Annals of Arid Zone 53(3&4): 177-183, 2014

Implications of Dynamics of Land Use Shifts in Rajasthan

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Abstract: Land use pattern of an area effect vegetation, land quality, local weather and quality of life. Within the interwoven fabric of time scale and spatial variability selected characteristics of land use pattern may serve as indicators and regulators of forces set into motion by human actions. From the simple clearing of trees to the accelerated conversion of fallow land into 'barren' the balance of natural system is impacted. It is very important to understand the land use pattern of any area and the dynamics of its shift overtime. This determines the ensuing per unit load on agriculture land, forest land, periphery areas to cities and factors responsible for land degradation. With the total geographical area of 3.42 lakh hectare, Rajasthan is largest state in the country. The state is highly diversified in terms of agro-climatic features. The Aravalli range of hills which starts from the south-west and spread upto north-east divide the state into two distinct geographical regions. The west of Aravalli is desert with arid and hyper arid situation. The major area of eastern part is semiarid and the remaining humid and sub-humid. Of the total population of 56.51 million in Rajasthan, 76.61% live in rural areas. There are 7.05 million rural households with 6.1 persons per household in the state whose main stay of life is agriculture and allied activities. Thus the pressure of population on land based activities is considerably high in the state. The study attempts to examine the shifts in the land use in Rajasthan and its implication on agriculture and ecology. The study is based on the data pertaining to 1990 to 2005. The results showed that permanent pastures and grazing lands and miscellaneous trees and grooves are declining having serious unfavorable implications for the ecology of Rajasthan. The land use dynamics show substantial shifts in the land use pattern towards non-agricultural sector. The shift is mainly from the culturable waste land part of agriculture sector and undesirable part of ecological sector. The forest area in Rajasthan is increasing at a meager rate of 0.96% per annum and at us still 7.8% of total geographical area. This is well below the required 9.0% norm for forest area decided by the government. Thus the growth in forest area by increasing the rate of forestation is very important to maintain the ecological stability. This is also necessary to maintain a balance with the ecological hazards generated by fast growing non-agriculture sector. The tendency of rapid growth of non-agriculture sector should be more on conservative terms before a sizeable portion of land mass gets blocked under non-agricultural uses.

Key words: Land use shifts, ecology.

Rajasthan has most vulnerable ecological environment in this area as 11 out of 32 districts of Rajasthan are in the desert belt. For the state of Rajasthan land use changes have comparatively larger and more important consequences as the recent phenomenal growth in human population and associated livestock and weakening social control on community property resources have stressed the natural resources and also set in motion their accelerated degradation. The state is severely facing the problem of land degradations through wind erosion, soil salinity, soil alkalinity, poor quality of soil and water logging in areas adjacent to canal irrigation systems.

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With the total geographical area of 3.42 lakh hectare, Rajasthan is largest state in the country. The state is highly diversified in terms of agro-climatic features. The Aravalli range of hills which starts from the south-west and spread upto north-east devide the state into two distinct geographical regions. The west of Aravalli is desert with arid and hyper arid situation. The major area of eastern part is semiarid and the remaining humid and sub-humid. Of the total population of 56.51 million in Rajasthan, 76.61% live in rural areas. There are 7.05 million rural households with 6.1 persons per household in the state whose main stay of life is agriculture and allied activities. Thus the pressure of population on land based activities is considerably high in the state. The

present economic activity mix prevalent in the state is the one developed by the people to withstand recurrent drought, scanty and erratic rainfall pattern and to meet the food security of the people.

Land Use Dynamics Model

The land use statistics in Rajasthan is reported under the following broad classes-

i. Total Reported area (R)

ii. Forests (Fr)

iii. Permanent Pastures and grazing land (P)

iv. Miscellaneous trees and grooves (T)

v. Non agricultural uses (Na)

vi. Barren/Unculturable land (B)

vii. Culturable wastes (Cw)

viii. Net Sown Area (Ns)

ix. Current fallow (Cf)

x. Other fallow (Of)

Accordingly, the land use accounting identity can be expressed as follows (Bardhan and Tewari, 2010):

$$R=Fr+P+T+Na+B+Cw+Ns+Cf+Of \quad \ldots\ldots\ldots(1)$$

The total geographical area of the state being constant, the land use changes can occur only between classes and over time they are linearly additive. Thus the accounting identity for land use changes can be expressed in the form of -

$$\Delta R=\Delta Fr+\Delta P+\Delta T+\Delta Na+\Delta B+\Delta Cw+\Delta Ns+\Delta Cf+\Delta Of \quad \ldots\ldots\ldots(2)$$

The total reported area or the total land endowment can be grouped into three broad sectors, viz., (i) ecological sector comprising of subsectors Fr, P, T and B, (ii) non-agricultural sector i.e Na, and (iii) agricultural sector comprising sub sectors like Cw, Ns, Cf and Of. The direction and magnitude of inter sectoral land transfers can provide important inferences regarding their environmental implications. The possible directions of major intra-sectoral as well as inter-sectoral land use changes are hypothesized in Fig. 1 (Pandey and Tewari 1987).

