https://doi.org/10.30799/jespr.181.19050401 J. Environ. Sci. Pollut. Res. - Volume 5 Issue 4 (2019) 383–386

ISSN: 2455-0272

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Study of Land Use and Land Cover of Ravine Area using Geospatial Satellite Data

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A R T I C L E D E T A I L S

Article history:
Received 04 October 2019
Accepted 17 October 2019
Available online 21 October 2019

Keywords:
Remote Sensing
GIS
LU/LC Cover
Ravines
Socio-Economic

A B S T R A C T

Study of ravine erosion is the one of the significant aspects to understand the land status, living habitat and its surroundings environment. In the present study, three distinguish sites site 1, site 2 and site 3 having the coordinates (26°25'40.46"N 78°54'1.94"E), (26°26'28.9"N 78°55'23.41"E) and (26°36'36.68"N 78°53'11.03"E) respectively, of the Bhind district, MP, were selected for ravine status. All the sites were similar vegetation in the case of flora and fauna along with crops. Observation based on native peoples (∑n=600) and GPS images of all sites revealed that decreasing the ravines belts/area along with loss of vegetation. The accurate validation of ground truth observation was analyzed through satellite data's which were collected by using Clouds-free Landsat-5 Thematic Mapper (TM), Landsat-7 Enhanced Thematic Mapper (ETM+) and Landsat-8 Operational Land Imager (OLI). The land sat sensor have 30 meters of spatial resolution respectively, while acquisition data for Land sat–5, Land sat–7 and Land sat–8 were 21/1/1992, 24/1/2002 and 26/2/2017 respectively. The analysis of image revealed that about 41% of ravine area were at 1992 out of the total LC like built-up, water bodies, agriculture land, barren land and flood plains area decreased up to 29.81% in the year of 2017. Among the studied parameters, agriculture land was increased from 1992 to 2017 (*i.e.* 8% increase). Maximum (70%) of built-up area were observed in the year of 2017 as compared with 1992, followed by barren land (≈32%) and ravine area (≈28%). Ravine soil loss was directly related with increase built-up area and agricultural land; both the activities are based on human development and thus ways these activities could be induce the development of barren land and also responsible for ravine loss.

1. Introduction

Ravine has specific feature of land forms which is deep narrow steep side valley formed by running water, ravines as a channel of transitory flow, denuded and guided essentially by the process of rejuvenated streams [1]. Ravines erosion is one of the major causes of land degradation, globally [2, 3]. In India ravines are found at the banks of mostly river which have about 4 million hectares of lands [4]. Several researchers earlier reported about ravine erosion in India of Yamuna Chambal ravine zone, Chhota Nagpur ravine zone etc., [5]. Ravine erosion cause serious threats which induce habitat destruction ecological un-stability which leads biodiversity loss [2, 6]. Recently scarcity of food fulfilment of increased rate of human population triggers engineering ecosystem *i.e.* agriculture ecosystem, which also encroaches the ravine area. Ravine erosion is largely governing by several factors like climate, topography, soil characteristics, vegetation, geological structure, character of streams and land use practices [6]. Loss of soil decreases considerably and has brought change in moisture and silt retention, growth of dense vegetation which covers in the gully beds [7]. Land degradation through river bank erosion leads adverse effect on drainage systems [6], which is ultimately govern floods along with point and non-point sources of pollution in ravine land, vegetation in these ravine belts suffers from several unfavourable conditions like a biotic and biotic stress as well as nutrient deficiency [3,8,9]. This is an important issue to understand that hazards are often converted to disaster by human activities which related to land degradation/loss, while ravine erosion are slow process due to trenching of river channel [10,11]. To mitigate the adverse effects due to ravine erosion, we must be studying the physical (on site), sociological and climatic aspects of affected ravine region [6], develop ravine reclamation schemes, sustainable agricultural practices etc. Several researchers have drawn their attention towards ravine development [12-14, 3] with special reference of Chambal ravine (1979). Geographical information system (GIS) and remote sensing (RS) are broadly apply to analyze the real status of land use/land cover (LU/LC), hydrological conditions, forest covers, soil and topographical condition etc., [15]. Monitoring and assessment of targets (surface or sub-surface of earth etc), information derived by RS data have to merged or integrated with database of GIS, therefore RS and GIS application aid to collect, analyze and interpret the large data rapidly and is highly valuable for planning like watershed [11,15-18]. The present work based on the objective to evaluate the ravine status of district Bhind, MP, India by two ways (i) on site observation using GPS imaging and (ii) spatial observation by using GIS tools.

