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Changing land-use pattern in India: has there been an expansion of fallow lands?

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Abstract This paper examines dynamics of land-use pattern in India with a focus on fallow lands. We find significant changes in the land-use pattern, and a continuous expansion of fallow lands in spite of increasing demand for land for agricultural and non-agricultural purposes. The fallow lands are distributed across the country but have a greater concentration in the states of Bihar, Andhra Pradesh, Rajasthan, and Karnataka. These changes in the temporal and spatial distribution of fallow lands are due to increasing variability in the precipitation and irrigation water, and low level of mechanization. If these lands can be brought under cultivation would enhance agricultural production and food security of the poor and marginal farmers.

Keywords Land use, Fallow land, Rainfall, Mechanization

JEL classification Q24, O13, Q53, R33

1 Introduction

Land is the basic resource for agriculture, a primary source of livelihood for majority of India's rural population. Its allocation to different economic and non-economic activities depends on the population pressure of both human and livestock, changes in demand for food, feed and fibres, technological changes and pace of economic development that requires land for non-agricultural purposes and intensifies competition for land. However, the rapid population growth accompanied by expansion of industrial activities have been aggravating resource depletion and environmental degradation (Jodha 1989; Harte 2007) and alter the land use pattern (Palchoudhuri et al. 2015).

India has geographical area of 328.7 million hectares, of which around 42% is currently used for cultivation of various food and non-food crops. This proportion is one of the highest in the world, but due to excessive population pressure the per capita availability of arable land is much less than the world average. In 2010-11, around 21% of the geographical area was occupied by forests, 8% was utilized for non-agricultural purposes, 5% was barren and unculturable and 7.5% remained fallow (GoI, 2015). The average of land holding is just 1.1 hectares and it has been declining continuously causing concerns for food and livelihood security of millions of smallholder farmers. As the supply of land is fixed, the pathway to increase agricultural production and improve farmers' livelihood is to improve productivity and efficiency of land in a sustainable manner.

There have been a few studies in India that have examined the issues related to fallow lands. These find that irrigation (Giri 1966; Nadkarni & Deshpande 1979; Ramasamy et al. 2005; Bardhan & Tewari 2010), use of fertilizers (Giri 1966), monsoon rainfall (Nadkarni & Deshpande 1979; Ramasamy et al. 2005) and size of operational holdings (Nadkarni & Deshpande 1979; Ramasamy et al. 2005; Bardhan & Tewari 2010) are some of the factors that determine the extent of fallow lands. Ramasamy et al. (2005) also identify infrastructure and institutional factors, such as road

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density and access to institutional finance as important determinants of the extent of fallow lands. A few household level studies (Ranganathan & Pandey 2017; Ranganathan & Pandey 2018) have also identified tenancy, irrigation, mechanization, livestock holdings, non-farm income opportunities, and distance from nearest town as important factors in farmers' decision to leave the land fallow.

This paper addresses this important question: why there is an increase in fallow lands despite the fixed supply of land, declining size of land and increasing demand for land for non-agricultural uses? We examine this issue by analyzing changes in types of land or inter-sectoral shifts in land- uses and factors responsible for land being kept fallow by the farmers. In the following section, we discuss data and methodological approach that we employed in this paper. Section 3 discusses the results. Concluding remarks are made in the final section.

2. Data and methodology

2.1 Data

The analysis of land-use in this paper is based on secondary data compiled from various published sources. The data on land uses were taken from Directorate of Economics and Statistics (DES), *Ministry of Agriculture and Farmers Welfare, Government of India*. The use of NPK were taken from indiastat.com. The data related to sale of tractors and institutional credit outstanding were collected from publications of the Indian Agricultural Statistics Research Institute and Reserve Bank of India respectively; and the data on rainfall were sourced from the Indian Metrological Department, Government of India.

