



Growth and Dynamics of Land Use Pattern in North East Region of India

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ABSTRACT

North Eastern (NE) region comprising of eight states is the priority area where many government developmental programs are focused to improve agriculture and allied sectors. In fact, government aims to enhance the productivity of crops as well as to provide more livelihood opportunities to farmers particularly small and medium farmers. Among natural resources in the region 'land' plays an important role because of its unique terrain and hill regions. In this background the present study aims to examine the extent of land use and changes in land-use pattern. Further, an attempt is made to visualize the land-use by predicting the future scenario. Data pertained to land-use classification for 30 years from 1984-85 to 2015-16 have been collected and used for the purpose. The study revealed that the NE region has more than half of its geographical area under forest. Changes in the land use pattern during last 30 years revealed that forest area (14.64 m ha) and net sown area (4.56 m ha) are the land components which gained area, while land-not available for cultivation (3.13 m ha), other uncultivated land excluding fallow land (1.46 m ha) and fallow land (0.84 m ha) has given away. The net sown area in NE region has increased by 20.95 per cent in the past 30 years from 3.77 m ha to 4.56 m ha, while forest area has increased by 27.86 per cent from 11.45 m ha to 14.64 m ha. In fact, the NE region alone contributes about 60 per cent of India's increase in forest area during last 30 years (5.04 m ha). State wise analysis indicated that Arunachal Pradesh has the largest share of forest area of NE region (45.96 %), while Assam has the largest areas under land-not available for cultivation (78 %) and net sown area (61.72 %). It points towards the key role of Assam state in agricultural development of NE region. Among land use components, the predicted forest area would decline by 0.28 per cent (2020-21). The area which is not available for cultivation may expand by 0.10 per cent which means the development will take place in secondary and tertiary sectors. The agricultural area also may expand by 1.45 per cent during 2020-21 as compared to 2015-16. Therefore, developmental strategies should focus on improving the forest area in NE region to maintain optimum environmental and ecological balances.

1. Introduction

North Eastern (NE) region is the priority area where many government developmental programs are focused to improve agriculture and allied sectors. In fact, government aims to enhance the productivity of crops as well as to provide more livelihood opportunities to farmers particularly small and medium farmers. Among natural resources in the region 'land' plays important role because of its unique

terrain and hill regions. NE region of India is known for its diversified natural resources, biodiversity and cultural heritage. The region comprised of eight states namely Arunachal Pradesh, Assam, Mizoram, Meghalaya, Nagaland, Tripura and Sikkim with a landmass of 2.6 million Sq. Km accounting for 7.9 per cent of India's total geographical area. The agricultural production system in the region is

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characterized mainly by CDR (Complex Diverse Risk-prone) type, subsistence farming, undulating topography and defective land-use pattern with an annual soil loss of 46 tons/ha (Birthal et al. 2006; Roy et al., 2015).

Land is the primary resource for any activities particularly in agriculture. It refers to a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes and swamps), the near-surface sedimentary layers and associated groundwater and geo-hydrological reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.) (FAO/UNEP, 1997; Young 2009). Land use is characterized by the arrangements, activities and inputs by people to produce change or maintain a certain land cover type (Di Gregorio and Jansen, 1998). Land use defined in this way establishes a direct link between land cover and the actions of people in their environment (Bardhan and Tiwari 2010). Land uses are classified in to nine folds viz. forest area; area under non-agricultural uses; barren and un-culturable land; permanent pasture and other grazing land; land under miscellaneous tree crops, etc.; culturable Waste Land; fallow lands other than current fallows; current fallows; net area sown. Area under non-agricultural uses and barren and un-culturable land are clubbed into 'not available for cultivation'. Permanent pasture and other grazing land, land under miscellaneous tree crops, etc. and culturable waste land all together called as 'other uncultivated land excluding fallow land'. Fallow land other than current fallows and current fallows together called as 'fallow land' (<http://mospi.nic.in/47-land-use>). In this background the present study aims to examine the extent of land use and changes in the land use pattern in NE region. The study has also attempted to predict the future scenario of land use pattern.