The possible land use shifts within the ecological sector may occur as follows- The land use may shift from T and P to Fr which has positive ecological implications. The shift from Fr to P does have some adverse implications. The shift from B to Fr also has favourable ecological consequences. However, the shift from Fr and T to B will have serious adverse ecological effects. Thus the ecological sector can be divided into two sub sectors, viz., (i) the desirable ecology E_1 comprising Fr, T and P and (ii) undesirable ecology E_2 comprising B. Thus the net changes in the ecological sector (ΔE) can be budgeted as:

$$\Delta E=\Delta E_1+\Delta E_2 = (\Delta Fr+\Delta P+\Delta T)+(\Delta B) \quad \ldots\ldots\ldots(3)$$

Similarly, the net changes in the agricultural sector (ΔA)can be budgeted as:

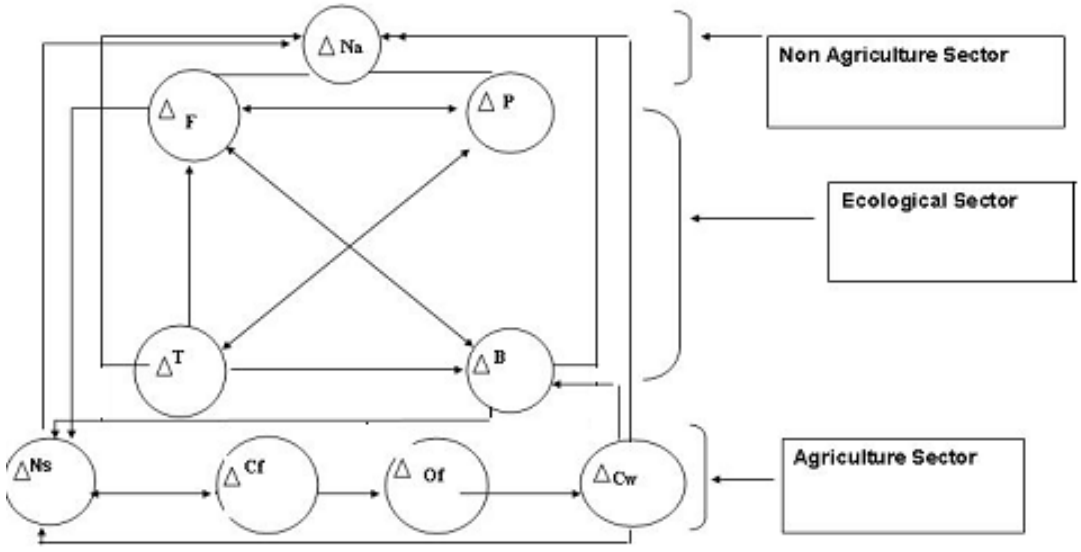

Fig. 1. Flow chart of dynamics of land use changes.

$\Delta A=\Delta N_s+\Delta Cf+\Delta Of+\Delta Cw$ .....(4)

As land use changes from the non-agricultural sector to agricultural sector are not possible, the net changes in the agriculture sector will have serious ecological implications. If the net change in agricultural sector is positive (+ΔA), it will be at the cost of ecological sector, while if it is negative (-ΔA) the land use shift may be towards ecological sector or non-agricultural sector or both, but in any case it will be against agricultural sector. Thus to maintain an optimum balance between ecological sustainability and agricultural and non-agricultural growth is burning question of the day.

If there is net addition to the agriculture sector (+ΔA) then also intra-sector dynamics of components of agriculture sector is very important.

ΔA is positive and ΔNs is also positive	Situation is favorable for the agricultural growth although at the cost of ecological sector
ΔA is positive and ΔNs is zero	The situation is unfavorable for the agricultural growth as well as ecological sector as it indicates addition to N_s on the one hand and depletion in Ns on the other by way of shifting of land use to Cf, Of and Cw leaving net sown area unchanged.