We analyze changes in land-use pattern in 17 major states for the period 1984-85 to 2011-12. These states are: Andhra Pradesh, Assam, Bihar (including Jharkhand), Gujarat, Haryana, Himachal Pradesh, Jammu &Kashmir, Karnataka, Kerala, Madhya Pradesh (including Chhattisgarh), Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh (including Uttarakhand) and West Bengal.

Our analysis of land use pattern at all-India level spans over six decades starting from 1950-51. To see how the land-use pattern has evolved over time we divide the entire time period into six sub periods following Rada (2016): (i) pre-green revolution period from 1950–1968, (ii) initial green revolution period from 1968–1975, (iii) period of wider technology discrimination from 1975–1988 (iv) period of agricultural diversification from 1988–1995 (v) post-economic reforms period from 1995–2004, and (vi) the period of agricultural growth recovery from 2004–2012.

2.2 Methods

2.2.1 Assessment of shifts in land use

Land-use in India is classified into nine broad categories. These are represented by the following equation.

$$R= F_r+ P+M+N+U+W+F_e+F_o+C \quad \ldots(1)$$

where, R represents the reporting area, F_r the forest area, P the area under permanent pastures, M the area under miscellaneous tree crops, N the area put to non-agricultural uses, U the barren and unculturable land, W the culturable waste land, F_e the current fallow land, F_o the fallow land other than current, and C the net sown area.

Differentiating R with respect to time, we get

$$\Delta R= \Delta F_r+ \Delta P + \Delta M + \Delta U + \Delta N + \Delta W + \Delta F_e+ \Delta F_o+ \Delta C \quad \ldots(2)$$

The terms in Eq. (2) can be rearranged to reflect the desirable and un-desirable changes in the land use as:

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

where, ΔE is the net change in ecological sector and equals to $\Delta F_r+ \Delta P + \Delta M$; ΔN is the net change in non-agricultural use, and ΔA is the net change in agricultural sector and equals to $\Delta W+ \Delta F_e + \Delta C$.

ΔE can be further be further written as: $\Delta E_1 + \Delta E_2$, where, $\Delta E_1 = \Delta F_r+ \Delta P + \Delta M$; and $\Delta E_2= \Delta U$.

ΔE_1 is the change in the desirable ecological sector, and ΔE_2 is the change in the undesirable ecological sector.

To examine the intra-sectoral and inter-sectoral shifts in the land use, we follow Jean-Philippe Puyravaud (2003) method that provides rate of change in land use.

$$r = \frac{1}{t_2 - t_1} \ln \frac{A_2}{A_1} \quad \ldots(4)$$

where, A_1 and A_2 represent the types of land uses at time t_1 and t_2, respectively. A value of r shows the annual rate of change in a particular category of land-use.

2.1.2 Location coefficient

Location coefficient (b) identifies spatial distribution of a land category across, and can be defined as:

$$\beta = \frac{N_{ij} / N_j}{N_j / N_s} \quad \ldots(5)$$

where, N_{ij} is area of j^{th} land use category in i^{th} state, N_i is the sum of area of all land categories in state i, N_j is the area of j^{th} land category at all-India level, and N_s is the sum of all land categories at all-India level.

A higher value of b implies a higher regional concentration of a particular category of land-use or vice versa.

2.3 Determinants of fallow lands

At all India-level, we run a linear regression of the following form to identify the factors responsible for changes in fallow lands:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon$$

where, Y is the proportion of current fallow land to net sown area. X_1 is rainfall (June to September), X_2 is nutrient use (NPK in thousand tons), X_3 is tractor sales (number of tractors), X_4 is the proportion of net irrigated area to net sown area, X_5 is the proportion of non-food area to net sown area, X_6 is institutional agricultural credit outstanding (in billion rupees), and is ε error term.