2. Materials and Methods

To achieve the objectives of study, relevant secondary data on different category of land-use variables were collected across North-Eastern states of India and all India level for the time period of 1984-85 to 2015-16 (Directorate of Economics and Statistics, Government of India; <https://eands.dacnet.nic.in>)

Compound Annual Growth Rate:

Temporal and spatial trends was studied using compound annual growth rate (CAGR) at the all India level and across NE states to know the growth and dynamics of utilization of land use. Equation for estimation of CAGR is as follows:

$$Y_t = ab^t e^{u_t} \dots\dots\dots (i)$$

Where,

Y_t = Value of dependent variable for which growth rate is to be estimated at time 't'

a = Intercept

b = Regression coefficients

t = Time variable

u_t = Error term corresponding to t^{th} observation

The equation (i) is estimated after transforming it to logarithmic form as follows,

$$\ln Y = \ln a + t \ln b + u_t$$

The present compound growth rate is computed using the relationship.

$$r = \{ \text{antilog} (\ln b) - 1 \} \times 100$$

Instability Index:

Variability in land use pattern is measured in relative terms by the Cuddy Della Valle index which is used as a measure of variability in time-series data. The simple coefficient of variation over-estimates the level of instability in time-series data characterized by long-term trends, whereas the Cuddy-Della Valle index corrects the coefficient of variation, by:

$$CDVI = (CV) \sqrt{1 - R^2}$$

Where, CDVI is the Cuddy-Della Valle index, i.e., corrected coefficient of variation (CV). CV is the simple estimate of the coefficient of variation (in percent), and R^2 is the coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom (Vekariya et al. 2020; Anjum S and Madhulika 2018; Kolar et al. 2020).

Markov Chain Analysis:

To assess the dynamism in direction of area under different land-use pattern during TE2011-12 to TE2015-16, transitional probabilities were calculated based on linear programming (LP) approach (Fisher, 1976) using LPSolve IDE – 5.5.2.5. Markov chain analysis develops a transitional probability matrix 'P', whose elements P_{ij} indicate the probability (share) of land switching from the i^{th} group to the j^{th} group over time (Lee et al. 1965; Nüsser and Gerwin 2008). Its diagonal elements represent retention share of respective group in terms of area under particular groups. This can be algebraically expressed as Equation:

$$E_{jt} = \sum [E_{it-1}] P_{ij} + e_{jt}$$

$$i = 1, \dots, n$$

Where

E_{jt} = Area under crop to the j^{th} crop group in year 't'

E_{it-1} = Area under crop of i^{th} crop group during the year 't-1'

P_{ij} = The probability of shift in area under i^{th} crop group to j^{th} crop group

e_{jt} = The error-term statistically independent of E_{it-1} , and

n = The number of crop groups.

The transitional probabilities P_{ij} arranged in $(m \times n)$ matrix have the following properties:

$$\sum_{i=1, \dots, n} P_{ij} = 1 \text{ and } 0 \leq P_{ij} \leq 1$$

The transitional probability matrix (T) based on LP framework is estimated using Minimization of Mean Absolute Deviation (MAD).

$$\text{Min, } OP^* + I e$$

$$ST$$

$$X P^* + V = Y$$

$$GP^* = 1$$

$$P^* > 0$$

where, P^* is the transitional probability matrix, '0' is the zero vector, 'I' is an appropriately dimensional vector of areas, and 'e' is the vector of absolute errors. With the help of transition probability matrix, the estimated values have been worked out and attempted to predict the future scenario of the land use pattern.

3. Results and Discussion

Land-use changes in NE region have been explained over the period of 1984-85 to 2015-16 based on the available land-use statistics. Percentage share of land-use such as forest area, land not available for cultivation, other uncultivated land excluding fallow land, fallow land, net sown area and gross cropped area to the total geographical area have been calculated and percentage share of land-use of the region to all India level have been captured to understand the actual dynamics of the land-use pattern in that region. To understand the dynamics of land-use in NE region, we considered TE1986-87 as period I (base year) and TE 2015-16 as Period II.