2. Experimental Methods

2.1 Study Sites and Data Collection

In the present study, study area was Bhind district [26.4450°N, 78.7476°E] of the state Madhya Pradesh which covers about area of 4459 km². The sites of ravine area were mostly at the bank of river Yamuna, Chambal, Quari and Sindh which connect to the district Bhind. Ravine area-based study was conducted two ways (i) onsite study with GPS imaging and (ii) using Landsat satellite. Onsite study and field work for collection of ground truth data were based on self-administration questionnaire among native peoples and Garmin global positioning system (GPS) respectively, in February 2017. GPS camera was also used to collect GPS photographs of various land cover types. This information was used as a training data for supervised classification of the satellite data. Satellite data was collected by using Clouds-free Landsat-5 Thematic Mapper (TM), Landsat-7 Enhanced Thematic Mapper (ETM+) and Landsat-8 Operational Land Imager (OLI). The land sat sensor have 30 meters of spatial resolution respectively while acquisition data for Land sat–5, Land sat–7 and Land sat–8 were 21/1/1992, 24/1/2002 and 26/2/2017 respectively.

2.2 Data Processing

Information of different object on the earth surfaces was stored as a digital number (DN) and DN converted to reflectance using two steps

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https://doi.org/10.30799/jespr.181.19050401

Cite this Article as: Sudhir K. Upadhyay, Prabhat K. Chauhan, Study of land use and land cover of ravine area using geospatial satellite data, J. Env. Sci. Pollut. Res. 5(4) (2019) 383–386.

process. The first step was to convert DN to radiance using the bias and gain values specified in the header file of Land sat data, and in second step was radiance value converted in to reflectance. Lλ = gain x DN + bias; where Lλ is the radiance value, DN is the pixel value, gain is the gain value of a specific band and bias is the bias value of a specific band $\rho\lambda = \pi L\lambda d^2/ ESUN\lambda \cos\theta s$, ρλ = unit less planetary reflectance, Lλ = spectral radiance, d = Earth–Sun distance in astronomical units, ESUNλ = mean solar exo-atmospheric irradiances and θs= solar zenith angle in degree.

2.3 Database Preparation of Ravine Area

Database preparation and image interpretation was done by earlier described methods [10, 19] with essentially involved geo-referencing the digital Landsat-5 data to topographical maps. To begin with, the survey of India topographical maps at 1:50000 scales were scanned at 300 dots per square inch (dpi). The digital outputs thus obtained were rectified for scanning errors and were projected onto the coordinate system by specifying the projection details, and were used as reference images for co-registration of Landsat data. Initially, the ground control points (GCPs) identifiable both on the reference map as well as on Land sat data were precisely located with the help of a cursor. A total of 27 GCPs were identified and the residual rms registration error was computed. A few GCPs were eliminated in order to maintain registration error to a sub-pixel level. The digital Land sat data was subsequently re-sampled to a 30m resolution with a sub-pixel accuracy using a second order polynomial transform and the cubic convolution re-sampling approach [19,18]. The dynamics of badlands was studied using four LU/LC classes; *i.e.* water bodies, ravines, built-up, agriculture land, flood plain and barren land [20]. LU/LC classes were classified as earlier method described by Lillesand et al. and Ranga et al. [19, 21,].