Since we have a panel data-set of states, we also run fixed effects as well as random effects regressions to quantify marginal effects of different factors associated with fallow lands: The fixed effects model is:

$$Y_{it} = \beta_0 + \beta_1 X_{1,\,it} + \beta_2 X_{2,\,it} + \beta_3 X_{3,\,it} + \varepsilon_{it}$$

The fixed effect of regression model allows us to have a separate intercept for each cross-sectional unit i.e., state by controlling for the state specific factors.

The random effects model can be written as:

$$Y_{it} = \beta_0 + \beta_1 X_{1,\,it} + \beta_2 X_{2,\,it} + \beta_3 X_{3,\,it} + \varepsilon_{it} + U_{it}$$

where, U_{it} is within-state error term.

All other variables are defined as above.

3 Results and discussion

3.1 Inter-sectoral changes in land-use

Table 1 shows inter-sectoral changes in land-use at all-India level during 1950–51 to 2011–12. There has been a significant shift in the land-use in favour of non-agricultural activities throughout the period, but at varying rates over time. The shift in land-use to agriculture was favorable until the period of wider

Table 1. Inter-sectoral changes in land use in India

Categories	Pre-green revolution period (1950-68)	Initial green revolution period (1968-75)	Wider technological discrimination period (1975-88)	Diversification period (1988-95)	Post-reforms period (1995-2004)	Growth recovery period (2004-11)	Overall (1950-2012)
DE	0.00	-0.045	-0.003	-0.007	0.000	0.001	-0.007
ΔE_1	0.011	0.007	0.002	0.006	0.004	0.003	0.006
ΔE_2	-0.011	-0.052	-0.006	-0.013	-0.003	-0.002	-0.013
ΔA	0.002	0.003	0.000	-0.001	-0.001	-0.001	0.001
ΔN	0.03	0.027	0.011	0.01	0.012	0.011	0.017
Net sectoral changes*	0.036	-0.021	0.008	0.004	0.013	0.013	0.012
DR	0.004	0.001	0.001	0.001	0.001	0.001	0.002

Source: Authors' estimates.

Note: *the net sectoral change is equal to algebraic sum of $\Delta N + \Delta E_1 + \Delta E_2 + \Delta A$