Utilization of land in India has been classified into nine major folds which are further grouped into six main categories. The present status and dynamics of land use in NE region and at all India level are depicted in the Table 1. The total geographical area of the region including 8 states is 26.22 m ha. Out of which, statistics are available only from 24.64 m ha (DES, MoA&FW, GoI, 2020), which makes some areas to the extent of 6 per cent still not covered or classified under the land use categories. The share of NE region in India's total geographical area is 7.98 per cent which accounts for one twelfth of the total geographical area of the country. The NE region is endowed with plenty of natural resources. Forest is the major natural resource. The region was blessed with the forest area of 14.64 m ha during TE2015-16 which was substantially increased from 11.45 m ha during TE1986-87. The share of forest area accounts to be 55.85 per cent of total NE region's geographical land. India has 71.82 m ha forest area in TE2015-16 which accounts merely 21.85 per cent to the total geographical area. Remarkably, the NE region has 20 per cent of the total forest area of the country. Therefore, it is evident that the NE region is significantly contributing to the environmental and ecological balance of the nation. The total land not available for cultivation was 4.88 m ha (18.61%) during TE 1986-87 in the NE region, which was substantially decreased to 3.13 m ha (11.95%) in TE2015-16 period. This is due to the utilization of barren and un-culturable land into forest, agriculture and other purposes. The NE region shares 7.13 per cent out of India's total land which is not available for cultivation.

Table 1. Land-use pattern in all India and in North-East India region and dynamics of change

Particulars	All India				NE region				Share of NE region in all India	
	P-I		P-II		P-I		P-II		P-I	P-II
	Area	%	Area	%	Area	%	Area	%	%	%
Geographical area	328.73		328.73		26.22		26.22		7.98	7.98
Reporting area	304.67	92.68	307.78	93.63	23.13	88.21	24.64	93.97	7.59	8.00
Forest area	66.78	20.31	71.82	21.85	11.45	43.66	14.64	55.85	17.14	20.39
Not available for cultivation	40.82	12.42	43.94	13.37	4.88	18.61	3.13	11.95	11.95	7.13
Other uncultivated land excl. fallow land	31.18	9.48	25.75	7.83	1.73	6.60	1.46	5.57	5.55	5.67
fallow land	25.44	7.74	25.92	7.88	1.30	4.96	0.84	3.21	5.11	3.24
Net sown area	140.46	42.73	140.35	42.70	3.77	14.38	4.56	17.40	2.68	3.25

Note: P-I refers to Period I (triennium ending 1986-87) while P-II refers to Period II (triennium ending 2015-16)

Source: DES, MoA&FW, 2020

The total other uncultivated land excluding fallow land in NE region accounts 5.67 per cent of the total uncultivated land of India and had declined during past thirty years from 1.73 m ha (6.60%) in TE1986-87 to 1.46 m ha during TE2015-16. The current fallow lands are the cropped area which kept fallow during the current year but was cultivated in the previous year. The fallow lands other than the current fallow are the lands which taken up for cultivation but are temporarily out of cultivation for a period of not less than one year and not more than five years. The NE region had 1.30 m ha (4.98%) fallow land during the period I which was also declined to 0.84 m ha (3.21%) in period II. The region has only 3.24 per cent share in total fallow land of India. The total agricultural area i.e. net sown area of the region in period II was 4.56 m ha (17.40%). It was increased by 0.79 m ha in three decades. It comprised minimal share (3.25%) in the country's net sown area.

In all India level, the net sown area was almost same in last three decades i.e. around 140 m ha (42% of geographical area). Whereas, the net sown area in NE region has increased 20.95 per cent to its base period which indicates that even though the overall country's net sown area has marginally declined in last three decades, the NE region has contributed to maintain the same level of country's net sown area. The total forest area in the country has increased by 5.04 m ha (7.5%) over the three decades. The NE region is the major contributor in the increased country's forest area. The NE region has contributed 63.29 per cent (3.19 m ha) in the increased forest area. The fallow land in NE region has declined by 35.38 per cent from the base period whereas in all India level, the area under fallow land was remained same during past 3 decades. The area under not available for cultivation in the NE region has declined by 1.75 m ha (35.8%) but in India it has been increased by 3.12 m ha during TE2015-16. If we look at the area under other uncultivated land excluding fallow land, it was declined both in all India as well as in NE region in past three decades (table 1).