3. Results and Discussion

In the present study, three distinguish sites namely site 1 [Khera Shyampura; ravinous area ≈10 km], site 2 [Dhochara; ravinous area ≈30 km] and site 3 [Bhagwasi; ravinous area ≈15 km] having the coordinates (26°25'40.46"N 78°54'1.94"E), (26°26'28.9"N 78°55'23.41"E) and (26°36'36.68"N 78°53'11.03"E) respectively, of the Bhind district, MP, were selected for ravine status (Fig. 1). All the sites having similar vegetation in the case of flora and fauna along with crops (Table 1), irrigation practices of site-2 and site-3 were depend on the river and tube wells, while site 1 depends on only river water. Socio economic study revealed that the peoples who belong to site-1 and site-2 were mostly depends on mining of Sindh River followed by agriculture practices, also engaged in other occupation at site 3.

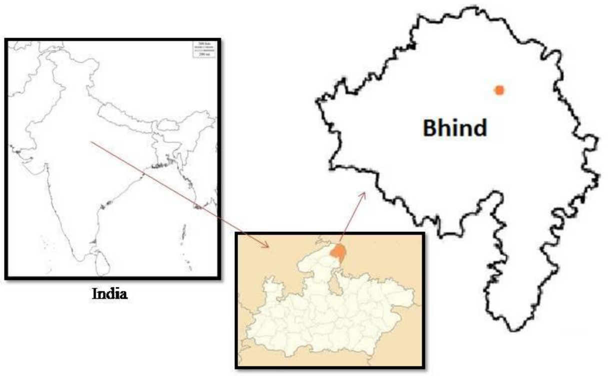


Fig. 1 Study sites of Ravine area; district Bhind, Madhya Pradesh, India

All these three sites located at ravines area of district Bhind and based on ravines area for their economic importance in terms of animals grazing, wood collection, and habitat of wildlife etc. Observation based on native peoples (∑n=600) of all sites revealed that decreasing the ravines belts/area along with loss of vegetation (Fig. 2). Similar finding and approach of the studies were earlier described by Haigh [1], vegetation study with reference of badland reported by Ranga et al. [20]. Soil erosion in ravine areas has serious threats for living habitat and its surroundings environment, features of soil erosion [8,9,21] and its impacts on vegetation productivity has more concern with sustainable environment [9,20,22]. Using GIS and satellite data analysis, ravines have been formed due to erosion of the soil by the various rivers such as Chambal, Yamuna, Dikrong river basin and their tributaries from the Himalayas [14].

In addition to a unique spectral response in the multispectral images, shallow ravines are generally confined to the periphery of the major rivers and along the small streams [23], deep ravines occur very close to the water course of the major rivers, and medium ravines are encountered between shallow and deep ravines along the major rivers [14,24,25]. During post-monsoon season, ravines appear as different shades of red, indicating vegetation of different type and density, while during pre-monsoon season, ravines appear as different shades of bluish green or greenish blue, indicating senesced or dry vegetation [19,21]. Apart from these categories' peripheral lands, which are prone to further erosion due to overland flow, cultivated valleys and river terraces have also been delineated [10,20].

Table 1 Different parameters based on Socio-economic study at Bhind district Madhya Pradesh, India

Parameters	Site 1	Site 2	Site 3
Flora	*Vachellia nilotica, Prosopis juliflora, Azadirachta indica, Calotropis gigantean* etc.	*Vachellia nilotica, Ficus religiosa Azadirachta indica, Calotropis gigantean* etc.	*Vachellia nilotica,Ficus benghalensis, Ficus religiosa Azadirachta indica, Calotropis gigantean* etc.
Fauna	*Boselaphus tragocamelus, Bos indicus, Bubalus bubalis, Capra aegagrus hircus, Ovis aries,*	*Boselaphus tragocamelus, Bos indicus, Bubalus bubalis, Capra aegagrus hircus, Ovis aries,*	*Boselaphus tragocamelus, Bos indicus, Bubalus bubalis, Capra aegagrus hircus, Ovis aries,*
Crops	*Brassic campestris, Triticum aestivum, Cicer arietinum Pisum sativum* etc.	*Brassic campestris, Triticum aestivum, Cicer arietinum Pisum sativum* etc.	*Brassic campestris, Triticum aestivum, Cicer arietinum Pisum sativum* etc.
IS	The irrigation mostly occurs by Wells, and Tube wells.	Mostly irrigation occur by Sindh river, Wells, and Tube wells	The irrigation mostly occurs by river, wells, and tube wells.
MOV	Main occupation of people of is Sindh river mining.	Main occupation of people of is Sindh river mining and laboring	Main occupation of people of is Laboring and other occupations.
EIRA	Grazing of animals, collection of wood fuels and habitat of wild animals	Grazing of animals, collection of wood fuels and habitat of wild animals	Grazing of animals, collection of wood fuels and habitat of wild animals