Table 2. Inter-sectoral changes in land use at state level

State	ΔE	ΔE_1	ΔE_2	ΔA	ΔN	ΔR	ΔE	ΔE_1	ΔE_2	ΔA	ΔN	ΔR
	Diversification period (1988-95)						Post-reforms period (1995-2004)					
AP	0.009	0.002	0.007	0.002	-0.003	0.002	-0.018	0.000	-0.018	-0.003	0.019	-0.002
Assam	-0.008	-0.001	-0.007	0.001	0.01	0.000	-0.001	-0.003	0.002	0.142	0.005	0.018
Bihar	0.002	0.002	0.000	-0.004	0.016	0.000	-0.087	-0.003	-0.084	0.009	-0.035	0.000
Gujarat	-0.002	-0.001	-0.001	0.000	0.004	0.000	0.000	0.000	0.000	0.002	0.001	0.001
Haryana	-0.031	-0.021	-0.01	-0.001	0.025	0.000	-0.046	-0.048	0.002	-0.001	0.007	-0.001
HP	-0.003	0.009	-0.011	0.000	-0.006	0.005	0.173	0.015	0.158	-0.006	0.086	0.03
J&K	0.004	0.000	0.004	-0.001	-0.005	0.000	-0.029	-0.028	-0.001	0.003	0.001	-0.017
Karnataka	-0.002	-0.001	-0.002	-0.001	0.007	0.000	-0.002	-0.001	-0.001	0.000	0.006	0.001
Kerala	-0.063	-0.005	-0.057	0.001	0.009	-0.001	-0.041	-0.002	-0.039	-0.004	0.032	-0.001
MP	-0.022	0.001	-0.023	0.001	0.008	0.000	-0.017	0.002	-0.019	0.000	-0.026	0.000
Maharashtra	-0.002	-0.002	0.000	-0.001	0.013	0.000	0.001	0.000	0.001	-0.002	0.012	0.000
Orissa	0.033	-0.001	0.034	0.000	0.018	0.001	0.039	-0.003	0.042	-0.006	0.015	-0.001
Punjab	0.034	0.017	0.017	-0.001	-0.01	0.000	-0.146	-0.002	-0.144	0.002	0.008	0.001
Rajasthan	-0.014	-0.007	-0.006	0.001	0.009	-0.001	-0.010	-0.004	-0.006	-0.001	0.006	-0.002
Tamil Nadu	-0.007	0.006	-0.012	0.002	0.005	0.002	0.006	0.003	0.004	0.005	0.011	0.005
UP	-0.013	-0.002	-0.011	0.000	0.006	0.000	-0.062	-0.001	-0.061	-0.001	0.004	-0.001
WB	-0.126	0.001	-0.126	-0.001	0.009	0.000	-0.050	-0.005	-0.046	-0.002	0.004	-0.001
	Growth recovery period (2004-12)						Overall (1984-12)					
AP	-0.005	-0.001	-0.004	0.006	0.009	0.004	-0.004	0.000	-0.005	0.002	0.008	0.001
Assam	-0.009	-0.005	-0.004	-0.176	0.014	-0.023	-0.006	-0.003	-0.003	0.001	0.010	0.000
Bihar	-0.001	0.001	-0.001	-0.002	0.004	-0.001	-0.03	0.000	-0.03	0.001	-0.004	0.000
Gujarat	-0.004	-0.001	-0.003	0.005	0.003	0.002	-0.002	-0.001	-0.001	0.002	0.003	0.001
Haryana	-0.001	-0.015	0.013	0.000	0.019	0.002	-0.03	-0.031	0.000	-0.001	0.019	0.000
HP	0.019	0.000	0.019	0.002	-0.033	0.000	0.066	0.009	0.057	-0.002	0.019	0.013
J&K	0.009	-0.001	0.01	-0.002	-0.015	-0.001	-0.006	-0.010	0.004	0.000	-0.006	-0.007
Karnataka	-0.001	-0.001	0.000	-0.31	0.008	-0.114	-0.002	-0.001	-0.001	-0.089	0.008	-0.033
Kerala	-0.061	0.002	-0.063	-0.004	0.022	0.001	-0.059	-0.002	-0.057	-0.002	0.022	-0.001
MP	-0.009	0.000	-0.009	0.000	0.012	0.000	-0.018	0.001	-0.019	0.000	-0.002	0.001
Maharashtra	0.000	0.000	0.000	-0.001	0.005	0.000	-0.001	-0.001	0.000	-0.001	0.011	0.000
Orissa	0.026	-0.003	0.029	-0.021	0.026	-0.006	0.036	-0.002	0.038	-0.008	0.021	-0.002
Punjab	0.094	0.016	0.078	-0.002	0.005	0.001	-0.011	0.011	-0.022	0.000	0.000	0.000
Rajasthan	-0.011	-0.006	-0.005	0.004	0.007	0.001	-0.013	-0.006	-0.007	0.001	0.008	-0.001
Tamil Nadu	-0.009	-0.004	-0.005	-0.005	0.003	-0.003	-0.003	0.002	-0.005	0.001	0.007	0.002
UP	-0.018	0.000	-0.018	-0.002	0.011	-0.001	-0.033	-0.001	-0.032	-0.001	0.007	-0.001
WB	-0.068	-0.001	-0.067	-0.004	0.009	-0.001	-0.091	-0.002	-0.090	-0.002	0.008	-0.001

Source: Authors' estimates.

Note: AP stands for Andhra Pradesh, HP for Himachal Pradesh, J&K for Jammu & Kashmir, MP for Madhya Pradesh, UP for Uttar Pradesh and WB for West Bengal.

technological dissemination (1975-88) but at the cost of undesirable ecological sector. From then onwards, the net change in land for agriculture was negative, showing a shift in the land-use shift towards ecological or non-agricultural sectors or both. It may also be noted that there was no significant shift in the land-use from non-agriculture to agricultural activities.

