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Ecological Assessment of Land Use Changes in Rajasthan: Beginning of Twenty-first Century

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ABSTRACT

Individuals and societies rely heavily on the land for economic activity. The utilization of land is complex and a constantly changing process. Divisive issues and planning must be formed on a thorough understanding of such processes. In this context, we intend to investigate (i) the spectral shifts in different land classes; and (ii) land-use growth and instability. The research took place in Rajasthan, which was purposefully selected and centered on a dataset spanning the years (2000-01 to 2017-18). The outcome of the land study found that the percent share of a forest, non-agriculture uses, tree crops and groves, and area sown increased in the first two decades of the twenty-first century, while the percent share of barren and unculturable, permanent grazing, culturable waste, and fallow lands decreased. The results of compound growth rate analysis revealed that forest, tree crops and groves, and area sown all grew significantly and positively. Barren and uncultivated land, permanent pasture, culturable waste, old fallow, and current fallow land, on the other hand, witnessed significantly negative growth. Massive land areas were converted from the A and E sectors to the NA sector, which would be a matter of concern for decision-makers and policy-makers in the coming years. In order to accommodate the increasing demand for rapid urbanization and industrialization, this issue of conversion of non-agricultural purposes can be resolved by using land area vertical direction rather than parallel to the ground. Better land policies must be enacted to prevent the shifting pattern in land.

Keywords: Growth, coefficient of variation, ecological, non-agricultural, assessment, net sown area

Agriculture must be developed to reduce poverty and improve economic and social prosperity (Singh and Baleka, 1999). Due to increased population pressure on natural resources such as land, water, biodiversity, and other resources to meet rising food demand. Agriculture is now set for technical modernization to assure food and nutrition security, export earnings, and alleviate poverty, particularly in rural areas. Land and water have long been critical components of the global life support system and a valued resource for most of the population because agriculture is a land-based profession. People's attitudes toward and usage of land have a significant

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impact on their social and economic well-being, as well as its quality.

The ecosystem is incomplete without land; hence it must be protected. Numerous environmental issues are caused by changes in land use (Sharma *et al.* 2011). Land use planning strives to choose and implement land uses that meet the people's present needs while preserving resources for future generations. Land use policies play an essential role in maintaining ecological balance and environmental health. The land serves as a focal point for the majority of individual or society's economic activity. In terms of supply, it is more inelastic. The utilization of land is a continuously changing phenomenon. It follows that political conversations and program planning should be based on a detailed understanding of these mechanisms. An analysis of temporal dynamics in land use patterns over time allows for a better understanding of the current scenario of arable land utilization, and appropriate measures can be taken to strike a balance between farmer remuneration and an ecologically sustainable system (Rejula and Singh, 2015). As a result, conducting a detailed examination of the pattern and size of land-use changes in a specific location is essential for food security. In this context, the current study was conceptualized to look into the ecological assessment of land-use patterns in Rajasthan, with the goals of (i) looking into temporal changes in various land classes and (ii) looking into the growth and dynamics of changes between different land classes.

MATERIALS AND METHODS

The state of Rajasthan was specifically chosen for this study. This study is based on data sets from 2000-01 to 2017-18. The data for this study was compiled from various issues published by the DES, GOR, and Jaipur.

(i) Dynamics of Land Use

The Land Use Dynamics Model was used to analyze the dynamics of shifts in land use classes (Pandey and Tewari, 1996; Gajja and Purohit, 1998; Rathore, 2007; Takle *et al*. 2007; Wani *et al.* 2009; Bardhan and Tewari, 2010; Amale and Shiyani, 2019 and Meena, *et al.* 2021).

Model

$$R = F + NA + BU + P + M + C + OF + CF + S \quad \ldots(1)$$

Total reporting area (R) = Forest (F) + Non-agriculture use (NA) + Barren and unculturable (BU) + Permanent pastures & other grazing (P) + Miscellaneous tree crops & groves (M) + Culturable waste (C) + Old fallow (OF) + Current fallows (CF) + Net sown area (S).

The land use changes over time can be expressed in linearly additive form as below:

$$\Delta R = (\Delta F + \Delta P + \Delta M + \Delta BU) + (\Delta NC) + (\Delta C + \Delta OF + \Delta CF + \Delta S) \quad \ldots(2)$$

$$\Delta R = (\Delta E + \Delta NA + \Delta A) \quad \ldots(3)$$

Where; R denotes total reporting area, ΔE denotes increase or decrease in ecological, ΔNA denotes increase or decrease in non-agricultural, and ΔA represents an increase or decrease in agricultural.