IS = (Irrigation System), MOV= (Major Occupation opt by villagers), EIRA =(Economic important of Ravine area), Site 1 [Khera Shyampura (26°25'40.46"N 78°54'1.94"E). Ravine area covers 10 km of total area of Khera Shyampura, Dhochara] Site 2 [(26°26'28.9"N 78°55'23.41"E). Ravine area covers 30 km of total area of Dhochara. Site 3 [Bhagwasi (26°36'36.68"N 78°53'11.03"E). Ravine area covers 15 km about of total area of Bhagwasi.

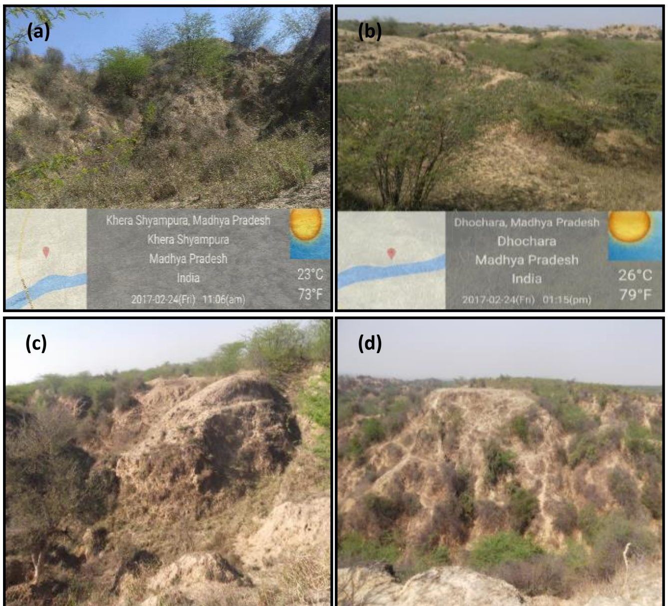


Fig. 2 Field photograph of different sites of ravine area of Bhind district [26.4450° N, 78.7476°E] India.(a) Image at Khera shyampura, (b) image at Dhochara, and (c) & (d) image Bhagwasi of Madhya Pradesh, India

In the present study, loss of ravines land and vegetation was observed on sites and its GPS images shown in Fig. 2. The accurate validation of ground truth observation was analyzed through Landsat satellite, namely

