The sustainable use of natural resources in agricultural sector is challenging issue around the world before agricultural policy makers to accomplish the tasks of food security for the growing population and to achieve a desirable level of development. In a developing country like India, land is not only an important factor of production, but also the basic means of subsistence for majority of the people. The challenge of natural resources management is evident from the fact that with a mere 2.4 per cent share of the world’s land and only 4.0 per cent share of the world’s freshwater resources, the agricultural sector of India has to cater to 17.5 per cent of the world’s population (Anon., 2016a).

Land and water are the crucial natural resources for development activity of any state or nation. However, land is required for both agriculture and non-agricultural purposes, including establishment of housing, industries, roads, parks, railway lines as well as other mercantile activities. Unplanned diversification as well as urbanisation often results in non-sustainable patterns of development. Such a market driven land uses may yield higher returns in the short run, but may arise unmanageable problems for future generations due to unplanned exploitation of these natural resources. Generally, it is considered that development activities require more land and there is a general fear that it might encroach upon agricultural land, particularly the fertile land in the rural areas. Hence, the conflict between declining availability of agricultural land and population increase, as well as more requirement of land for industrial and infrastructure development has attracted special attention of political system, academics, industry, civil society and other stakeholders. It is generally perceived that large-scale conversion of agricultural land to non-agricultural uses has occurred and the issue of acquisition of large tracts of fertile land by corporates and displacement of farmers, agricultural workers, and other rural communities has become a major political rather than socio-economic issue. It is high time to determine whether the perceptions are consistent with empirical evidence on
land use competition and identify main drivers that contribute to loss of agricultural land.

The information on land use pattern is necessary to develop future research strategies on land use planning and policies. Economic rationality requires the optimum utilization of land to maximize the welfare of the society by meeting diverse needs. The land use pattern is ultimately determined by the factors like human inhabitation, socio-economic, political, technical and institutional changes. An analysis of structural changes in the land use pattern over a period of time provides scope for planned and judicious management of land. Despite this, a little attention has been paid to such a systematic study regarding land use dynamics in different districts and regions of Gujarat. This study entitled “An Economic Analysis of Land Use Dynamics in Gujarat” was therefore undertaken with the following objectives.

1. To study temporal changes in land use pattern in Gujarat.
2. To find out nature and extent of structural variation in land use pattern.
3. To identify the factors responsible for temporal changes in land use pattern.
4. To study the impact of changes in land use pattern on cropping intensity.
5. To analyse the ecological implications of land use dynamics in Gujarat.
6. To suggest suitable policy measures.

The present study was based on the secondary data on land use for the period from 1970-71 to 2014-15, collected from various published sources viz; Land Use Statistics at a Glance published by the Directorate of Economics and Statistics, New Delhi. Districtwise time series data on area under land use categories, population, average rainfall, land holders, industrial units, road length, net irrigation, gross irrigation, etc., were obtained from various issues of Statistical Abstract of Gujarat State, Handbook of Basic Statistics Gujarat State published by the Directorate of Economics and Statistics (DES), Government of Gujarat, Gandhinagar. The entire period of 1970-71 to 2014-15 was decomposed into three periods, viz; Pre-liberalization, Post-liberalization and Overall Period.

To fulfil the specific objectives of the study, appropriate analytical tools and techniques were adopted. A temporal change in land use pattern was estimated with the percentage change, compound growth rates and instability. Markov Chain analysis
was employed to examine the nature and extent of land use shift between major land use categories. Multiple regression analysis was used to identify the important factors responsible for the changes in land use dynamics. To identify the impact of land use shift on cropping intensity, multiple regression of double log form was used. In order to study intra and inter sectoral land use shift, the land classes have been grouped into three broad sectors: (i) Ecological sector (ii) Non-agricultural sector and (iii) Agricultural sector. Annual rate of changes were estimated to study the intra and inter sectoral land use shift.