The total reported area can be divided into three major sectors for examining sectoral dynamics: (1) ecological (E), (2) non-agricultural (NA), and (3) Agricultural (A).

Thus, the net change in the ecological sector (E) can be expressed as;

$$\Delta E = (\Delta E_1 + \Delta E_2) \quad \ldots(4)$$

Where; $\Delta E_1 = \Delta F + \Delta P + \Delta M$ and $\Delta E_2 = \Delta BU$

Similarly, the increase or decrease in the agricultural (A) might be written as follows:

$$\Delta A = (\Delta C + \Delta OF + \Delta CF + \Delta S) \quad \ldots(5)$$

The following are the total inter-sectoral land use shifts:

$$\Delta R = (\Delta E_1 + \Delta E_2 + \Delta NA + \Delta A) \quad \ldots(6)$$

(ii) Analysis of growth

The compound annual growth rate in different land use classes was computed by fitting the following exponential trend equation.

$$Y_t = Y_0 (1 + r)^t$$

Where; Y_t = land area of a particular class in t^{th} year

Y_0 = land area of a particular class at beginning of the year

r = CGR (Compound growth rate)

t = 2000-01 to 2017-18 years

The above functional equation now become:

$$Log\ Y_t = Log\ Y_0 + t\ Log\ (1 + r)$$

$$r = \{Antilog\ (1 + r) - 1\} \times 100$$

(iii) Analysis of instability

The instability index is a straightforward analytical technique for detecting r instability in time series data (Ramasamy *et al.* 2005; Gupta and Sharma, 2010; Gairhe *et al.* 2011 and Rejula and Singh 2015). The Cuddy-Della Valle Index (Cuddy and Della Valle, 1978) is used to measure the instability in the land.

$$Cuddy\ Della\ Valle\ Index\ (CDV) = CV \sqrt{(1 - R^2)}$$

Where, CV stands for coefficient of variation (%), R^2 represents the coefficient of determination adjusted for the degree of freedom.

RESULTS AND DISCUSSION

Changes in land use pattern over time

To investigate changes in land use patterns over time, the percentage of area under different classes of land to the total reported area of Rajasthan state was measured. Table 1 shows that in the year 2000-01, the majority of Rajasthan's total reported area was under net sown area (46.30 %) followed by culturable wasteland (14.32%), forest area (7.61%), barren and unculturable (7.49%), old fallow (7.13%), current fallow (7.05%), non-agriculture land (5.08%), permanent pasture (4.98%) and tree crops and groves (0.04%). Considering over time changes in land use, increasing percentage share was observed in case of the forest, land put to non-agricultural use, miscellaneous tree crops and groves, and net sown area, while decreasing percentage share was observed in case of barren and unculturable, permanent pasture, culturable waste and in both the fallow lands.

Table 1: Percentage changes in land use pattern in Rajasthan state

Sl. No.	Land Use Classes	Area (per cent)	
		2000-01	2017-18
1	F	7.61	8.04
2	NA	5.08	5.78
3	BU	7.49	6.95
4	P	4.98	4.88
5	M	0.04	0.07
6	C	14.32	11.17
7	OF	7.13	5.81
8	CF	7.05	5.08
9	S	46.30	52.22
	R	34264789 (100.00)	34287067 (100.00)

Source: Statistical abstract, Government of Rajasthan

Growth in land use classes

The compound annual growth rates and instability index of different land use classes in Rajasthan have been estimated for the period 2000-01 to 2017-18 and are given in Table 2.

Table 2: Compound growth rate and instability index of land use classes

Land use classes	CAGR (%)	CDV Index (%)
F	0.03**	0.12
NA	0.10^{NS}	0.51
BU	-0.10*	0.80
P	-0.02*	0.10
M	0.51*	2.52
C	-5.16*	11.75
OF	-0.44*	3.89
CF	-1.47*	24.04
S	0.44**	3.40

*indicates significant at 1% and ** indicates significant at 5% level of probability.

Source: Author's computed from secondary time series data.