https://doi.org/10.30799/jespr.181.19050401

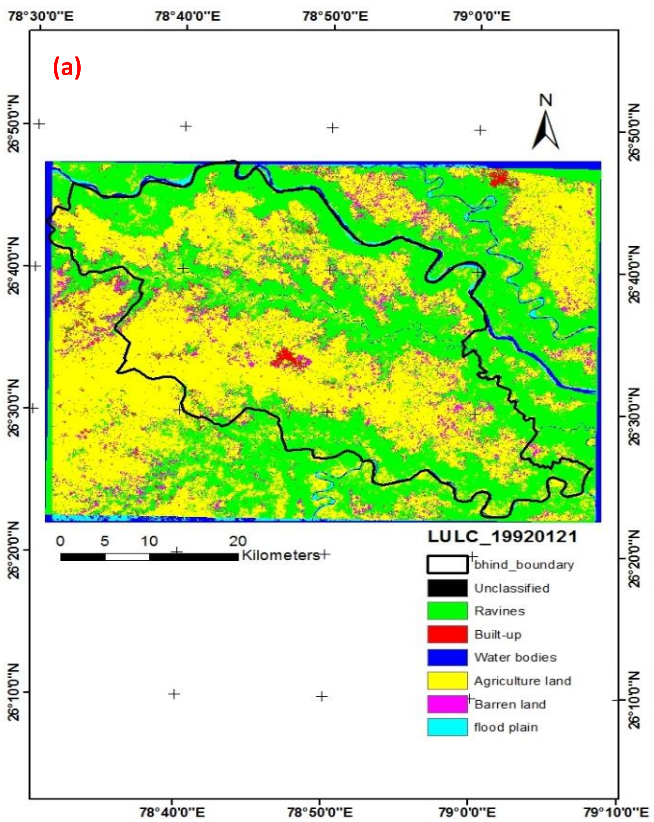
Landsat-5, Landsat-7 and Landsat-8 with acquisition date 21/01/1992, 24/01/2002 and 26/02/2017 respectively at 30 m of spatial resolution (Table 2). The images of Landsat satellite of LU/LC shown in Fig. 3 of year-1992, 2002 and 2017 respectively. The analysis of image revealed that about 41% of ravine area were at 1992 out of the total build up, water bodies, agriculture land, barren land and flood plains area decreased up to 29.81% in the year of 2017 (Table 3 and Fig. 3). Among the studied parameters, agriculture land was increased from 1992 to 2017 (ie., 8% increase) shown in Table 3. Maximum (70%) of built-up area were observed in the year of 2017 as compared with 1992, followed by barren land (≈32%) and ravine area ((≈28%) shown in Fig. 3. Wang et al. [26] reported similar ecological functional study of mountain area in China based on land use and land cover change over past two decades. In the present study, ravine soil loss was directly related with increase built-up area and agricultural land; both the activities are based on human development and thus ways these activities could be induce the development of barren land was observed (Table 3). Land use/land cover (LU/LC) classification is an important application of remote sensing, which involves extraction of thematic information from satellite data [11]. It determines the spectral relationship between spectral signatures and various classes that are of interest to the user [16, 27]. LU/LC information is also useful for effective management of land resources and policy designing. Plantation like bamboo in ravine bed checks ravine soil erosion and improve ravine soil health [28-30].

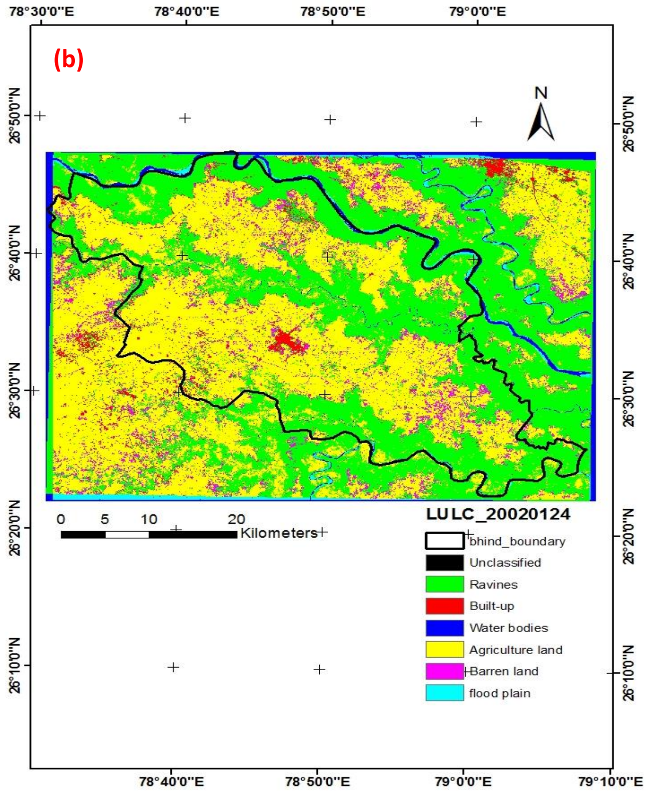
Table 2 Land sat data details of the present study