The temporal changes in land use pattern of Gujarat state as a whole envisaged that, land put to non-agricultural uses, net area sown and area under forest have increased by 8.43, 4.66 and 0.32 per cent, respectively during Period-II, but fallow other than current fallow, current fallow, land under miscellaneous tree crops & groves, cultivable waste, barren & unculturable land, and permanent pastures & other grazing lands have declined by 91.46, 20.60, 20.34, 1.82, 1.51 and 0.48 per cent, respectively.

At aggregate level of India, area under non-agricultural uses has increased by 25.96 per cent while it has increased by 8.43 per cent in case of Gujarat between Period-I and Period-II, implying thereby almost three times more increase in India compared to that of Gujarat. The area under cultivable waste declined by 18.19 per cent in India during Period-II over the Period-I, while a decline was only 1.82 per cent for the Gujarat state as a whole. The increase in the net area sown was observed at Gujarat state as well as at aggregate level of India, but the increase in case of Gujarat was as high as 4.66 per cent while it was only 0.28 per cent at national level. Net irrigated area increased by 51.23 and 85.96 per cent at All India level and Gujarat state, respectively in the same period. Notable results of the comparative analysis of change in gross irrigated area at India and Gujarat is that, it increased by 62.70 per cent at country level, while it was 101.68 per cent in case of Gujarat state during Period-II over the Period-I.

The area under forest has declined in 10 districts of Gujarat which ranged from 0.66 to 33.40 per cent in the Period-II over the Period-I. However, it increased in the eight districts, among which, the highest increase was observed in Ahmedabad (40.96%), followed by Surendranagar (32.21%), Vadodara (19.26%), Sabarkantha (17.86%), Mehsana (16.54), etc. The regionwise analysis revealed that the forest area
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increased in North Gujarat (9.79%) and Kachchh (9.12%), while it has declined in South Gujarat, Middle Gujarat and Saurashtra by 3.25, 2.71 and 1.94 per cent, respectively during the Period-II over the Period-I. Afforestation, reforestation and other forest development programmes were the reasons behind the increase in forest area in some districts. On the other hand, deforestation, settlement of tribales in forests, conversion of forest areas to other categories etc. are the reasons for reduction in area under forests in majority of the districts in Gujarat.

Though, barren and uncultivable land has declined by 1.51 per cent during the period of investigation at the state level, it showed notable increase in 10 districts with the highest increase in Valsad (69.13%), followed by Bharuch (59.12%), Vadodara (44.86%), Mehsana (44.04%), Amreli (40.40%), etc. The remaining districts of Gujarat registered a decline (within the rage of 2.05% to 25.44%) in the barren and uncultivable land during Period-II over the Period-I. The regionwise analysis revealed that the area under barren and uncultivable land increased in all the regions of Gujarat, except in the Kachchh during the period under study.

The land put to non-agricultural uses increased in all the districts and ultimately in all the regions of Gujarat. It was the highest in South Gujarat (11.51%), followed by North Gujarat (9.27%), Saurashtra (8.50%), Middle Gujarat (7.92%) and Kachchh (0.88%) during Period-II over the Period-I. The area under permanent pastures and other grazing lands has declined in 12 districts of Gujarat in the range of 0.13 to 8.69 per cent in Period-II over the Period-I. Moreover, it has also decreased in all the regions of Gujarat.

All the regions of Gujarat, except the Kachchh, experienced remarkable decline in cultivable waste. An alarming increase (45,268 ha) in area under cultivable waste was experienced in Kachchh region during Period-II over the Period-I. Though a remarkable decline in four regions of Gujarat was observed, the addition of cultivable waste land in case of Kachchh region was considerably higher (45,268 ha), which resulted in the marginal decline (1.82 %) in area under cultivable waste at the state level.

The results revealed that area under current fallow declined in majority of districts (12 out of 19) of Gujarat within the range of 5.90 to 60.30 per cent, whereas, the regions of Kachchh and Middle Gujarat registered the increase in area under
current fallow by 35.49 and 4.87 per cent respectively during Period-II over the Period-I.