The state level analysis of inter-sectoral shifts in the land-use shows a decline in the land for agriculture in favour of non-agricultural and ecological sectors in Haryana, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Rajasthan, Orissa, Uttar Pradesh, and West Bengal during the post-reforms period (1995-2004) (Table 2) primarily owing to increasing

urbanization and industrialization. On the other hand, there was an increasing trend in the land for agriculture in Gujarat, Andhra Pradesh and Assam but at the cost of ecological sector (mainly undesirable). In Bihar, Jammu & Kashmir and Madhya Pradesh there was a shift in the land-use towards agriculture at the cost of non-agricultural sector.

To cross-check results obtained from the aggregated categories of land-use, we estimate growth rates for individual land categories, and results are presented in the appendix table A1 and A2. At all India level, the highest growth is recoded for the non-agricultural uses (1.28%), followed by area under forests (0.58%), current fallows (0.51%) and net sown area (0.17%). On the other hand, barren and unculturable land witnessed a negative growth of 1.54% per annum, and was followed by land under miscellaneous tree, culturable waste, other uncultivated land excluding fallow lands, and fallow land other than current fallows. The current fallows in India have shown a positive growth trend while the area under fallows other than current fallows have shown a declining trend over time. The area under current fallows recorded a compound growth rate of 0.51% per annum, while the area under other fallows declined at the rate of -0.23 % per annum.

Appendix table A2 provides compound annual growth rates in different categories of land-uses for states. There is a positive trend in the land used for non-agricultural purposes across the states because of rising demand for it for housing, industrial activities and infrastructure creation. Barren and unculturable land increased only in Himachal Pradesh and Orissa; and declined in all other states with Punjab experiencing the highest rate of decline.

Assam experienced the highest rate of increase in current fallow lands, and was followed by Odisha, Kerala, Maharashtra and Himachal Pradesh. But there was a significant decline in it in Punjab, Haryana and Tamil Nadu.

The instability indices[1] for different land-uses are shown in appendix table A3. The fallow lands (including current fallows and other than current fallows) and barren, and unculturable lands are more unstable than other land categories. Forest lands show the least instability, followed by land for non-agricultural uses, and net sown area.

3.2 Spatial distribution of fallow lands

Locational coefficients estimated to know the pattern of concentration of fallow lands are presented in table 3. There is a sharp increase in the concentration of fallow lands in Tamil Nadu, Rajasthan, Assam, Bihar, Uttar Pradesh and Andhra Pradesh. The more disturbing feature is their very high concentration in Bihar, Andhra Pradesh, Tamil Nadu, Rajasthan, and Karnataka. This probably is due to increase in the instability of surface irrigation, and erratic rainfall. On the other hand, there was a decline in the concentration of current fallows in Gujarat, Haryana, Punjab, and Tamil Nadu.

3.3 Determinants of fallow lands

Often, farmers leave some part of their land uncultivated for a season to improve physical and chemical properties of soil, or because its remoteness (Bamwerinde et al. 2006; Gellerich et al. 2007; Bakker and Van Doorn 2009). They also leave land fallow because of several other reasons including lack of resources, poor irrigation facilities, extreme weather conditions and soil erosion. We assess the role of a few factors associated with current fallow lands. Table 4 presents results of the linear regression, and of the Newey method. The Newey estimator is used to overcome the problems of autocorrelation and heteroscedasticity, that are often present in the time series.

There is an inverse relationship between the monsoon rainfall and proportion of current fallow lands to the net sown area. A one-unit increase in rainfall leads to 0.097% decline in the proportion of current fallow lands. Fertilizer use (NPK) also shows a negative relationship with proportion of current fallow lands but it is not statistically significant. However, we find significant decline in the proportion of current fallow lands with improvements in mechanization i.e., tractor. The irrigation turns out to be significant and positive showing increase in fallow lands with an increase in the irrigated area. An increase in the proportion of non-food area also leads to a decline in fallow lands.