Now the overall inter-sectoral land use transfers can be budgeted as :

$\Delta R= \Delta E_1+\Delta E_2+\Delta A+\Delta N_a$ .....(5)

Equation (5) and equation (2) are same except that equation (5) being expressed in aggregate sectoral terms, facilitates quick glance at inter-sectoral transfers.

Methodology

Time series data of basic land use statistics for the period 1990-91 to 2004-05 has been collected from publications of Directorate of Agriculture, Rajasthan (Statistical Cell). The period under consideration has witnessed a pressure on agriculture land due to increasing land to man ratio. Agricultural and ecological sectors are constantly under pressure due to increasing demand for housing roads railways industry and other facilities for growing population. Thus the period under reference reflects combined pressure of accelerated growth in both agricultural and non-agricultural sectors on the land use pattern. To estimate compound growth rate of various land use classes, linear and compound time trend equations were estimated. The analysis is done for the state as well as its different economic regions which are also the broad agro-climatic regions.

Results and Discussion

Table 1 shows the decadal changes in the land utilization pattern from 1960-61 to 2000-01. In 1960-61, 38.74% of the state's reporting area was utilized for crop production. This increased to 46.30% in 2000-01. Thus, within four decades the net cropped area showed an increase of 37.3%, largely due to increase in irrigated area. The cultivable wasteland decreased from 20.21% to 14.32% in the same period. This change has been more pronounced in districts covered under the western dry region. Such decline in cultivable waste and fallow area has been reflected in an increase in the net sown area. The area under forest increased from 2.4% to 7.61% during the same period. However, these data do not provide a realistic picture of the forest cover in Rajasthan as only 11.22% of the forest area is dense forest while 59% area is under shrubs.

The results of the study are summarized in Table 2. The compound time trend equations gave in general slightly better results and therefore were selected for the study. The mean values of land use under different classes are also presented in the table so as to give an idea of the average magnitude around which the shifts in land use have occurred in the state after 1990-91.

The compound growth rate figures indicate that the forest area in Rajasthan is increasing at a very slow rate of 0.96% per annum. The growth in forest area is mainly in the regions of Ganganagar, Bharatpur, Bhilwara and Jaipur. Although growth in forest area is positive in all the regions of Rajasthan still forest area is only 7.8% of total geographical area, which is well below the minimum norms of 33% of geographical area under forests as set under the National Forest Policy (1952). The land use shift towards non-agricultural uses shows positive growth at compound growth rate of 0.84% per annum. Jaipur region which is fastly

Table 1. Land utilization pattern in Rajasthan state

Item	1960-61		1970-71		1980-81		1990-91		2000-01	
	Area	Share	Area	Share	Area	Share	Area	Share	Area	Share
Geographical area	33841	100.00	34109	100.00	34227	100.00	34252	100.00	34265	100.00
Forest	814	2.40	1355	3.97	2088	6.10	2353	6.86	2606	7.61
Land under non -agricultural use	1095	3.23	1162	3.40	1507	4.40	1490	4.35	1740	5.08
Barren and uncultivable for cultivation	5153	15.22	4716	13.82	2917	8.52	2790.0	8.14	2566	7.49
Area not available for cultivation	6248	18.46	5878	17.23	4424	12.92	4280	12.49	4306	12.57
Permanent pasture and other grazing lands	1684	4.97	1807	5.29	1834	5.35	1912	5.59	1707	4.98
Land under miscellaneous tree crops and groves	16	0.04	9	0.02	24	0. 07	22	0.06	14	0.04
Cultivable wasteland	6841	20.21	6112	17.91	6415	18.74	5567	16.25	4908	14.32
Other uncultivable and excluding fallow land	8541	25.23	7928	23.24	8273	24.17	7501	21.89	6629	19.34
Other than fallow land	3104	9.17	9326	27.34	2089	6.10	1927	5.62	2444	7.13
Current fallow land	2022	5.97	1443	4.23	2085	6.09	1814	5.29	2415	7.05
Total fallow land	5126	15.14	3769	11.04	4174	12.19	3741	10.92	4859	14.18
Net area sown	13112	38.74	15179	44.50	15268	44.60	16377	47.81	15865	46.30
Total cropped area	14013	41.40	16720	49.01	17350	50.69	19380	56.58	19230	56.12
Area sown more than once	901	2.66 (6.42)	1550	4.54 (9.27)	2082	6.08 (12.00)	3003	8.76 (15.49)	3365	9.82 (17.49)