The remarkable decline in all the districts of Gujarat in case of area under fallow other than current fallow during Period-II over Period-I was noticed where the changes ranged from -25.01 to -100.00 per cent. It is explicitly observed that net area sown increased in majority of the districts (13 out of 19) of Gujarat within the range of 0.05 to 28.84 per cent during the Period-II over the Period-I. Almost in all the districts, area sown more than once has increased in the range of 3.98 to 156.44 per cent during Period-II over the Period-I. Except Bharuch and Bhavnagar districts, all the districts of the Gujarat has recorded the positive change in total cropped area during the aforesaid time period. All the districts of Gujarat recorded a remarkable increase in net as well as gross irrigated areas during Period-II over Period-I.

The trend of land use pattern of Gujarat state as a whole during the Period-I, inferred that land put to non-agricultural uses, area under forest and current fallow significantly increased by 0.75, 0.78 and 6.14 per cent per annum, respectively. In contrast, barren and uncultivable land, permanent pastures and other grazing land, net area sown, cultivable waste and fallow other than current fallow in Gujarat declined by 0.17, 0.20, 0.32, 0.49 and 12.91 per cent per annum, respectively during the Period-I.

During Period-II, permanent pastures and other grazing land, land put to non-agricultural uses and net area sown in Gujarat state as a whole significantly increased by 0.02, 0.21 and 0.43 per cent per annum, respectively. However, cultivable waste, barren and uncultivable land, forest, fallow other than current fallow and current fallow declined by 0.05, 0.12, 0.14, 3.07 and 4.27 per cent per annum, respectively. The results of instability indices revealed that among all land use categories, the fallow other than current fallow was more unstable while permanent pastures and other grazing land category was more stable in Gujarat state as a whole. During all the three study periods, area sown more than once, net irrigated area and gross irrigated area significantly increased in Gujarat state.

The results of First order Markov chain employed for analyzing the land use shift revealed that other uncultivable land excluding fallow land was more stable among all the land use categories with the retention of 87.80 per cent of its previous
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years’ share at the national level during Overall Period. The net area sown, area under forest, land not available for cultivation and fallow land retained 81.80, 62.10, 46.20 and 12.90 per cent, respectively of its previous years’ share during current year in India. It can be observed from the results that during Overall Period, net area sown was a major gainer among the different land use categories with the gain of 48.10, 25.20 and 12.20 per cent from fallow land, land not available for cultivation and other uncultivable land excluding fallow land, respectively. At All India level, fallow land was recorded as highly unstable land use category during the entire period of study which experienced the retention of 12.90 per cent of its previous years’ share in current year.

The net area sown was highly stable among all the land use categories with the retention of 84.30 per cent of its previous years’ share during Overall Period in Gujarat. The land not available for cultivation, other uncultivable land excluding fallow land, forest and fallow land retained 74.30, 55.40, 51.20 and 28.10 per cent, respectively of its previous years’ share in current year at the state level in Gujarat during Overall Period. As observed in Period-I and Period-II, net area sown was a major gainer among the different land use categories during the Overall Period also with the gain of 53.00, 20.90 and 19.20 per cent from fallow land, land not available for cultivation and forest, respectively.

The area under different land use categories in Gujarat were predicted for next twelve years (TE 2020-21 to TE 2029-30) using TPM. The projected land use dynamics implying that the land use categories viz; forest, land not available for cultivation and other uncultivable land, except fallow land are likely to loose their area in coming years whereas the area under net area sown and fallow land are likely to remain same in the future.

Regionwise Markov chain analysis of land use pattern in Gujarat for different periods revealed that except Kachchh in Period-I and Overall Period, all regions showed probability of retention of its previous years’ share in current year in case of net sown area. Almost in all the regions, during all the three study periods, net area sown was major gainer land use category from previous years’ share of other land use categories.
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The results of the districtwise transitional probability matrix showed that the land use category of net area sown and forest showed some retention of its previous years’ share in current year in majority of the districts during all the periods under study. Almost in all the districts, net area sown was the major gainer from other land use categories. Fallow land was the most unstable land use category in majority of the districts of Gujarat during all the periods under study.