[1] Cuddy-Della Valle Instability Index (per cent) $= CV \times \sqrt{1 - R^2}$. where, CV is the coefficient of variation in percent, and R^2 is the adjusted coefficient of determination from a time trend regression.

Table 3. Locational coefficients of fallow land in states

States	Wider technological discrimination period (1984-88)		Diversification period (1988-95)		Post-reforms period (1995-2004)		Growth recovery period (2004-12)		Overall (1984-12)	
	FL	CF	FL	CF	FL	CF	FL	CF	FL	CF
AP	1.66	2.42	1.63	1.97	1.67	2.11	1.64	2.05	1.65	2.10
Assam	0.33	0.23	0.31	0.22	3.84	4.80	1.58	1.93	1.81	2.18
Bihar	1.87	2.32	1.78	2.24	1.65	2.25	1.86	2.66	1.77	2.38
Gujarat	0.08	1.58	0.07	1.00	0.03	0.85	0.02	0.52	0.04	0.90
Haryana	0.01	1.16	0.00	0.96	0.01	0.84	0.05	0.66	0.02	0.86
HP	0.14	0.29	0.18	0.29	0.13	0.27	0.12	0.27	0.14	0.28
J&K	0.05	0.39	0.05	0.46	0.07	0.49	0.15	0.44	0.08	0.45
Karnataka	0.72	1.21	0.67	1.23	0.67	1.62	0.73	1.50	0.69	1.43
Kerala	0.22	0.23	0.22	0.24	0.25	0.35	0.35	0.40	0.27	0.32
MP	0.62	0.39	0.57	0.39	0.53	0.40	0.55	0.40	0.56	0.40
Maharashtra	1.03	0.55	1.13	0.70	1.22	0.77	1.11	0.91	1.14	0.76
Orissa	0.68	0.44	0.46	0.21	0.72	0.47	0.77	0.88	0.66	0.52
Punjab	0.01	0.23	0.07	0.27	0.03	0.17	0.01	0.13	0.03	0.19
Rajasthan	2.15	1.75	1.79	1.17	2.02	1.52	1.74	1.08	1.90	1.34
Tamil Nadu	1.93	2.28	2.49	1.68	2.94	1.77	3.42	1.48	2.82	1.74
UP	0.88	0.78	0.90	0.78	0.74	0.76	0.59	0.90	0.76	0.81
WB	0.29	1.01	0.15	0.71	0.10	0.63	0.07	0.85	0.13	0.77

Source: Authors' estimates.
Note: FL stands for fallow land other than current fallow land, and CL stands for current fallow land.

Table 4. Linear regression estimated of determinants of fallow lands at all-India level

	Liner	Difference	Newey
Rainfall	-0.097***	-10.155***	-0.097***
	(3.38)	(3.94)	(3.85)
NPK	-0.000	-0.000	-0.000
	(0.32)	(0.19)	(0.32)
Tractors	-0.949	0.000	-0.949**
	(1.21)	(0.18)	(2.20)
Proportion of net area irrigated	0.520**	0.974**	0.520**
	(2.11)	(2.33)	(2.60)
Proportion of non-food area in total area	-0.427*	-0.941**	-0.427*
	(1.71)	(2.75)	(1.90)
Credit outstanding	0.155	-0.779	0.155
	(0.22)	(0.37)	(0.26)
Constant	17.016	-0.081	17.016***
	(3.95)	(0.17)	(5.76)
Number of observations	32	31	32
R-squared	0.560	0.602	
Adjusted R-squared	0.454	0.502	

t- statistics in parentheses. ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.