No.	Sensor	Acquisition date	Spatial Resolution (m)
1	Land sat -5	21/01/1992	30
2	Land sat-7	24/01/2002	30
3	Lands at-8	26/02/2017	30

Table 3 Observation of land use and land cover by using Landsat satellite data of Bhind district, Madhya Pradesh, India

Parameters	Year 1992		Year 2002		Year 2017	
	Area (sqkm)	%	Area (sqkm)	%	Area (sqkm)	%
Ravines	566.11±16	41.43	554.90±22	40.61	407.39±11	29.81
Built-up	23.02±5	1.68	30.31±2.3	2.22	78.21±4.2	5.72
Water bodies	14.68±3	1.07	14.66±1.5	1.07	17.26±2.1	1.26
Agriculture land	681.1±7	49.85	678.06±18	49.62	747.80±16	54.72
Barren land	74.77±8	5.47	82.61±5	6.05	110.99±14	8.12
Flood plain	6.78±2	0.50	6.00±1	0.44	4.89±1.2	0.36





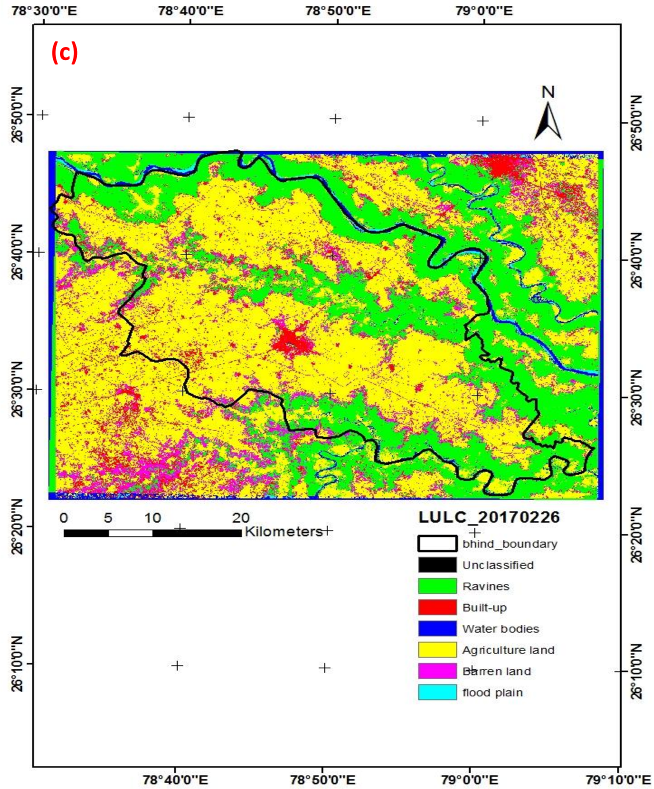


Fig. 3 Landsat based land use and land cover (LU/LC) image map including ravine area in a) 1992, b) 2002 and c) 2017 of Bhind district, Madhya Pradesh, India

4. Conclusion

The study revealed the rapid change in variation of land use and land cover of ravine area at Bhind district, Madhya Pradesh India. This study demonstrates that the Land sat multispectral and multi temporal data in the delineation of reclamative groups of ravines, which is a prerequisite for carrying out any preventive or curative measures. Onsite and satellite both the studies revealed that fall down in the ravine area along with loss of native biodiversity which triggers due to uncontrolled human activities. This study could be contributed for ravenous area reclamation program, which helps to sustain ecology of ravines area.

https://doi.org/10.30799/jespr.181.19050401

Cite this Article as: Sudhir K. Upadhyay, Prabhat K. Chauhan, Study of land use and land cover of ravine area using geospatial satellite data, J. Env. Sci. Pollut. Res. 5(4) (2019) 383–386.

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