The results of multiple regression analysis indicated that the area under forest was positively influenced by the rainfall. The population has showed negative influence on the area under forest in Gujarat during the period 1970-71 to 2014-15. As far as the barren and uncultivable land is considered, it was negatively influenced by the number of factories in the state. The regression coefficient for the same was 0.267 and it was statistically significant. Land put to non-agricultural uses was positively influenced by road length and the population. It is noteworthy that corresponding regression coefficients for road length (30.941) and population (0.094) were statistically significant. Net irrigated area and road length were negatively influenced the extent of area under fallow other than current fallow while population has positive influence during the period of study. The corresponding regression coefficients of net irrigated area, road length and population were 0.147, 41.865 and 0.084, respectively which were statistically significant too. As far as the net area sown is considered, extent of net irrigated area showed positive influence on the net area sown in Gujarat with the significant regression coefficient of 0.788.

The results of multiple regression of double log form used to study the impact of changes in land use pattern on cropping intensity showed that cropping intensity was influenced positively by changes in the area put to non-agricultural uses. The regression coefficient of land put to non-agricultural uses (0.763) signified that the increases in land under non-agricultural uses would also compel to increase the cropping intensity at the Gujarat state as a whole.

Area under permanent pastures & other grazing lands and cultivable waste showed significant and negative impact on cropping intensity in case of North Gujarat during the study period. In South Gujarat region, cropping intensity was positively influenced by the land put to non-agricultural uses (0.086) and area under fallow other than current fallow (0.004). The surprising relationship between net area sown and the cropping intensity was observed in the region of Kachchh, where the regression
coefficient of net area sown (0.082) was negative and significant in relation with cropping intensity. The reason for that un-expectable impact of net area sown might be due to the fact that during the last two decades, area under fruit crops recorded an increase by manifold in Kachchh region and these annual crops are not replicated in enhancing the cropping intensity but added in the net area sown.

Districtwise impact of changes in land use pattern on cropping intensity revealed that, almost in all the districts, area under forest did not show any significant influence on the cropping intensity. None of the districts experienced the significant influence of barren and uncultivable land on cropping intensity in Gujarat during the period of 1970-71 to 2007-08, except the Panch Mahals. As far as the impact of change in area under non-agricultural uses on cropping intensity is considered, cropping intensity was positively influenced in the districts of Rajkot, Ahmedabad, Kheda, Panch Mahals and Vadodara by land put under non-agricultural uses with the statistically significant regression coefficients of 1.478, 0.299, 0.986, 0.719 and 0.159, respectively during the study period. The positive influence of non-agricultural land on cropping intensity might be due to the pressure of this land use category on agricultural land to maintain or even increasing the agricultural production from the same piece of land.

Except in some cases, it has been observed that almost in all the regions, districts and at the state level, change in land use categories did not reflect considerable impact on cropping intensity in Gujarat. Considering this, an attempt has been made to investigate the other factors having impact on cropping intensity. The results showed that, net irrigated area influenced the cropping intensity significantly more than any other variables at the state level. The regression coefficient of net irrigated area (0.150) signified that the increase in land under irrigation increased the cropping intensity. Disaggregated analysis at the districtwise revealed that except in case of Amreli, Banaskantha, Kheda and Vadodara districts, land not available for cultivation was unable to exert the significant influence on the cropping intensity in remaining districts of Gujarat. The cropping intensity in all the districts of Gujarat was positively influenced by the net irrigated area. Except in the districts of Surendranagar, Mehsana, Ahmedabad and Valsad, the regression coefficients of all the districts were statistically significant and ranged between 0.016 and 0.216.
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The inter-sectoral budgeting analysis was carried out to find the pattern and extent of dynamics in land-use shifts. It can be concluded that as compared to Period-I, inter-sectoral budgeting in ecological sector was favourable in Period-II at the national level. Though the area under ecological sector has declined in both the periods, the rate of decline was negligible (1798 ha/annum) in Period-II over Period-I (357800 hectares). There was a positive shift (184225 ha/annum) of land towards the agricultural sector during the Period-I which tilted unfavourably during Period-II, where it declined by 106850 hectares per annum at an aggregate of India.

