow land during the agricultural calendar year of 2001-02, which is the second ranking class among all the classes of this category. It comprises 662.92 km² (11.25 per cent) of the total study area. Fallow land area ranges between the minimum of 2.25 km² (2D2A5h) and the maximum of 121.19 km² (2D2A2h) sharing 3.04 and 31.84 per cent of the geographical area of respective sub-watershed.

Kharif crops: This class ranks third in terms of area coverage at the time of satellite pass over the study area. The area under this class varies between the minimum of 0.27 km² (2D2Ali) and the maximum of 16.31 km² (2D2A3a) sharing 0.24 and 8.29 per cent of the geographical area of these sub-watersheds. The less area mapped is due to less amount of rainfall in the study area during the monsoon period in 2001. The rainfall data of four raingauge stations such as Jaipur, Bonli, Gangapur city and Sapotra are considered situated in upper to lower parts of the study area reporting –26 per cent, -28 per cent, -20 per cent and –21 per cent in comparison to mean annual rainfall of the respective raingauge stations. Hence, most of the arable area has to be left without sowing.

Double cropping area: The area mapped under this class is only 49.5 km² (0.84 per cent) of the total study area. It varies between the minimum of 0.0094 km² (2D2A4h) and the maximum of 3.38 km² (2D2A5f) comprising 0.01 and 1.72 per cent of the geographical area of respective sub-watershed.

Others

There are only two classes such as water bodies and settlement/built-up area under this category. The settlement/built-up area covers only main settlements with an area of 134.33 km² (2.28 per cent) of the total Morel sub-catchment. Similarly, only the main water bodies cover an area of 18.68 km² (0.32 per cent) owing to the sieving of the classes. The maximum built-up area shared is 75.14 km² (2D2A5a) constituting 47.58 per cent area of the respective sub-watershed, which represents built-up area of Jaipur city. The maximum area under water bodies reported is 4.75 km² (4.0 per cent) falling in the sub-watershed 2D2A1i.

Conclusion

Spectral signatures of clayey soil, fallow land and field plots with *doli* (mud walls) have been found mixed with ravine land class of non-arable category. The mixing of signatures of fallow lands in ravine land class had been separated especially in the upper central part of the study area. It is evident that considerable variations in range are found in area coverage under different classes in context of both inter and intra land use/land cover classes. *Rabi* crop area dominates among all the classes in the Morel sub-catchment. Area under Ravine land cover is just next to the most dominating class of *rabi* cropland in the study area, which requires immediate implementation of conservation measures at sub-watershed level to arrest further land degradation in the study area. Less than the average amount of rainfall is not the single factor responsible for low acreage recorded under *kharif* cropland mapped, but the harvest timings of the dominating *kharif* crop like *bajara* (millet) has also affected, which generally occurs preceding mid of the October month of which the satellite data had been used in the study. However, distribution of rainfall in terms of time and space has an important bearing in shaping crop acreage in semi-arid conditions of the study area. Built-up area of small civic units could not be mapped because of its mixing with other classes of land use/land cover. Aggregation of classes provides dependable consistency in mapping of land use/land cover attributes. Area statistics pertaining to spatial pattern of land use/land cover at sub-watershed level could be of much help for agricultural and general land use/land cover planning in semi arid conditions like the Morel sub-catchment.

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