Table 5. Results of the panel regression for fallow land

	Fixed effect	Random effect
Proportion of net area irrigated	-0.371***	-0.286***
	(3.59)	(3.83)
Proportion of non-food area in total area	0.087	0.013
	(0.64)	(0.13)
Rainfall	-0.554*	-0.595**
	(1.78)	(2.22)
Constant	29.539***	29.325***
	(5.03)	(5.00)
Number of observations	420	420
R-squared	0.043	
Adjusted R-squared	0.003	

t- statistics in parentheses. ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.

The regression results of the panel fixed effects and random effects models are presented in table 5. The proportion of current fallow lands is negatively and significantly associated with the net irrigated area and rainfall. The effect of rainfall seems to have a greater influence. These results indicate that in regions with low and erratic rainfall farmers tend to leave more of their land uncultivated.

In an earlier study conducted by the authors using household level data from India Human Development Survey (IHDS) for 2011-12 finds that with access to irrigation and ownership of machines (tractors and power-tillers) farmers leave less of their land fallow (Ranganathan & Pandey 2018). A well-functioning lease market is also observed to reduce the proportion of land to be left fallow. On the other hand, the decision to leave the land fallow is also determined by the herd size; larger the herd size, greater is the probability of leaving a larger proportion of land fallow.

4 Conclusions

Our findings show a marginal increase in the land for cultivation at the cost of undesirable ecological sector. There has been a continuous expansion in land for non-agricultural uses mostly diverted from the ecological sector. The inter-state sectoral changes in the land-use pattern in Haryana, Karnataka, Kerala, Maharashtra, Uttar Pradesh, West Bengal and Himachal Pradesh showed a decline in agriculture sector at the cost of non-agricultural sector. In Odisha and Himachal Pradesh there is a decline in the land for agriculture at the cost of either ecological or non-agriculture or both sectors.

The fallows have expanded in the country. There is a concentration of fallow lands in Tamil Nadu., Rajasthan, Uttar Pradesh, Bihar and Andhra Pradesh. The regression analysis identifies erratic rainfall and poor mechanization as important factors for increase in fallow land area.

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Appendix Table A1. Compound annual growth rate of land use for different purposes in India

	FR	ANA	BUL	NAS	OUL	LMIS	CWL	FL	CF
Pre-green revolution period (1950-68)	1.99	1.83***	-0.64**	0.86	3.60	-5.79***	-2.39	-3.39	-0.02
Initial green revolution period (1968-75)	0.47*	2.17**	-4.94***	0.13	-0.65*	-0.68	1.15	-0.81	2.22
Wider technological discrimination period (1975-88)	-0.04	1.01	-0.40*	-0.18	-0.53***	-0.19*	-1.18	0.81*	2.44**
Diversification period (1988-95)	0.37***	1.02	-1.26*	0.08	-0.78***	0.41*	-1.09	-0.60**	-0.40
Post-reforms period (1995-2004)	0.19***	1.08**	-0.58***	-0.37	-0.65**	-0.94	-0.69***	1.48	2.31
Growth recovery period (2004-11)	0.00	1.05**	-0.21	0.02	-0.27**	-1.22*	-0.92*	-0.26	0.24
Overall (1950-2012)	0.58	1.28	-1.54	0.17	-0.24*	-1.20	-0.91	-0.23*	0.51

Source: Authors' estimates.
Note: FR stands for forest, ANA stands for area under non-agricultural uses, BUL stands for barren and un-cultural land, NAS stands for net area sown, OUL stands for other uncultivated land excluding fallow land, LMIS stands for land under misc. tree crops and groves not included in net area sown, CWL stands for cultural waste land, FL stands for fallow land other than current, CL stands for current fallow land.
***, ** and * denote significance at 1%, 5% and 10% levels, respectively.