Note: Figures in parenthesis are percentages to total cropped area.
Source: Trends in Land use statistics, Department of Agriculture.

becoming the industrial and educational hub of the state has shown highest growth in non agricultural land. Besides forests, permanent pastures and grazing lands and miscellaneous trees and grooves are important sub sectors of ecological sector. Both permanent pastures and grazing lands as well as miscellaneous trees and grooves are depleting very fast at a compound growth rate of -0.53 and -2.93 respectively. Permanent pastures and grazing land are decreasing in all the regions of the state except Ganganagar and Bhilwara region where the change in permanent pastures are not significant. In case of miscellaneous trees and grooves, only one region Jodhpur which is the desert belt of the state is showing significant negative growth at a very high rate of -9.36%. In all other regions no significant change is seen in case of miscellaneous trees. The only comfort that can be drawn from the growth rates shown in Table 2 is in terms of declining growth in barren and other unculturable land in all the regions of the state. This barren land could be being increasingly used for non-agricultural uses or it might be being reclaimed to increase cultivated area or for afforestation. Culturable wasteland is showing a similar declining growth in all the regions except Udaipur region. The net sown area has remained unchanged throughout the state. Fallow lands have also remained unchanged throughout the state except in Udaipur region where old fallows increasing at a fairly high rates may cause a serious ecological and agricultural concern as such lands fastly get converted overtime into barren lands.

The land use shift from different sectors in the study period were used to examine inter-sectoral as well as intra-sectoral dynamics of land use changes. The net sectoral changes, as worked out through equations (3) and (4) are shown in Table 3, which indicates the absolute land shifts among different sectors from 1990-91 to 2004-05.

As is evident from Table 3, most of the land that is being released from E2 barren and unculturable land is shifting towards

Table 2. Region wise compound growth rates of different land use classes in Rajasthan (1990-91 to 2004-05)

Regions	General climate and soil type	Total reported area (R)	Land use classes								
			Non Agril. Use (Na)	Forest (Fr)	P. pastures & grazing land (p)	Miscellaneous tree and grooves (T)	Barren and uncultureable land(B)	Net sown area (Ns)	Current fallow (cf)	Old fallow (Of)	Culturable waste (Cw)
			N		E1		E2		A		
All Rajasthan											
CGR			0.84*	0.96*	-0.53*	-2.93*	-0.78*	-	-	-	-1.26*
GM		34256108	1691328	2518863	1742339	15324.8	2620136	16009846	2115451	2186046	5044857
Jodhpur region	Arid to extreme arid climate, desert clay soil										
CGR			0.98*	0.56*	-0.13*	-9.36*	-0.12*	-	-	-	-1.04*
GM		13478383	454508.5	323757	676918.7	1333.6	101702	5469067	1093316	1178315	3103083
Ganganagar region	Arid climate, calcareous alluvial soil										
CGR			-	1.57*	-	-	-1.03*	-	-	-	-2.56*
GM		6486536	427838.7	150132	107684.5	3287.4	43436.2	3776386	486995.9	399311.8	923274.6
Bharatpur region	Semi-arid climate clay loam soil										
CGR			-	1.58*	-2.98*	-	-1.38*	-	-	-	-
GM		2593963	1409111.8	354192.6	107162.2	1863.57	285613.6	1511745	70166.55	60114.54	57018.6
Jaipur region	Semi-arid climate send to silty loam and clay soil										
CGR			1.02*	1.42*	-0.21*	-	-2.95*	-	-	-	-
GM		3648445	193427	243738.2	267548.5	1950.91	203781.5	2202107	204268.7	182221.2	131908.7
Bhilwara region	Sub-humid climate sandy loam soil										
CGR			0.93*	1.56*	-	-	-1.26*	-	-	-	-1.10*
GM		2502074	130705.3	269218.9	252302.1	474.4	360155.8	805730.2	78257.8	113785.7	452549.1
Udaipur region	Sub-humid plains and aravali hills clay loam silty loam soil										
CGR			0.32*	0.83*	-1.20*	-	-1.07*	-	-	2.78*	0.63*
GM		2353742	187798.2	562357.7	143971	3422.7	504283.6	591892.6	45616.5	130810.7	179593
Kota region	Humid south eastern plains medium black soil										
CGR			0.80*	0.30*	-0.85*	-	-0.86*	-	-	-	-1.25*
GM		3152730	153538.8	616263.7	177725.9	2875.52	204745.5	1688777	112205.7	108386	190409.3

CGR= Compound growth rate (e^b –1) in per cent, GM = Geometric mean (y) in ha, - indicates insignificant estimates.
* indicates significant at 1.0% l.o.s.
Study period for Udaipur and Bhilwara region is 1991-92 to 2004-05.