Growth rates were worked out for NE region on land use pattern to get more detailed picture on temporal dimensions of the dynamics of land use pattern in the region. The decade wise growth rate viz. Decade I (1986-87 to 1995-96); Decade II (1996-97 to 2005-06); and Decade III (2006-07 to 2015-16) for NE region for the period 1986 to 2015 has been estimated and it is given in the Table 2. During first decade, the forest area (0.25%), the net sown area (0.59%) and the total cropped area (1.03%) had shown significant positive growth over the years whereas land not available for cultivation (-0.36%), other uncultivated land excluding fallow land (-0.42) and fallow land (-3.79%) shown significant negative annual growth. In contrast, during second decade, the land- not available for cultivation exhibit significant positive growth i.e. 0.53 per cent per annum followed by net sown area (0.48% per annum) while other uncultivated land excluding fallow land declined significantly at an annual growth rate of 1.54 per cent per annum. In third decade, except net sown area, forest (-0.08 %) and land not available for cultivation (-0.59 %) shown significant negative growth. Overall, from the period 1986-87 to 2015-16, the area under forest cover, net sown area and total cropped area had shown significant positive growth i.e., 1.01 per cent, 0.66 per cent and 0.67 per cent, respectively. While, land not available for cultivation (-1.78 %), other uncultivated land excluding fallow land (-0.76 %) and fallow land (-1.20 %) recorded negative significant growth.

The declining trend in area under not available for cultivation may be due to decline in the un-culturable and barren land overshadows the increase in the area under non agriculture purposes viz. for secondary and tertiary sector developments. In NE region, there is a traditional practice of Jhum cultivation, an age old practice where village communities/individual families select the plot in the jungle and clear the vegetation and practice agriculture for few years and left fallow for recuperation. However, the distorted jhum cultivation (short cycle <5 years), a consequence of land use pressure and intensive agriculture has resulted in the decline

Table 2. Compound growth of different land-use pattern in NE region

	1986-87 to 1995-96	1996-97 to 2005-06	2006-07 to 2015-16	1986-87 to 2015-16
Forest	0.25**	0.66 ^{NS}	-0.08**	1.01*
Land not available for cultivation	-0.36**	0.53*	-0.59**	-1.78*
Other uncultivated land excluding fallow land	-0.42***	-1.54**	0.36 ^{NS}	-0.76*
Fallow land	-3.79*	-0.13 ^{NS}	-0.94**	-1.20*
Net sown area	0.59*	0.48*	1.14*	0.66*
Total cropped area	1.03*	0.05 ^{NS}	1.90*	0.67*

Note: Level of significance: * - 1%, ** - 5%, *** - 10% and NS - Non Significant

in the fallow land over the years (1.20% per annum). Forest Survey of India (FSI, 2015) and Wastelands Atlas of India (WAI, 2010) documented the decline in the shifting cultivation area in the previous decade. There is a remarkable growth in the net area sown as well as total cropped area in three decades which resulted from intensive agriculture by inhabiting the area from other categories of land use.

Instability index is a measure of extent of variability or the absence of stability in time-series data. The instability indices for various land use categories were worked out decade wise from 1986-87 to 2015-16 and these are presented in the table 3. During the first decade (1986-87 to 1995-96), highest variability was observed in the fallow land and remaining categories exhibit least variability in their respective land utilization. During the second decade (1996-97 to 2005-06)

fallow land fluctuates more followed by other uncultivated land excluding fallow land and forest area. In third decade, the forest area has shown least variability among the land use pattern and also as compared to the previous decade's forest area. The other uncultivated land excluding fallow land had portrayed more variability followed by total cropped area and fallow land category. Interestingly, the total cropped area and forest area had shown more variation over the past thirty years (1986-87 to 2015-16). The variation in the third and second decade might cause more influence on the overall increase in the fluctuation of the total cropped area and forest area respectively. The net sown area has shown least variation over the years. In decade-wise analysis, fallow land showed more variability because of distorted jhum cultivation in the NE region.