Appendix Table A2. State-wise compound annual growth rate of land use for different purposes in India 1984–2012)

States	FR	ANA	BUL	NAS	OUL	LMIS	CWL	FL	CF
AP	0.18***	0.95	0.39**	0.003	1.89	0.53**	-1.19	0.37*	-0.37
Assam	-0.27	1.18	-0.37	0.13	-0.67	-1.01	-1.49	3.60	6.18*
Bihar	-0.12***	0.88	-0.07	-0.52	-0.39*	1.14	-0.17	0.36*	0.14**
Gujarat	-0.15**	0.26	-0.14	0.50***	0.02	-0.50	0.03	-5.82	-4.10***
Haryana	-6.97	2.72	-0.97*	0.004	0.07	8.36	0.65	5.93**	-1.95**
HP	0.74	3.54	7.54	-0.36	1.31	2.12***	0.23	0.38	1.26
J&K	-1.61	0.18*	0.18*	0.09**	-0.03	-0.47	-0.16*	4.65*	-0.72*
Karnataka	0.01*	0.82	-0.10	-0.15*	-0.93	-0.63	-0.47	0.64**	1.25**
Kerala	0.001	2.49	-5.63	-0.28***	-21.03*	-9.82*	-1.42*	2.70	2.73
MP	0.31	0.79	-1.28	-0.08**	-1.19	-8.17	-0.46***	-0.07	0.13
Maharashtra	0.07*	1.14	0.16	-0.19	-0.34*	0.74*	-0.52	0.66**	2.07
Orissa	0.15*	2.50	3.76	-0.93	-1.74	-4.46	-0.45	1.75*	5.19
Punjab	0.13	0.46	-4.99***	-0.01	-0.79	0.46	-8.03***	-7.39	-3.70**
Rajasthan	0.87	0.82	-0.80	0.53*	-0.35	-1.85**	-1.30	-0.13	-1.20
Tamil Nadu	0.01	0.85	0.40***	-0.67	-0.94	1.84	0.81***	2.74	-1.37**
UP	-0.004	1	-1.71	0.04*	-0.93	1.21	-1.65	-1.66	0.60**
WB	0.28***	0.68	-10	-0.11*	-1.37**	0.19	-6.94	5.43	0.18

Source: Authors' estimates.
Note: FR stands for forest, ANA stands for area under non-agricultural uses, BUL stands for barren and un-cultural land, NAS stands for net area sown, OUL stands for other uncultivated land excluding fallow land, LMIS stands for land under misc. tree crops and groves not included in net area sown, CWL stands for cultural waste land, FL stands for fallow land other than current, CL stands for current fallow land.
***, ** and * denote significance at 1%, 5% and 10% levels, respectively.

Appendix Table A3. Instability of land use pattern in India during the different periods

Periods	FR	ANA	BUL	NAS	OUL	LMIS	CWL	FL	CF
Pre-green revolution period (1950-68)	0.045	0.066	0.041	0.015	0.102	0.358	0.022	0.051	0.078
Initial green revolution period (1968-75)	0.011	0.026	0.019	0.015	0.012	0.073	0.036	0.048	0.163
Wider technological discrimination period (1975-88)	0.005	0.006	0.022	0.016	0.009	0.013	0.013	0.038	0.113
Diversification period (1988-95)	0.002	0.011	0.005	0.003	0.008	0.029	0.008	0.023	0.036
Post-reforms period (1995-2004)	0.002	0.005	0.023	0.022	0.007	0.031	0.006	0.043	0.172
Growth recovery period (2004-11)	0.000	0.009	0.012	0.008	0.001	0.014	0.011	0.026	0.053
Overall (1950-2012)	0.061	0.049	0.100	0.030	0.126	0.355	0.056	0.145	0.120

Source: Authors' estimates.

Note: FR stands for forest, ANA stands for area under non-agricultural uses, BUL stands for barren and un-cultural land, NAS stands for net area sown, OUL stands for other uncultivated land excluding fallow land, LMIS stands for land under misc. tree crops and groves not included in net area sown, CWL stands for cultural waste land, FL stands for fallow land other than current, CL stands for current fallow land.