Table 3. Sectoral land use dynamics

Regions	Absolute land shifts between sectors ('000 ha)				
	Non. Agril. sector	Ecological sector		Agril. sector	Total reported area
	ΔNa	ΔE_1	ΔE_2	ΔA	ΔR
All Rajasthan	285.60	95.30	-298.70	-69.00	13.00
Jaipur	60.30	14.30	-18.60	-56.80	-0.70
Ganganagar*	7.40	12.30	-1.60	-21.80	-4.40
Bharatpur	-1.30	68.70	-62.20	-37.90	-32.70
Jaipur	32.00	37.90	-39.60	15.70	46.00
Bhilwara*	13.90	64.90	-75.80	9.30	12.30
Udaipur*	12.70	21.50	-58.00	35.10	11.30
Kota	22.20	4.70	-27.40	0.03	-0.40

*The period considered for these regions is from 1991-92 to 2004-05.

non-agricultural sector. Thus most of the land for the growth of non-agricultural sector is diverted from barren and unculturable land. Favorable ecological sector E1 comprising of forests, permanent pastures and miscellaneous trees and grooves is also showing a net positive growth in all the regions of the state. The land use shifts are not favourable for agriculture sector. If the land shift from agriculture sector is towards desirable part of ecological sector E1, then it is unfavourable for agriculture and favourable for ecological sector but if it is towards non-agriculture sector, then it is unfavorable both for agriculture as well as ecological sector. In all the regions of Rajasthan except Bharatpur the land is being shifted towards non-agriculture sector. This implies that more and more of land is being used for the infrastructural development demanded by growing population and to some extent towards industrial development.

In Jodhpur, Ganganagar and Bharatpur regions the land shifts are from agriculture sector towards other sectors. In Jodhpur region a sizeable portion of land for non-agriculture purposes has shifted from agriculture sector. This is possible because in agriculture sector the land use class of culturable waste land includes desert areas and Jodhpur region consists of desert districts of Rajasthan. In Ganganagar and Bharatpur regions the land shifting from agriculture sector is mostly being used for afforestation purposes. Jaipur and Kota regions are growing industrial and educational regions where pressure for abadi land is maximum as they have highest population densities in the state. In these regions the land shifts are prominent towards non-agriculture sector from undesirable part E2 of ecological sector. In Bhilwara and Udaipur regions the land is shifting mainly from undesirable part E2 of ecological sector towards non-agriculture, desirable part E1 of ecological sector and towards agriculture sector. Thus the land shifts in these two regions are favorable for ecological as well as agriculture sector. Considering the land use changes within agriculture sector as indicated in Table 1 it can be explicitly seen that in all the regions of the state no significant changes have occurred in net sown area and fallow lands. Thus whatever land is shifting from the agriculture sector, it is mainly from the culturable waste land part of it. It is also supported by the negative compound growth rates of culturable wasteland in all the regions of the state.

Thus the land use dynamics show substantial land use shifts towards non-agriculture sector mainly from undesirable part of ecological sector E2 and culturable wasteland part of agriculture sector (A). While a part of these land use shifts towards non agricultural sector Na can be attributed to urban and industrial expansion, the other part is due to the expansion in rural roads, market yards, irrigation networks which basically form the supporting infrastructure for agriculture growth. It has to be seen that the development in urbanization, industrial expansion and infrastructure growth should be made on more conservative norms.

Policy implications

Growth in forest area in all the region of Rajasthan is a positive step towards ecological stability of this arid and semi arid state. The rate of growth of afforestation has to be increased to maintain a balance with the ecological hazards generated by fast growing non-agriculture sector. It has to be seen that out of these newly afforested areas how much share belongs to the real forest area. A proper follow up of afforestation should be ensured to maintain the ecological balance. Use of productive land nearby the cities for the development of housing and infrastructure through government acquisition should be checked and as far as possible barren lands should be used for this purpose. The tendency of shooting growth of non-agriculture sector should be on more conservative terms before a sizeable portions of land mass gets blocked under non-agricultural uses.

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