Table 3. Instability index for land use pattern in North-East India

	1986-87 to 1995-96	1996-97 to 2005-06	2006-07 to 2015-16	1986-87 to 2015-16
Forest	0.81	3.30	0.20	3.09
Not available for cultivation	1.03	0.87	1.91	1.14
Other uncultivated land excluding fallow land	1.86	4.24	3.97	2.18
fallow land	8.10	4.97	2.65	2.22
Net sown area	1.17	1.09	1.08	0.93
Total cropped area	0.92	1.45	2.95	3.41

Table 4. Structural changes in Land-use pattern in NE region (TE 2011-12 to TE 2015-16)

Land use components	Forest	Not available for cultivation	Other uncultivated land excl. fallow land	fallow land	Net sown area
Forest	0.91	0.09	0.00	0.00	0.00
Not available for cultivation	0.21	0.52	0.00	0.27	0.00
Other uncultivated land excl. fallow land	0.33	0.00	0.53	0.00	0.14
fallow land	0.21	0.00	0.79	0.00	0.00
Net sown area	0.00	0.04	0.00	0.00	0.96

Table 5. Prediction of land-use pattern for the TE2020-21

Land-use	Area in lakh ha				
	Forest	Not available for cultivation	Other uncultivated land excl. fallow land	fallow land	Net sown area
TE 2015-16	146.41	31.33	14.59	8.41	45.63
TE 2020-21	146.00	31.36	14.31	8.41	46.29
% change	-0.28	0.10	-1.92	0.00	1.45

The transitional probability matrix contains per cent probabilities of categories of land use as possible outcomes. Each land use category is entered in row as well as in column. Hence it is a squared matrix. The value of each element p_{ij} should lie between zero and one. Each row total should be equal to one. The diagonal elements represent the probability of retention of previous area which implies the stability of the particular land use category. The row elements of particular category reflects the probability per cent loss of own land use pattern to its competing category. The column entries of particular group provide the probability of gain in own group from other groups considered for the period of TE2014-15 to TE2018-19.

Transitional probabilities of land use pattern for NE region are presented in the Table 4. From the table it is evident that in NE region's net sown area has the highest probability of retention of 0.96 that is the net cultivated area retain its previous area share from one period to other period with the probability of 96 per cent and it may gain area from the other uncultivated land excluding fallow land with the 14 per cent probability. There is least probability (4%) that it may lose its area to non-agricultural purpose. Forest area has the retention probability of 91 per cent. It may gain area from the categories viz. not available for cultivation, other uncultivated land, fallow land with the probability of 21%, 33% and 21% respectively. Land not available for cultivation has the retention probability of 52 per cent and with 27 per cent probability that its area might converted to fallow land and might converted to forest area with 21 per cent probability. The land under other uncultivated area has the retention probability of 53 per cent.

Using these transition probabilities, we predicted the transition of land-use for TE 2020-21 (Table 5). From the table 5, it may be caution that the forest area may reduce to 146 lakh hectares (-0.28%) during TE2020-21. The other uncultivated land also may decline to 14.31 lakh hectares (-1.92%). The decreased area may shift towards agriculture because predicted net sown has increased to 46.29 lakh hectares (1.45%) and area under not available for cultivation may increase to 31.36 lakh hectares. It indicates that the area may shift towards non-agriculture purpose.

4. Conclusion

The NE region has more than half of its geographical area under forest. The total forest area in All-India has increased by 5.04 m ha (7.5%) during the last 30 years. The NE region is the major contributor (63.29% i.e. 3.19 m ha) in the increase in country's forest area. The net sown area in NE region has increased 20.95 per cent to its base period which indicates that even though the overall country's net sown area has marginally declined in last three decades, the NE region has contributed to maintain the same level of net sown area.

The forest area (1.20% per annum) and net sown area (0.66% per annum) of the region has been significantly increased over the years. The fallow land in NE region has declined by 35.38 per cent from the base period and instability is more than the other land use categories, whereas in all India level, the area under fallow land was marginally increased (0.48 m ha) during past 3 decades. The area not available for cultivation in India has been increased (3.12 m ha) but in contrast, the NE region had shown decline in that area of about 1.75 m ha (35.8%). If we look at the area under other uncultivated land excluding fallow land, it was declined both in all India as well as in NE region in past three decades. The cause of concern is that the predicted forest area would decline by 0.28 per cent in 2020-21 while area under not available for cultivation may expands by 0.10 per cent which means the development will takes place in secondary and tertiary sectors. The agricultural area also may expand by 1.45 per cent during TE2020-21 as compared to TE15-16. Therefore the study suggests that policy makers should be cautious about declining forest cover and hence developmental strategies should focus on improving the forest area in NE region to maintain optimum environmental and ecological balances.

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