For the state level, inter-sectoral budgeting for Period-I and Period-II indicates that, though the area under ecological sector declined in both the periods, the rate of decline was more (13655 ha/annum) in Period-I over Period-II (4557 ha/annum). It is desired that the decline in area under ecological sector should be on account of equal or relatively more decline in undesirable ecology sector and the same was reflected during the Period-I. However, it is interesting to note that the scenario of area shift under desirable ecology (E1) compared to undesirable ecology (E2) has not been favourable in Period-II, where land-use shift has been occurring from the desirable ecology towards agricultural and non-agricultural sectors. The area under agricultural sector declined in Period-I while, it has substantially increased in Period-II. Against the constant growth of area under non-agricultural sector at the national level, the Gujarat has experienced eight times lower annual increase in area under non-agricultural sector during Period-II (2187 ha/annum) over Period-I (17555ha/annum).

Districtwise budgeting of inter-sectoral land use shift in Gujarat implying that the area shift under desirable ecology compared to undesirable ecology has not been found favourable across different districts. During Period-II, except the Kachchh, Rajkot, Banaskantha, Jamnagar, Surendranagar and Kheda, remaining districts showed a decline in the area under the desirable ecological sector which may have serious implications in the long-run. While the area under undesirable sector increased in remaining districts viz; Panch Mahals, Amreli, Bharuch, Surat, Valsad, Vadodara and Bhavnagar during the Period-II. Inter-sectoral land use shift in case of agricultural sector reveals that, except the Kachchh, Jamnagar, Rajkot, Junagadh and Valsad, all the districts experienced the decline in area under agricultural sector during Period-I. On the flip side, more than half of the districts of the Gujarat state, experienced increase in area under agricultural sector, during Period-II. In some
districts, part of increase in agricultural sector may be observed due to increase in these cultivable wastes and fallow lands which, from the ecological point of view, can be considered as desirable one over the increase in undesirable ecological and non-agricultural sector.

**Policy Implications**

The policy implications emerged from the study are listed below:

1. The recommended share of forest to total geographical area is 33 per cent to maintain ecological balance and sustainability. Considering this, state has to follow stiff actions and made necessary policy provisions to restrain ecological imbalance.

2. Major reason for the land remaining fallow is scarcity of irrigation. This suggests to increase irrigation facilities and reserve irrigations through small size water harvesting structures like farm ponds and percolation tanks.

3. The state should initiate pro-active role in provision of input and infrastructural support systems to farmers to bring barren and uncultivable land under cultivation.

4. Soil reclamation programmes should be encouraged and intensive awareness campaigns should be organized to promote soil reclamation. Use of the resistant crop varieties in problematic soils and further to avoid extensive agricultural practices leading to soil degradation an integrated approach of efficient use of fertilizers based on Soil Health Card reports has to be promoted and effectively administered.

5. Though conversion of other land categories to non-agricultural uses is unavoidable due to population pressure, rapid industrialisation etc., it is better to use the undesirable land categories (other uncultivated land excluding fallow) for non-agricultural purpose.

6. Conservation of the pastures and grazing lands and creation of fodder banks to meet the shortage of fodder with combination of silage fodder system have great significance for the livestock sector.

7. The existing irrigation capital stock should also be made functional to improve its efficiency. There is need for huge expansion of cropped area under micro irrigation which may help to increase the cropping intensity.
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8. The unfavourable trend of desirable ecological sector and the vicious land use dynamics lead to the degeneration of this important natural resource, which is a matter of grave concern and needs to be managed on priority basis with the efforts from all the stakeholders particularly, policy makers in changing agro-ecological situations to minimize the effects of climate change.

9. The shift of area from desirable to undesirable ecological sector may have long term negative environmental implications. So, integration of agricultural and rural development programmes *viz.*; National Horticulture Mission, National Bamboo Mission, MNREGA *etc.* are necessary to make the use of barren and uncultivable land for cultivation, holistic rural development, natural resource management, and eco-restoration.