As per Table 2, positively significant growth in the forest has been observed over time (0.03%), tree crops and groves (0.51%), and net sown area (0.44%). Negative and significant growth, on the other hand, was witnessed in barren and uncultivated (0.10%), permanent pasture (0.02%), culturable waste (5.16%), and old fallow (0.44%), and current fallow (1.47%). Negative growth seems to be highest in culturable waste and lowest in barren and unculturable land. According to the analysis, the highest decline in culturable waste occurred, which could be attributed to population increase and rising demand for arable land.

Current fallows are characterized by high year-to-year fluctuations due to variations in rainfall in the state, resulting in the highest instability in current fallows (24.04%). The instability index was observed at 11.75 percent for culturable wasteland and 3.40 percent for net area sown. Permanent pastures and other grazing lands had the lowest levels of instability (0.10%). The highest instability in current fallows was also observed by Gairhe *et al.* (2011) in Karnataka state.

Inter-sectoral dynamics of land use change in Rajasthan

To study the dynamics of land use class shifts, the entire land resource was categorized into three main segments viz., ecological (E), agricultural (A), and non-agricultural (NA), The ecological sector is divided into two parts: (a) desirable ecology (E_1) and (b) undesirable ecology (E_2). The change in area or shift in different sectors of land use classes has been presented in Table 3. Net area in the ecological sector (E) decreased by 57068 hectares over the last 18 years in Rajasthan. Furthermore, the desirable sub-sector of ecology (E_1) registered an increase in area by 125989 hectares. This increase in area under the desirable ecology sub-sector has a positive impact on the ecology of Rajasthan. The undesirable sub-sector of ecology (E_2) registered a decrease in the area by 183057 hectares. This decrease in area under the undesirable ecology sector has a positive impact on the state's ecology, if it is more diverted towards the desirable ecology sector. Net area under the non-agricultural sector (NA) has increased by 243411 hectares. The net area under the agricultural sector (A) has decreased by 164065 hectares. This negative change in the agricultural sector over time indicates a negative impact on the agricultural sector. Similar kinds of findings were also reported by Gairhe *et al.* (2011) in Karnataka state.

It is clear from the preceding discussion that land was shifted from the agricultural and ecological to the non-agricultural sector over 18 years. The agricultural sector shifted more land to the non-agricultural sector than the ecological sector, causing agricultural and ecological harmony to be disrupted. The rising trend in the sown area has indicated an agricultural output potential that would be impressive.

Table 3: Dynamics of area shifts in area in ecological, agriculture and non-agricultural sector

Sectors	Shift in area (hectares)
Ecological [E]	
E_1	125989
F	149610
P	-34388
M	10767
E_2 (BU)	-183057
$E_1 + E_2$	-57068
Non-agricultural (NA)	243411
Agricultural sector [A]	
C	-1076926
OF	-452070
CF	-673235
S	2038166
C + OF + CF + S	-164065
Overall increase in land	22278

Source: Statistical abstract, Government of Rajasthan.

CONCLUSIONS AND POLICY IMPLICATIONS

It is clear from the analysis that the trend in forest area increased during the reference period due to numerous afforestation programs and the adoption of forest policy. There is still a need to expand the forest area to cover one-third of the geographic area. The land area used for non-agricultural purposes has increased. Several factors could be responsible for this trend, including increased population, urbanization, and industrialization. The net sown area has increased due to the green revolution, agricultural mechanization, and electrified pumps

for lifting water for irrigation. This increase in net sown area boosts agricultural production and food supply. The current fallows have a high instability index due to variations in rainfall patterns and distribution, which could be reduced by expanding and stabilizing irrigation areas in the state.

Consequently, stabilizing the irrigation area may be the most important step in ensuring better land resource utilization. The results of inter-sectoral budgeting revealed that massive land shifts occurred from the agricultural and ecological sectors (particularly from undesirable sub-sectors) to the non-agricultural sector. Such a trend of shifting land is unfavorable for the state's ecological balance and the agricultural sector. It will be a cause of concern for policymakers in the future. This is a significant problem that requires immediate attention. It can be addressed by vertically using land for non-agricultural purposes rather than horizontally to meet the growing need for urbanisation and industrialisation. The shifting trend in land from the ecological and agricultural sectors must be checked by formulating better land policies so that both the ecological and agricultural sectors can be sustained. The construction of houses and other facilities on agricultural land should be restricted, and land reform plans should be carefully implemented by laws and regulations.

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